Specialist Geohydrology Impact Assessment for the Proposed Transient Interim Storage Facility at Koeberg

Report Prepared for

Koeberg Operating Unit (Eskom)

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Koeberg Operating Unit (Eskom)

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Glossary of Terms

Aquifer: A geological formation that has structures or textures that hold water or permit appreciable water movement [from the National Water Act, 1998 (Act No. 36 of 1998)]. Also defined as the saturated zone of a geological formation beneath the water table, capable of supplying economic and usable volumes of groundwater to borehole(s) and / or springs.

Aquifer system: A heterogeneous body of interlayered permeable and less permeable material that act as a water-yielding hydraulic unit covering a region.

Borehole: Includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from the National Water Act, 1998 (Act No. 36 of 1998)].

Catchment: The area from which any rainfall will drain into the watercourse, contributing to the runoff at a particular point in a river system, synonymous with the term river basin.

Circa: Approximately, or about.

Conceptual model: A simplified, schematic representation of each site, which includes sources, pathways and receptors, as well as the main process characteristics of the geohydrological system. An idealisation of the geohydrological system at the sites on which the numerical model is based. The conceptual model also includes assumptions on the hydrostratigraphy, material properties, dimensionality, and governing processes.

Confined aquifer: An aquifer in which the groundwater is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined groundwater occurs.

Contamination: The introduction of any substance into the groundwater system by the action of humans. The degradation of natural water quality as a result of man's activities, regardless of whether or not contaminant concentrations reach levels that cause significant degradation of water quality and restrict its use.

Durov diagram: A graphical presentation using cation and anion hydrochemical facies, similar to a Piper Diagram, with a projection to a 4^{th} dimension, such as electrical conductivity (EC). The Durov Diagram consists of five fields, two triangular and three rectangular. This diagram provides, on a single illustration, a visual characterisation of the eight major ions and two other properties of groundwater. It is also used to compare groundwater chemistry from different aquifer systems.

Ecosystem: An organic community of plants, animals and bacteria and the physical and chemical environment they inhabit.

Electrical conductivity: A measurement of the ease with which water conducts electricity. Distilled water conducts electricity poorly, while sea water, with its very high salt content, is a very good conductor of electricity.

Ephemeral: Refers to watercourses that are generally storm-driven and in which flow occurs less than 20 % of the time; these watercourses have a limited (if any) baseflow component with no groundwater discharge.

Fault: A zone of displacement in rock formations resulting from tensional forces or compression in the earth's crust.

Formation: A general term used to describe a sequence of rock layers.

Fracture: Cracks, joints or breaks in the rock that can enhance water movement.

Geohydrology: The study of the properties, circulation and distribution of groundwater, in practise used interchangeably with hydrogeology; but in theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology.

Greywacke: A dark coarse-grained sandstone containing more than 15 percent clay.

Groundwater flow: The movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone. Groundwater naturally drains from higher-lying areas to low-lying areas such as rivers, lakes and the oceans. The rate of flow depends on the slope (gradient) of the water table and the transmissivity of the geological formations.

Groundwater resource: All groundwater available for beneficial use, including humans, aquatic ecosystems and the greater environment.

Groundwater: Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.

Hornfels: A dark, fine-grained metamorphic rock consisting largely of quartz, mica, and particular feldspars.

Hydraulic conductivity: Measure of the ease with which water will pass through porous material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (in m/d).

Hydraulic gradient: Change in hydraulic head per unit of horizontal distance in a given direction, i.e. the difference in hydraulic head divided by the distance along the groundwater flow path. Groundwater flows from points of high elevation and pressure to points of low elevation and pressure.

Intergranular aquifer: Groundwater contained in intergranular interstices of sedimentary and weathered formations.

Major aquifer system: Highly permeable formations, usually with a known or probable presence of significant fracturing, may be highly productive and able to support large abstractions for public supply and other purposes; water quality is generally very good.

Numerical modelling: The analysis of geohydrological processes using computer models.

Owner Controlled Area: A restricted area surrounding the reactor units to which only authorised personnel have access.

Piper diagram: The Piper diagram not only shows graphically the nature of a given water sample, but also dictates the relationship to other samples. For example, by classifying samples on the Piper diagram, geologic units with chemically similar water can be identified, and the evolution in water chemistry along the flow path defined. Two data points are plotted on the cation and anion triangles and are then combined into a quadrilateral field that shows the overall chemical property of the water sample.

Quaternary catchment: A fourth order catchment in a hierarchal classification system in which a primary catchment is the major unit.

Recent: Time period covering the last 10 000 years of the Earth's geological history

Recharge: The addition of water to the zone of saturation, either by the downward percolation of precipitation or surface water and / or the lateral migration of groundwater from adjacent aquifers.

Saturated zone: The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

Semi-confined aquifer: An aquifer that is partly confined by layers of lower permeability material through which recharge and discharge may occur; also referred to as a leaky aquifer.

Sole source aquifer: An aquifer that is needed to supply 50 % or more of the domestic water for a given area, and for which there are no reasonably available alternative water sources should the aquifer be impacted upon or depleted.

Spring: A point where groundwater emerges, usually as a result of topographical, lithological and / or structural control.

Storativity: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is a volume of water per volume of aquifer released as a result of a change in head. For a confined aquifer, the storage coefficient is equal to the product of the specific storage and aquifer thickness. This is a measure of the water stored and released in an aquifer and is used to quantify the safe yield of an aquifer system.

Transmissivity: Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer. Transmissivity is used to calculate the yield of a borehole, determine the safe yield of an aquifer system and predict groundwater movement.

Unconfined aquifer: An aquifer with no confining layer between the water table and the ground surface where the water table is free to fluctuate.

Water Management Area: An area that is established as a management unit in the national water resource strategy within which a catchment management agency will conduct the protection, use, development, conservation, management and control of water resources [from the National Water Act, 1998 (Act No. 36 of 1998)].

Water table: The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

Wellfield: An area containing more than one pumping borehole that provides water to a public water supply system or single owner (i.e. Municipality).

Wellpoint: A shallow, small diameter hole used to abstract groundwater from a primary aquifer.

Wetland: Land that is transitionary between terrestrial and aquatic systems, where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil [from the National Water Act, 1998 (Act No. 36 of 1998)].

List of Abbreviations

3D:	Three dimensional
***c*.:**	circa
CISF:	Central Interim Storage Facility
CoCT:	City of Cape Town
CSB:	Cask Storage Building
DSSR:	Duynefontein Site Safety Report
DWAF:	Department of Water Affairs and Forestry (now Department of Water and Sanitation)
DWS:	Department of Water and Sanitation
EC:	Electrical conductivity, measured as milli-Siemens per metre (mS/m)
EIA:	Environmental Impact Assessment
GRU:	Groundwater Resource Unit
IAEA:	International Atomic Energy Agency
K:	Hydraulic conductivity, measured as m/d
KNPS:	Koeberg Nuclear Power Station
KOU:	Koeberg Operating Unit
L/s:	litres per second
m/d:	metres per day
m^3/a:	cubic metres per annum
Ma	million years
mamsl:	metres above mean sea level
MAP:	Mean annual precipitation
mbgl:	metres below ground level
mg/ℓ:	milligrams per litre
Mm^3/a:	million cubic metres per annum
mS/m:	milli-Siemens per metre
NNR:	National Nuclear Regulator
PBMR DPP:	Pebble Bed Modular Reactor Demonstration Power Plant
SSR	Site Safety Report
S_y:	Specific yield
SFPs:	spent fuel pools
SRK:	SRK Engineers and Scientists (South Africa) (Pty) Ltd
T:	Transmissivity, commonly reported in units of m^2/d
TISF:	Transient Interim Storage Facility

1 Introduction

The Koeberg Operating Unit of Eskom Holdings SOC Limited (Eskom) has appointed SRK Consulting (South Africa) (Pty) Ltd (SRK) to undertake an Environmental Impact Assessment (EIA) for the proposed Transient Interim Storage Facility (TISF) at Koeberg Nuclear Power Station (KNPS) (“the Project”) in support of an application for an Environmental Authorisation and other related authorisations such as Water Use Authorisation and Heritage approvals. See **Figure 1-1** for locality.

The Project entails the construction of an interim used fuel dry storage facility (known as Transient Interim Storage Facility (TISF)) for the storage of dry casks on site to accommodate used fuel from the reactors for the operational life of KNPS, thereby ensuring the continued operation of KNPS. The TISF will be on vacant land within the Owner Controlled Area, which will be filled with casks in a modular fashion. The TISF will house a number of used fuel modular dry storage systems fabricated from metal casks, concrete casks, or concrete modules, which will be done in compliance with the National Nuclear Regulator (NNR) requirements and international standards.

1.1 Project Description

Spent fuel assemblies are stored in spent fuel pools (SFPs) within the KNPS. The current SFPs are being progressively filled and additional storage is required to accommodate spent fuel for the operational life of the plant.

The current SFPs in Units 1 and 2 will exhaust their storage capacity by March 2018 and September 2018, respectively. To ensure continued plant operation at Koeberg, KNPS proposes the construction of a TISF to make provision for dry fuel storage of used fuel on-site up to 2025.

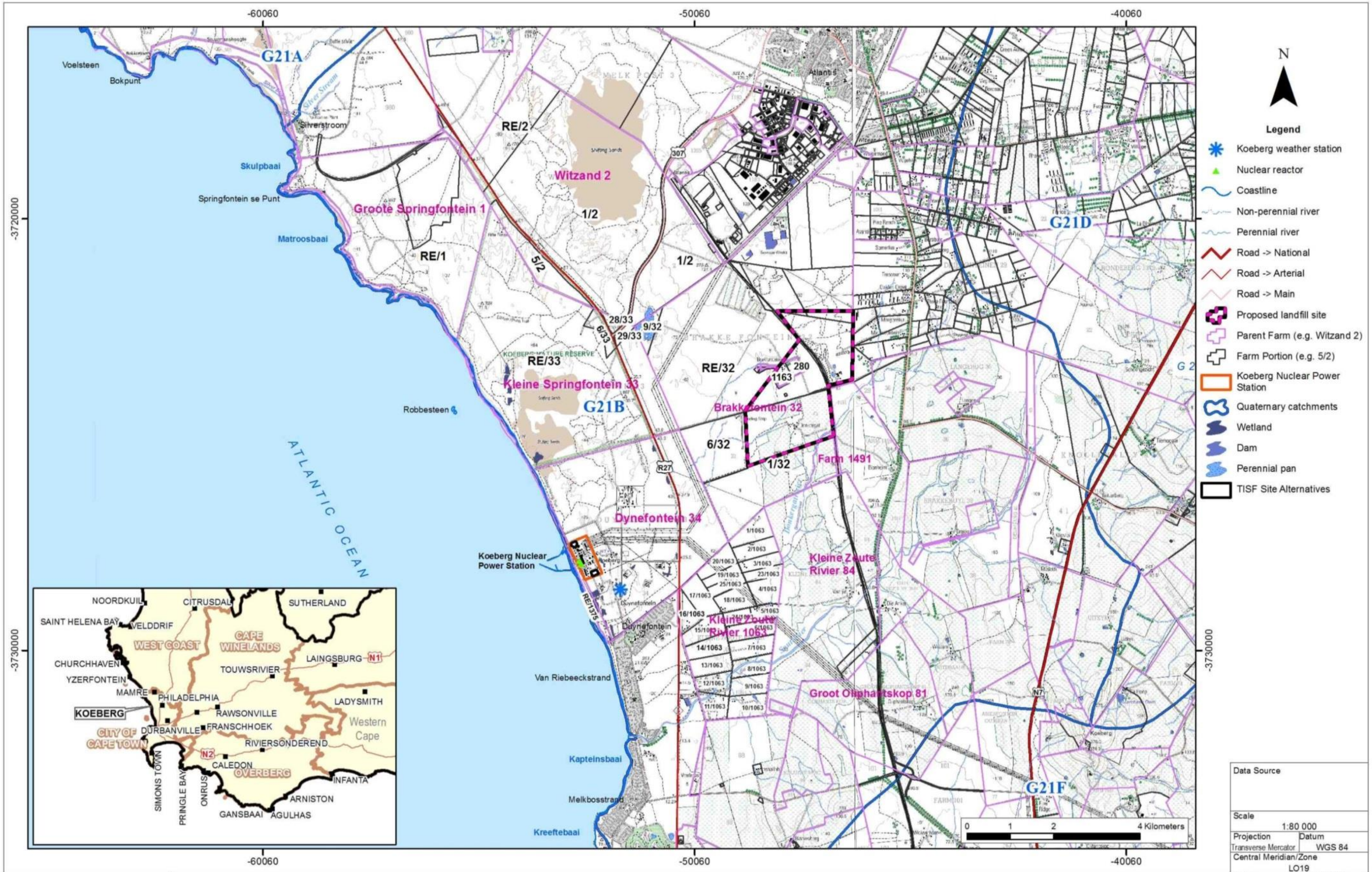
Currently 4 (four) metal casks are being stored horizontally in the Cask Storage Building (CSB) and in the interim an additional 7 (seven) metal casks will be added prior to the completion of the TISF. The dry storage of used fuel for the 4 (four) metal casks in the CSB are licenced until 2018. Extension of the NNR licence shall be applied for prior to the utilisation of the additional 7 (seven) metal casks in the CSB.

In addition to the 11 (eleven) metal casks in the CSB, the TISF shall accommodate all the dry storage casks required up to 2025 if the Central Interim Storage Facility (CISF) is available at that stage. If the CISF is not available by 2025, then the TISF can accommodate used fuel until the end of the operational life of the power station life.

The TISF will allow a combination of dry storage systems that includes metal and possibly concrete casks to be stored. The dry storage casks will accommodate used fuel which has been removed from the reactor vessel and has sufficiently cooled in the SFPs. The dry storage of used fuel at the TISF will operate in parallel with the SFP storage, which will continue to be necessary for the cooling and storage of used fuel recently removed from the reactor vessel. Used fuel needs to be cooled in the SFP before it can be placed in a cask.

Two (2) possible site locations for the TISF have been identified within the owner controlled area. The current preferred site, i.e. the CSB Site (Alternative 1), is located next to the CSB, on the northern boundary of the owner controlled area, whilst Alternative 2, the Ekhaya Site is located on the southern boundary of the owner controlled area (**Figure 1-2**).

The required footprint for the TISF will be 156 m (length) x 115 m (width) x approximately of 2 m (depth). Concrete piling might be required to comply with seismic requirements. The proposed excavations (up to a depth of 2 m) shall require a licence from the Department of Water and Sanitation (DWS) if dewatering of groundwater is required.



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KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT

LOCALITY AND EXTENT OF GEOHYDROLOGICAL STUDY AREA

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Data Source	
Scale	
Projection: Transverse Mercator	Datum: WGS 84
Central Meridian/Zone: LO19	
Date: 03/07/2015	Compiled by: GOES/FUBM
Project No: 478317	Fig No: 1-2

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KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
PROJECT SITE LAYOUT

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Revision: B Date: 14 10 2016

The casks will be approximately 6 m in height.

The final siting and design of the TISF preferred location will be determined by the geological, geo-hydrological and seismological characteristic of the site, as well as visual impacts of the development on the surrounding environment, including security, external event vulnerability and costs.

Existing roads will be used for transport of the casks and a detailed storm water management plan for the efficient draining of storm water and prevention of surface and groundwater contamination will be developed by Eskom.

The TISF is proposed to be constructed and filled with a number of storage casks in a modular fashion. These casks are proposed to be in the form of metal casks, concrete casks, or concrete modules.

1.2 Scope of Work

The following scope of work was provided:

- Describe the existing baseline characteristics of the Project site and place this in a regional context (study area);
- Identify and assess potential impacts of the Project and the alternatives, including impacts associated with the construction and operation phases, using SRK's prescribed impact rating methodology;
- Indicate the acceptability of the site alternatives and recommend a preferred alternative;
- Identify and describe potential cumulative impacts of the proposed Project in relation to proposed and existing developments in the surrounding area;
- Recommend mitigation measures to avoid and/or minimise impacts and/or optimise benefits associated with the proposed Project; and
- Recommend and draft a monitoring campaign, if applicable.

1.3 Deliverables

Although SRK requires that an interim baseline description be submitted to inform scoping, the main deliverable from each specialist will be an impact assessment report with appropriate maps, drawings and figures. Reports will consist of the following components:

- Baseline description: a description of the environment of the study area in its current state, relevant to the geohydrology of the Project site; and
- Impact assessment: an assessment of how the proposed Project will alter the *status quo* as described in the baseline description, and recommended measures to mitigate and monitor impacts.

Specialists should determine the spatial scope of their assessments using their professional judgment.

1.4 Methodology

The methodology employed for this specialist geohydrological baseline and impact assessments were as follows:

- Available studies undertaken at Koeberg were reviewed to determine baseline information available and to determine gaps in information;

- The existing groundwater resources potentially affected by the proposed Project were described and mapped, including groundwater levels, groundwater quality, hydrological linkages with other surface and groundwater resources and existing users of groundwater resources in the area;
- A specialist hydrogeological baseline report was drafted to inform the Scoping Report.
- A numerical flow model was compiled for Eskom's Duynefontein Nuclear-1 Project Site Safety Report (SRK, 2014). This model and scenario simulations, however, were not included in this assessment as the available data indicate that excavations for construction of the proposed facility will not extend to the water table. Dewatering will therefore not be a requirement.
- The potential hydrogeological impacts were assessed and an impact report (this report) drafted to inform the Environmental Impact Assessment Report.

1.5 Project Team

The geohydrological project team for the hydrogeology assessment comprised:

Des Visser Pr. Sci. Nat. **Principal Hydrogeologist**. Des has 28 years of experience in hydrogeology, impact assessments, project management, quality control and reporting. He has carried out numerous specialist groundwater studies and water supply projects, including Eskom's Nuclear Site Safety projects, solar power and mining projects in southern Africa. Des was the project manager and compiled this report.

Sheila Imrie Pr. Sci. Nat. **Principal Hydrogeologist, Specialist Groundwater Modeller**. Sheila has 16 years of experience in groundwater resources and IT in the UK and South Africa. She specialises in groundwater modelling, and has generated numerous flow and transport models for industry, government and Eskom's Site Safety Report (SSR) geohydrology model verification and validation. Sheila will carry out the numerical modelling to simulate dewatering of the excavation, if required, during impact assessment.

1.6 Information Sources

The SRK project team has been involved in groundwater studies at the Koeberg site since 2007 on the following projects:

- The geohydrology section for the Duynefontein Site Safety Report (DSSR) completed in 2014;
- Various groundwater and wetlands monitoring reports for Eskom's proposed nuclear site at Duynefontein from 2008 to September 2013;
- Various groundwater monitoring and specialist geohydrological reports for the proposed PBMR DPP site EIA compiled from 2007 to 2008;
- A specialist geohydrological report for Eskom's proposed Duynefontein Nuclear power station EIA completed September 2015;

These studies involved the following hydrogeological input:

- Review of available information;
- Site surveys, including hydrocensus and geophysics;

- Siting, drilling and testing of about 30 test and monitoring boreholes at the PBMR site, Duynefontein and KNPS[1] (see **Figure 1-2** for localities of these boreholes and sites);
- Numerical flow modelling;
- Monitoring of groundwater levels and chemistry over a six year period.

The above information proved invaluable in this specialist study, particularly the use of calibrated groundwater models.

2 Geohydrology Baseline

2.1 Physiography and Climate

The Project site is situated along the West Coast, approximately 30 km north of Cape Town CBD (**Figure 1-1**) and is located within the municipal boundaries of the City of Cape Town (CoCT). Access to the Project site is via the R27, or alternatively via Otto du Plessis Drive. The suburbs of Duynefontein and Melkbosstrand are located *c*.0.7 km and *c*.2.2 km south, of the Project site, respectively, while the industrial and residential town of Atlantis is located *c*.10 km northeast of the Project site.

The Project site falls within quaternary catchment G21B and in the Berg Water Management Area. The quaternary catchment has been subdivided into eight Groundwater Resource Units (GRUs) based mainly on geology and surface drainage features, as well as the bedrock topography and groundwater flow regime in the unconsolidated Cenozoic-age deposits (Woodford, 2007). The site falls within the Duynefontein GRU (Unit H).

The Duynefontein GRU extends from the edge of the Atlantis industrial area southwards to the Sout River near Van Riebeeckstrand. The western and eastern boundaries of the GRU are formed by the coastline and outcrops of the Tygerberg Formation rocks, respectively. The GRU is predominantly covered by geologically younger sediments of the Witzand and Springfontyn formations.

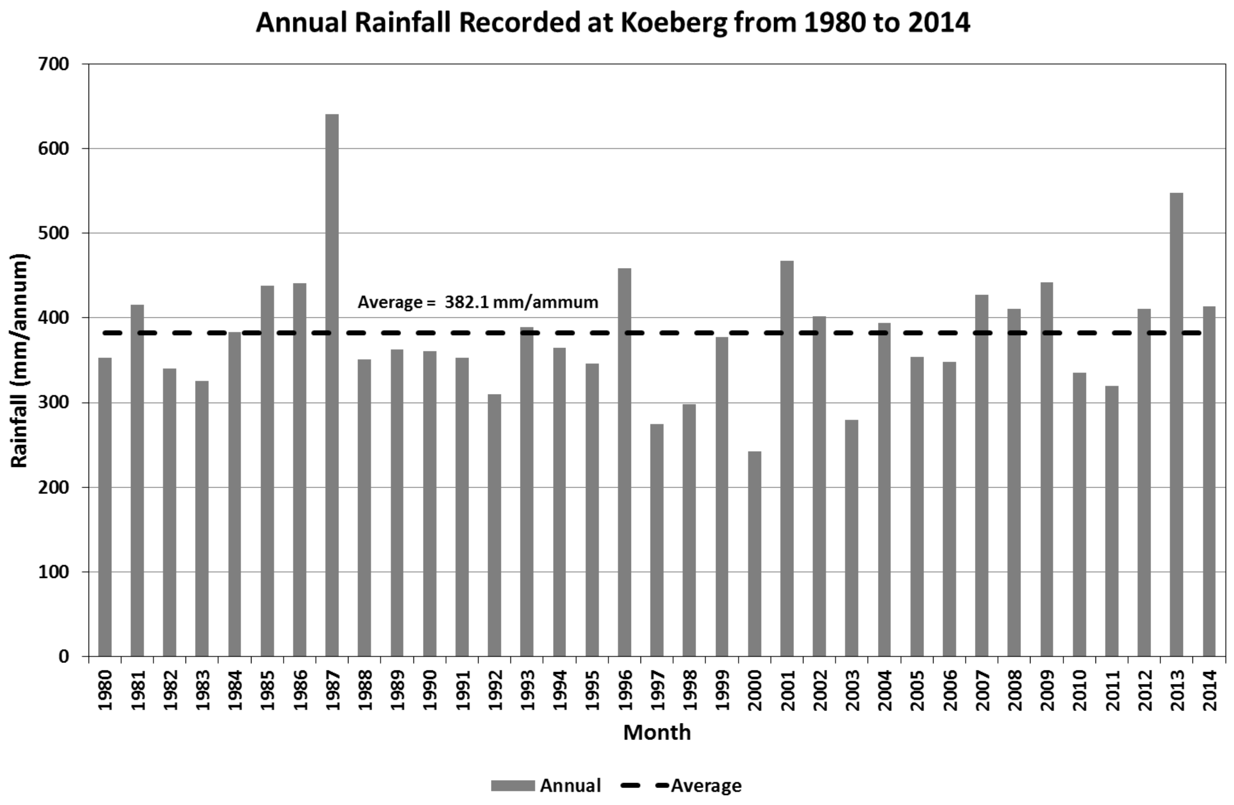
The topography is relatively flat with a gentle slope towards the coast. However, both ancient dunes stabilised by vegetation and Recent-age unconsolidated dunes with heights of <10 m are found north of the Project site along the coastline. No river channels drain the immediate Project site. However, the Sout and Diep rivers drain the broader areas within the study area (20 km radius around the Project site). The Donkergat River is a tributary of the Sout River. These rivers all flow in a south-westerly direction towards the coast. These tributaries are generally ephemeral in nature and only flow for short periods after significant rainfall events. Based on the nature of these rivers, Parsons and Flanagan (2006) suggested that groundwater does not discharge into the rivers. Most of the smaller streams ‘disappear’ in the flat sandy areas near the ocean and / or cannot maintain open river channels across the narrow raised dunes along the coast.

The site has a Mediterranean climate characterised by dry summers and wet winters. The average annual rainfall recorded at the KNPS from 1980 to 2014 is 382 mm/a (**Table 2-1** and **Appendix 1**), whilst a maximum of 640 mm was recorded in 1987 and a minimum of 242 in 2000 (Figure 2-1). Maximum average rainfall occurs during June (*c*.70 mm), July (*c*.65 mm) and August (*c*.57 mm), while the lowest average rainfall occurs during January (*c*.10 mm) and February (*c*.8 mm). Maximum monthly rainfall measured during this period occurred during June 1994 (157.4 mm), July 2001 (162.4 mm) and August 2013 (160.7 mm).

[1] SRK supervised drilling of the two monitoring boreholes P2a and P2b at the KNPS in July 2008.

Table 2-1: Monthly Rainfall Statistics for Data Recorded at Koeberg from 1980 to 2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	10.2	8.5	12.6	32.4	45.6	70.5	64.5	57.1	34.0	18.3	16.6	11.6	382.1
Minimum	0.0	0.0	0.0	2.8	1.3	12.0	22.8	12.8	2.5	0.6	0.4	0.3	242.4
Maximum	67.6	42.0	48.4	107.8	98.2	157.4	162.4	160.7	75.0	114.8	67.8	32.8	640.4
Median	5.5	5.5	7.2	29.0	38.9	68.5	57.3	54.2	30.0	13.4	13.0	8.6	365.0



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KOEBERG TISF GEOHYDROLOGY ASSESSMENT
CHART SHOWING VARIATION OF ANNUAL RAINFALL AT KOEBERG

Project No. 478317

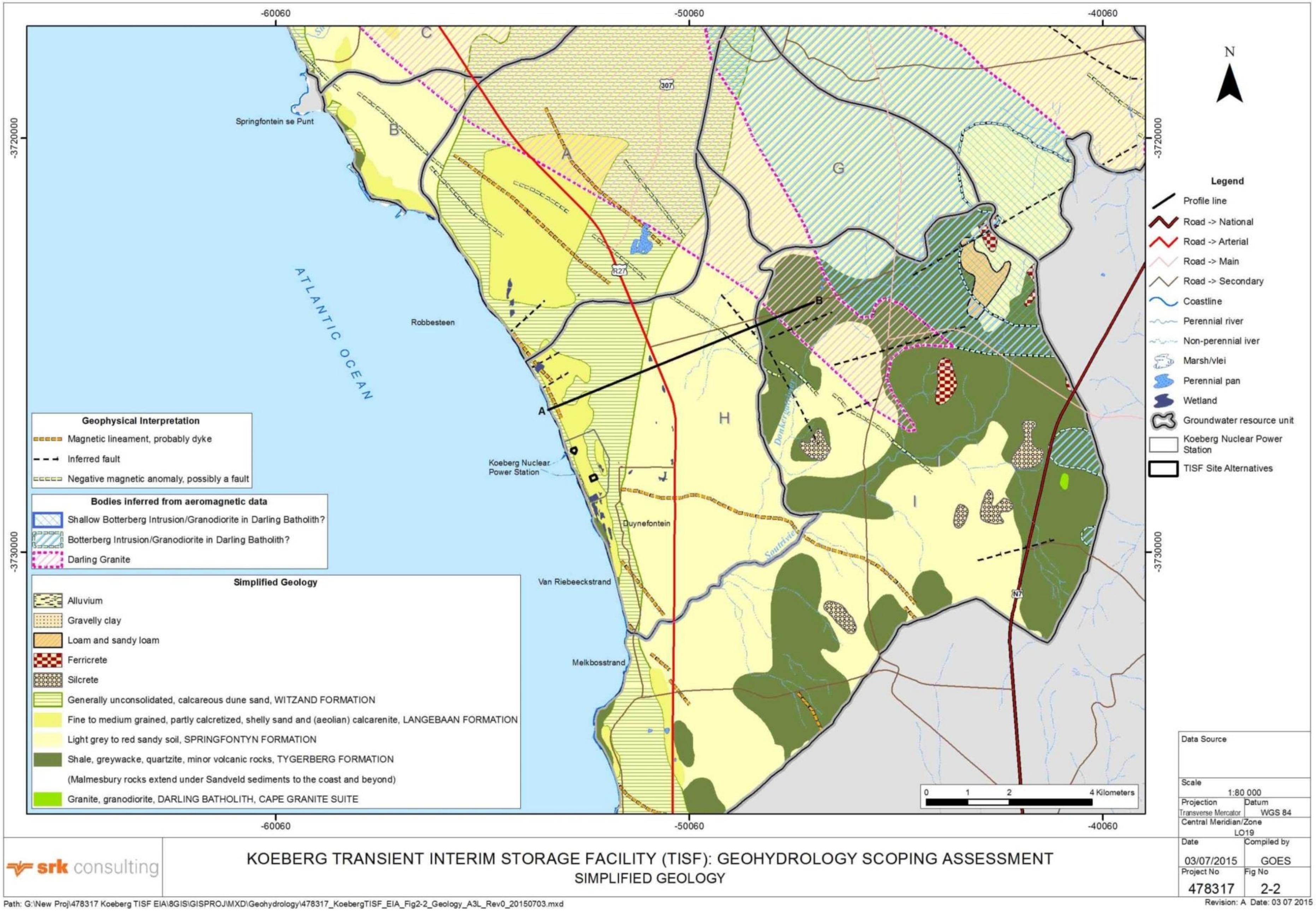
Figure 2-1: Chart Showing Variation of Annual Rainfall at Koeberg

2.2 Geology

The unconsolidated to semi-consolidated sediments underlying the Project site belong to the Sandveld Group, which is subdivided into the Elandsfontyn, Varswater, Velddrif, Langebaan, Springfontyn and Witzand formations. The lithostratigraphy of the Sandveld Group is summarised in **Table 2-2** (Johnson et al., 2006) and the surface geology is shown in **Figure 2-2**. The sediment thickness varies considerably and reaches a maximum thickness of between 40 and 70 m (Dyke, 1992). Boreholes drilled at and around the KNPS indicate a sediment thickness of *c*.22 m for the Project site.

Table 2-2: Summary of the Sandveld Group Lithostratigraphy (after Johnson *et al*., 2006)

Formation	Member	Origin	Type	Description	Epoch	Age (Ma)
Witzand		Aeolian	SAND	Fine- to medium-grained, whitish grey to slightly reddish, calcareous, cross-stratified, dune snails, echinoid spicules, forams and comminuted sea shells	Holocene	0.01 to 0
Springfontyn		Aeolian	SAND	Fine- to medium-grained, quartzitic sand, muddy and peaty in places	Pleistocene to Holocene	1.8 to 0.01
Langebaan		Aeolian	CALCAREOUS SANDSTONE	Cross-bedded, fine- to medium-grained, with calcrete layers	Late Pliocene to Late Pleistocene	2 to 0.2
Velddrif		Shallow marine	GRAVEL and SAND	Shelly and pebbly, cross-bedding	Plio-Pleistocene to Late Pleistocene	1.8 to 0.2
Varswater	Muishond Fontein	Estuarine / shallow-marine	SAND	Phosphatic, quartz-sand	Miocene to Pliocene	23 to 5
	Langeberg	Estuarine / shallow-marine	SAND	Non-phosphatic, carbonaceous clay and lignite lenses	Miocene to Pliocene	23 to 5
	Konings Vlei	Shallow-marine	GRAVEL	Pebbles and cobbles	Miocene to Pliocene	23 to 5
	Langeenheid	Estuarine	SAND	Argillaceous (clayey sand / silt)	Middle Miocene	14
Elandsfontyn		Fluvial	SAND and GRAVEL	Angular clasts, carbonaceous clay and lignite lenses	Early to Middle Miocene	23 to 14



Springfontein se Punt
ATLANTIC OCEAN
Robbesteen
Koeberg Nuclear Power Station
Duynefontein
Van Riebeeckstrand
Melkbosstrand
Legend
Profile line
Road -> National
Road -> Arterial
Road -> Main
Road -> Secondary
Coastline
Perennial river
Non-perennial iver
Marsh/vlei
Perennial pan
Wetland
Groundwater resource unit
Koeberg Nuclear Power Station
TISF Site Alternatives
Geophysical Interpretation
Magnetic lineament, probably dyke
Inferred fault
Negative magnetic anomaly, possibly a fault
Bodies inferred from aeromagnetic data
Shallow Botterberg Intrusion/Granodiorite in Darling Batholith?
Botterberg Intrusion/Granodiorite in Darling Batholith?
Darling Granite
Simplified Geology
Alluvium
Gravelly clay
Loam and sandy loam
Ferricrete
Silcrete
Generally unconsolidated, calcareous dune sand, WITZAND FORMATION
Fine to medium grained, partly calcretized, shelly sand and (aeolian) calcarenite, LANGEBAAN FORMATION
Light grey to red sandy soil, SPRINGFONTYN FORMATION
Shale, greywacke, quartzite, minor volcanic rocks, TYGERBERG FORMATION
(Malmesbury rocks extend under Sandveld sediments to the coast and beyond)
Granite, granodiorite, DARLING BATHOLITH, CAPE GRANITE SUITE
0 1 2 4 Kilometers
Data Source
Scale 1:80 000
Projection Transverse Mercator
Datum WGS 84
Central Meridian/Zone LO19
Date 03/07/2015
Compiled by GOES
Project No 478317
Fig No 2-2
Revision: A Date: 03 07 2015
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KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
SIMPLIFIED GEOLOGY
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The sediments of the Sandveld Group are underlain by meta-sediments belonging to the Tygerberg Formation of the Malmesbury Group. The Tygerberg Formation consists mainly of alternating greyish, medium to fine grained greywacke and phyllitic shale. Where intruded by the Cape Granite Suite (not present on-site) and narrow dolerite dykes (present on-site), the sediments are baked to massive bluish-grey hornfels along their contacts. These dykes, as well as faults in the vicinity of the site, have been delineated by the Council for Geoscience. The bedrock at the site consists of a steeply dipping, interlaminated and bedded succession of greywacke, siltstone and mudstone, with occasional shale interbeds of the Malmesbury Group. Gradational sequences and contacts are characteristic and the beds grade mainly from coarse to fine grained in upward-fining successions. The degree and depth of weathering varies considerably across the site. Unweathered greywacke is present within 6 m of the bedrock surface, while weathering of mudstone and siltstone extends to 26 mbgl in some places. The bedrock is brecciated along fault zones, and is intensely jointed and often sheared along such fault planes. Quartz veins, pyrite and clay gouge are ubiquitous in the joints and faults, especially where the wall-rocks of the faults are brecciated.

2.3 Geohydrology

2.3.1 Aquifer Types

Groundwater in and around the Project area occurs in two aquifers (**Figure 2-3**), namely:

- An upper unconfined primary (intergranular) aquifer locally known as the Atlantis Aquifer; which forms part of the more extensive Sandveld Aquifer, and beneath it
- A deeper semi-confined secondary fractured bedrock aquifer known as the Malmesbury Group Aquifer.

For purpose of this investigation only the upper Sandveld Aquifer is discussed in the subsections below as the deeper Malmesbury Group Aquifer will not be impacted by the proposed Project for the following reasons:

- The Malmesbury Aquifer is separated from the Sandveld Aquifer by a *c*.5 m thick clay layer. This clay layer forms a low permeable confining barrier to downward migration of any potential contaminants.
- The Malmesbury Aquifer is a confined aquifer with an upward flow gradient which prevents downward movement of potential contaminants from the upper unconfined Sandveld Aquifer into the Malmesbury Aquifer.

The Atlantis Aquifer is an important and significant primary aquifer with two wellfields (Witzand and Silwerstroom) situated >5 km north of the Project site supplying water to the surrounding towns (predominantly to Atlantis). Numerous boreholes exist in the study area around the Project site (**Figure 2-4**).

2.3.2 Aquifer Parameters

Hydraulic conductivity (K) for the various formations of the Atlantis Aquifer was found to range between 13 and 35 m/d, with the exception of the Varswater Formation (1 to 3.5 m/d). The average K at the Pebble Bed Modular Reactor Demonstration Power Plant (PBMR DPP) site next to the eastern boundary of the Koeberg Protected Area was found to be *c*.2.6 m/d (Murray and Saayman, 2000), with the more permeable upper layers of the primary aquifer ranging between 3 and 10 m/d, and the underlying, less permeable layers ranging between 4.0 x 10^{-3} and 5.0 x 10^{-3} m/d. Along the coastline at the western edge of the site, a K value of 12 m/d was obtained (Fleisher, 1993). K values derived for boreholes drilled in the Sandveld Aquifer for the proposed Duynefontein Nuclear site EIA, which are summarised in **Table 2-3**, ranged from 0.9 to 5.6 m/d (SRK, 2014). See **Figure 2-5** for the localities of these boreholes.

Table 2-3: Aquifer Parameters of the Sandveld Aquifer Underlying the Project Site

EIR BH No.	Transmissivity T (m^2/d)	Specific Yield (S_y)	Saturation Thickness (m)	Hydraulic Conductivity K (m/day)	Assumed Porosity (%)	Max. Test Yield (L/s)
SRK-KG2	22	2.0×10^{-1}	25.00	0.9	20	5.1
SRK-KG5	140	3.0×10^{-1}	25.00	5.6	20	5.1
SRK-KG8	57	1.1×10^{-1}	21.00	2.7	20	7.0
SRK-KG10	16	2.5×10^{-1}	17.00	0.9	20	5.4
Average	59	2.2×10^{-1}		2.5	20	5.6
Median	40	2.3×10^{-1}		1.8	20	5.3
Note: K was calculated by dividing T by saturation thickness, i.e. aquifer thickness. Aquifer Thickness = Borehole depth minus water level.						

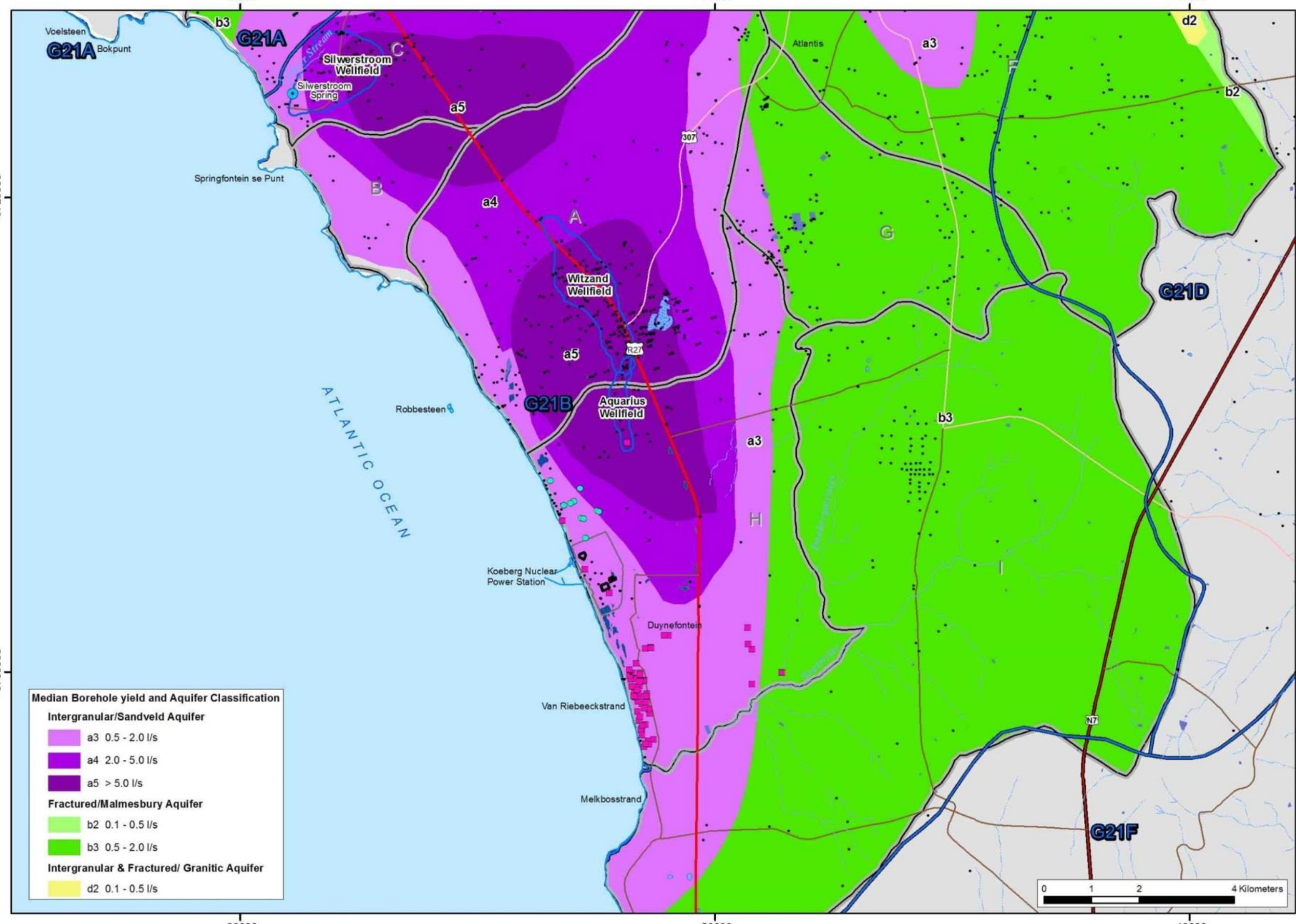
Specific yield (Sy) was determined to be between 4.0×10^{-2} (4 %) and 5.0×10^{-2} (5 %) (Murray and Saayman, 2000 and Bredenkamp and Vandoolaeghe, 1982). Specific yield values of between 1.98×10^{-1} (19.8 %) and 2.5×10^{-1} (25 %) were determined by Fleisher (1990) for the Atlantis Aquifer. Specific yield values determined from the Duynefontein site boreholes in the Sandveld Aquifer range from 1.1×10^{-1} to 3.0×10^{-1} for the primary aquifer (**Table 2-3**), i.e. 11 to 30 % and are typical ranges for this type of aquifer (SRK, 2014).

2.3.3 Depth to Groundwater

Seasonal rainfall variation does not significantly affect the groundwater flow direction or groundwater levels at the site. The influence of tides may impact on temporal variations in groundwater levels. Based on previous observations, groundwater levels west of the KNPS fluctuated by some 0.55 m during construction of the power units and by 0.70 m within the foundation area of the units (Dames and Moore, 1975a and Dames and Moore, 1975b).

Monitoring data of boreholes in close proximity to the site since 1985 show no indication of significantly declining water levels. It is, therefore, apparent that groundwater levels have not been negatively impacted by abstraction from the Witzand or Aquarius wellfields (SRK, 2014). Seasonal trends are evident, as is the short duration influence of pumping. Monitoring data for the Atlantis Aquifer are available from 1963, but these boreholes are located >5 km north of the Project site, and have therefore not been included in the assessment of monitored groundwater level data.

The water table ranges between 2 and 5 mbgl. The depth to groundwater mimics surface topography. Seasonal and tidal impacts are the dominant factors influencing local groundwater level fluctuations. The Aquarius (1.5 km north-east of the site) and Witzand wellfields are the closest groundwater abstraction areas to the site. Numerical modelling of the effect of abstraction from the Aquarius Wellfield on groundwater levels showed that there would be no significant impacts at KNPS (Du Toit *et al.,* 1995).



Data Source	
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Projection: Transverse Mercator	Datum: WGS 84
Central Meridian/Zone: LO19	
Date: 03/07/2015	Compiled by: GOES
Project No: 478317	Fig No: 2-3

srk consulting

KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT

AQUIFER TYPE AND BOREHOLE YIELD POTENTIAL

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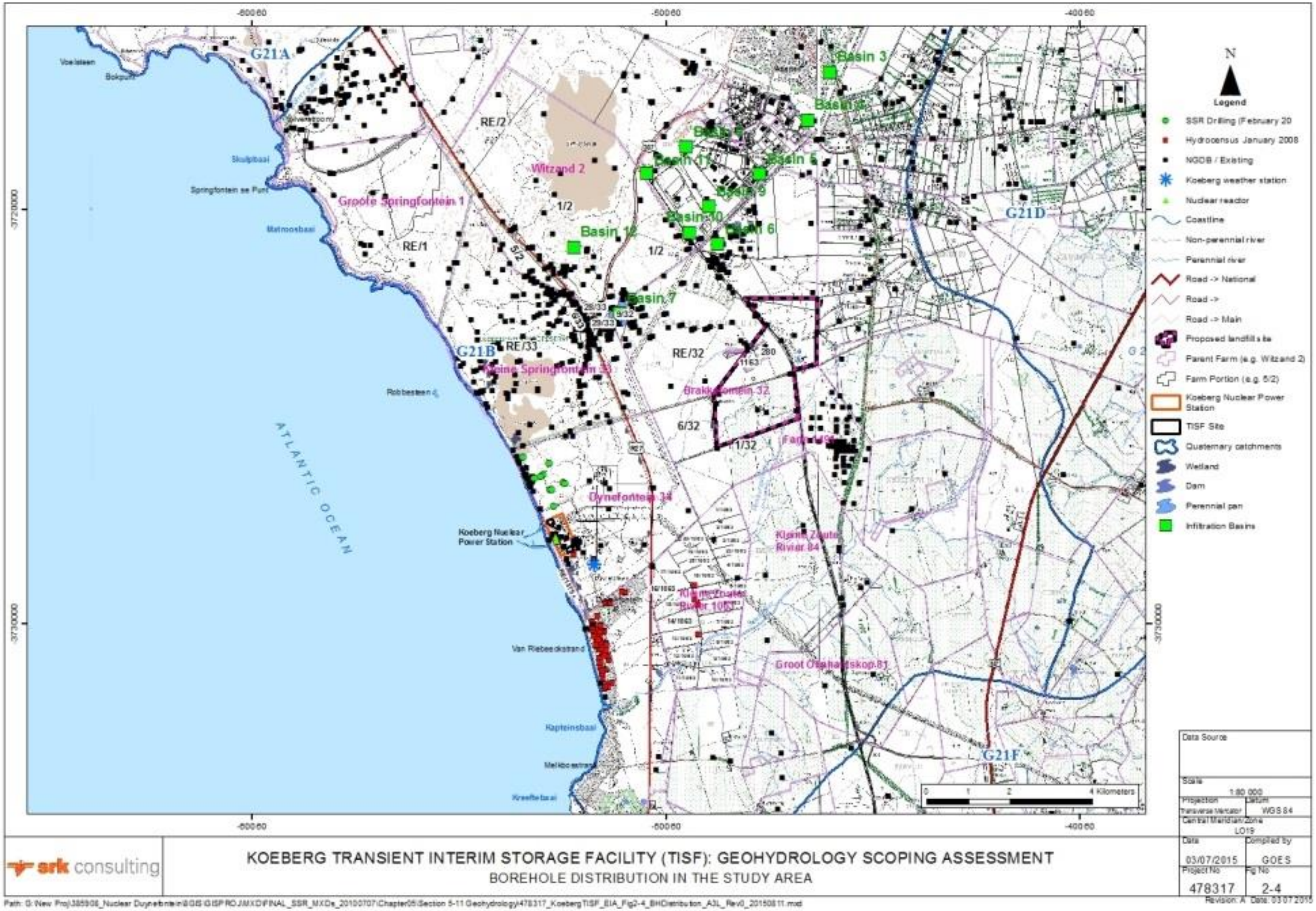
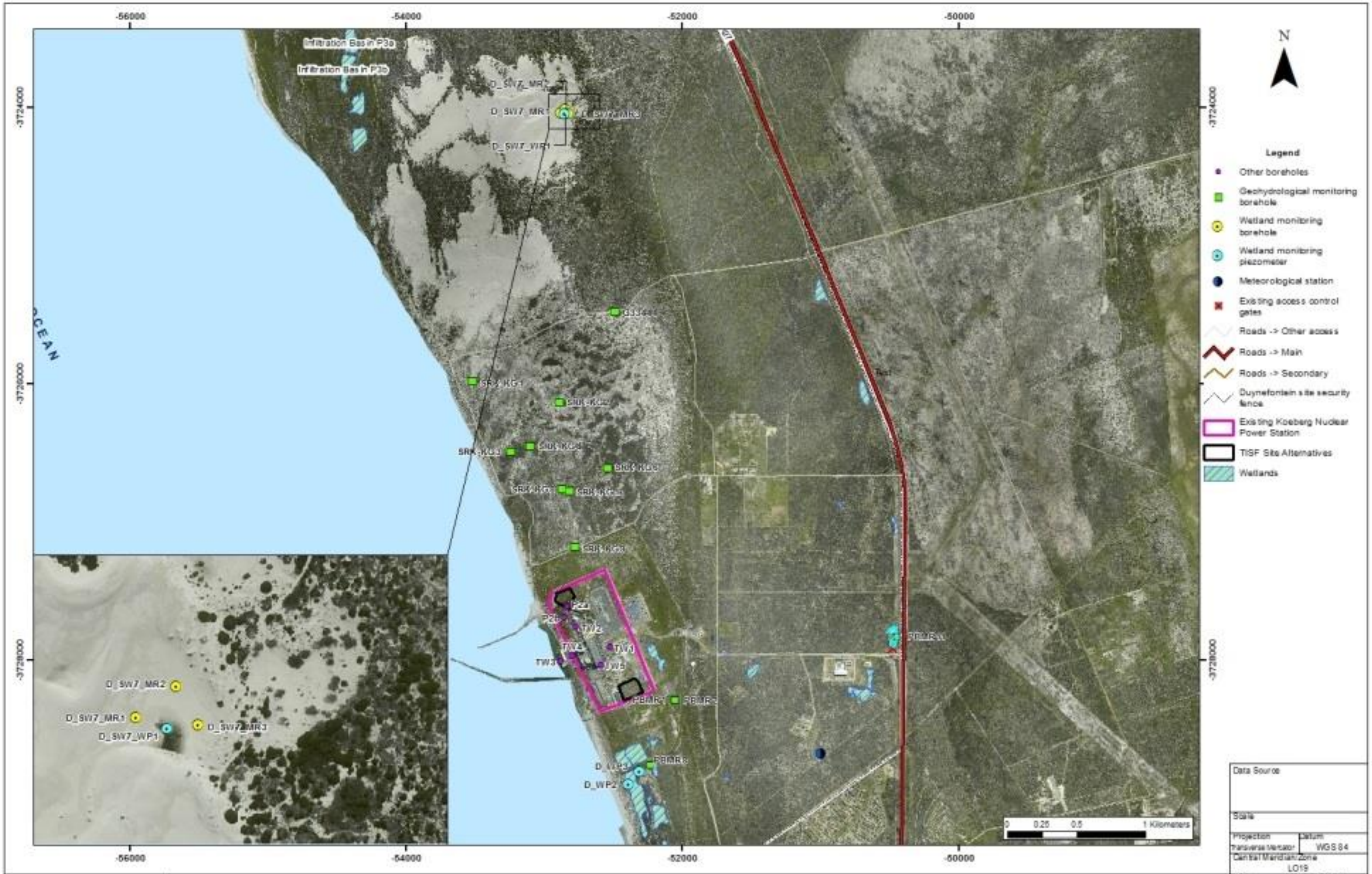
Revision: A Date: 03 07 2015


Atlantic Ocean
Koeberg Nuclear Power Station
Van Riebeeckstrand
Groote Springfontein 1
Witzand 2
Kleine Springfontein 33
Brakkefontein 32
Dynefontein 34
Groot Oliphantskop 81
G21A
G21B
G21D
G21F
Basin 3
Basin 7
Basin 12
Legend
SSR Drilling (February 20
Hydrocensus January 2008
NGDB / Existing
Koeberg weather station
Nuclear reactor
Coastline
Non-perennial river
Perennial river
Road -> National
Road ->
Road -> Main
Proposed landfill site
Parent Farm (e.g. Witzand 2)
Farm Portion (e.g. 5/2)
Koeberg Nuclear Power Station
TISF Site
Quaternary catchments
Wetland
Dam
Perennial pan
Infiltration Basins
Data Source
Scale 1:80 000
Projection Transverse Mercator
Datum WGS 84
Central Meridian/Zone LO19
Date 03/07/2015
Compiled by GOES
Project No 478317
Fig No 2-4
srk consulting
KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
BOREHOLE DISTRIBUTION IN THE STUDY AREA



srk consulting

KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT

SANDVELD AQUIFER BOREHOLE LOCALITIES NEAR THE PROJECT SITE

Data Source	
Scale	
Projection: Transverse Mercator	Datum: WGS 84
Central Meridian/Zone: LO19	
Date: 03/07/2015	Compiled by: GOES
Project No: 478317	Fig No: 2-5

Revision: A Date: 03.07.2015

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Boreholes in the Sandveld Aquifer (**Figure 2-5**) monitored since February 2008 to September 2013, using data loggers, indicate only minor variations in groundwater levels over the six years of data collection (**Figure 2-7**). Depth to water table vary according to surface topography, i.e. the higher the topography, the deeper the water table. Water table depths vary seasonally with higher levels during and after the wet season and deeper during the dry season.

Depth to water table in borehole KG10, located *c*.750 m north of the Project site, varies between 2.5 and 3.2 mbgl (13.1 - 13.8 mamsl) whilst in borehole G33444, which is further inland, it varies between 3.1 and 3.8 mbgl (25.1 – 25.8 mamsl). At borehole D-SW7-MR1 located *c*.3 km north of the Project site next to a dune-slack wetland, the water table depth ranges between 0.64 and 1.67 mbgl (*c*.31 to 32 mamsl).

At the wetland piezometers D-WP2 and D-WP3, which are located in one of the coastal wetlands south of the Project site, the water table depth ranges from 0 mbgl in the wet season to 1.0 mbgl in the dry season. Groundwater elevations at these two piezometers range from *c*.2 to *c*.3 mamsl and *c*.4 to *c*.5 mamsl, respectively

Water table depths measured since 2008 at boreholes P2a and P2b (**Figure 2-7**) located close to Alternative 1 ranged between 3.1 and 3.8 mbgl and between 5.0 and 5.5 mbgl respectively (SRK, 2008 and Hön *et al*, 2007 to 2015). Depth to water table measured since 2007 in boreholes TW1 and TW3, ranged between 0.8 mbgl and 1.7 mbgl whilst at TW2, TW4 and TW5 it ranged between 3.3 and 6.1 mbgl (Hön *et al*, 2007 to 2015). *Note: Borehole TW3 is right next to coast. Reason for high water table at TW1 is unknown, but is unlikely to be representing a natural water table in the upper unconfined Sandveld Aquifer. The high water table could be a result of nearby discharge, or the borehole might have been drilled into the lower confined Malmesbury Aquifer.*

Based on these measurements, the depth to water table at Alternative 1 is expected to be between 3 and 4 mbgl, which is deeper than the proposed TISF's excavation depth of 2 m, hence groundwater dewatering will probably not be required during construction. Similarly, water depths measured at boreholes close to Alternative 2, i.e. 3.2 to 3.5 mbgl at TW5 (Hön et al, 2007 to 2015), and at PBMR3, for the period 11 February 2008 to 15 March 2010, the water depth varied between 2.28 and 3.31 mbgl (SRK, 2010).

It is predicted that global warming will cause a future increase in sea levels worldwide (SRK, 2014). Modelling of potential sea level rise at the site has a possible rise in sea level of about 1.2 m over the next 50 years (Bates *et al*, 2008). Numerical modelling carried out for the DSSR (SRK, 2014) of the effects of this rise on the groundwater table indicates that groundwater levels at Alternative 1 could rise between 0.9 and 0.8 m and at Alternative 2 between 0.7 and 0.6 m, with effects (0.1 m) being propagated up to about 1 000 m inland.

2.3.4 Groundwater Flow

Using the available water level elevation data from the numerous boreholes around the Project site, a detailed site groundwater level contour map was compiled (**Figure 2-8**). These contours indicate the direction of groundwater flow to be from inland, across the Project site, in a south-westerly direction towards the coast, where it discharges into the ocean. The hydraulic gradient across the site determined from the water table elevation contours in **Figure 2-8** is *c*.0.0125 rising to *c*.0.025 closer to the coast. Groundwater therefore flows under a relatively low gradient at a calculated flow rate of *c*.2.6 m/d, which indicates a relatively quick migration across the Project site, towards the coastline.

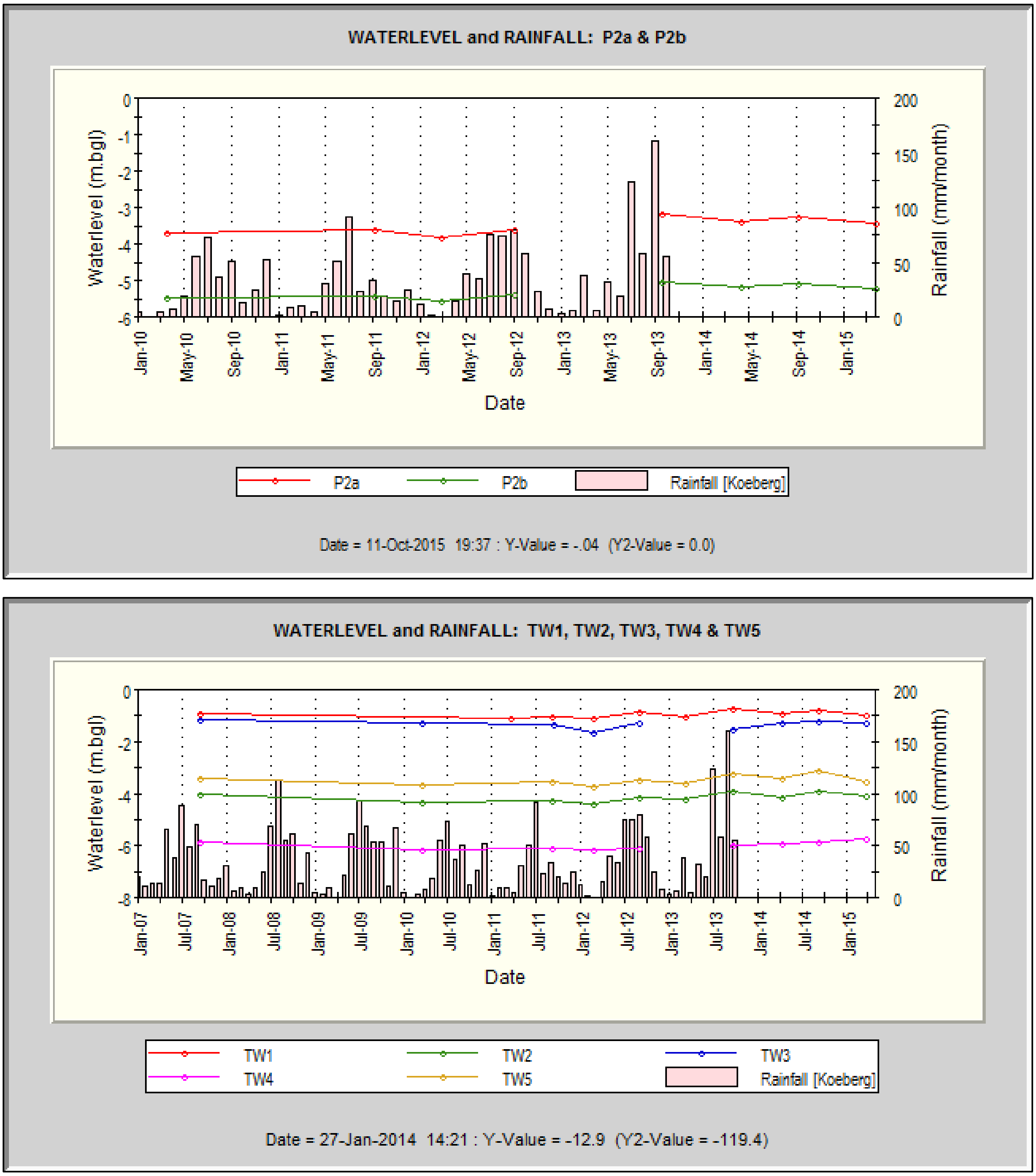
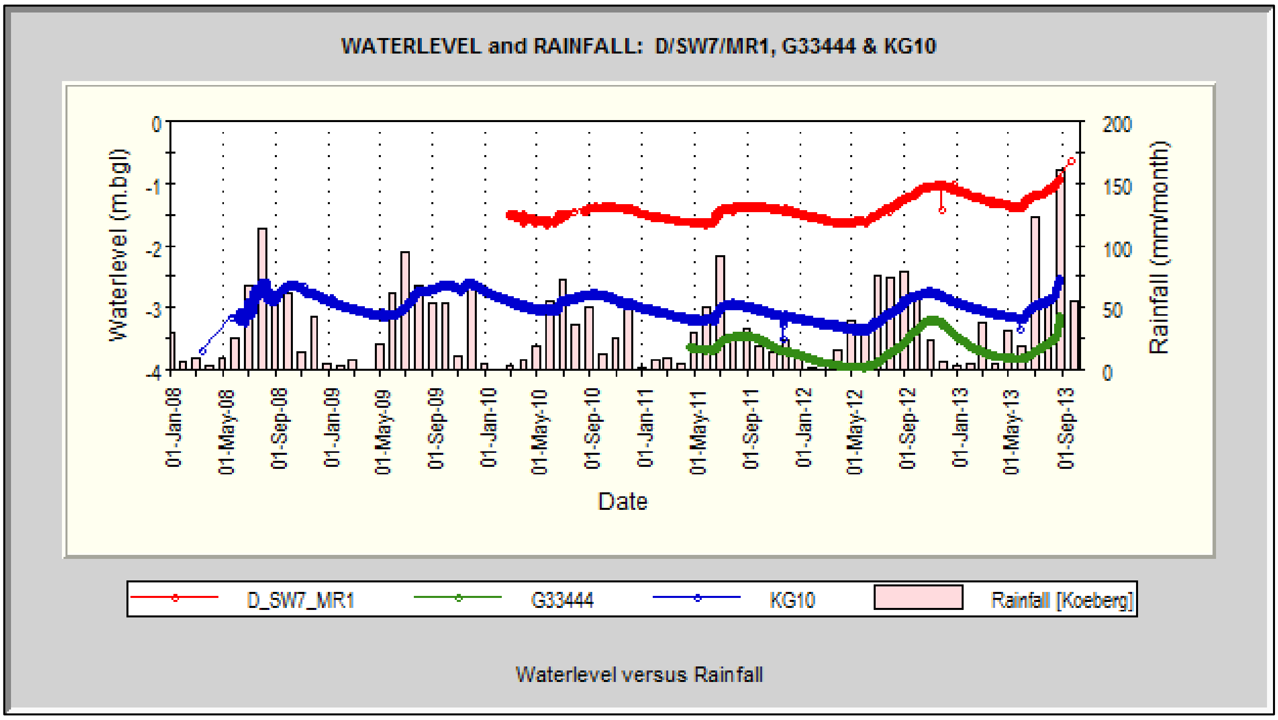


Figure 2-6: Groundwater Level Fluctuation in Monitoring Boreholes on the KNPS site



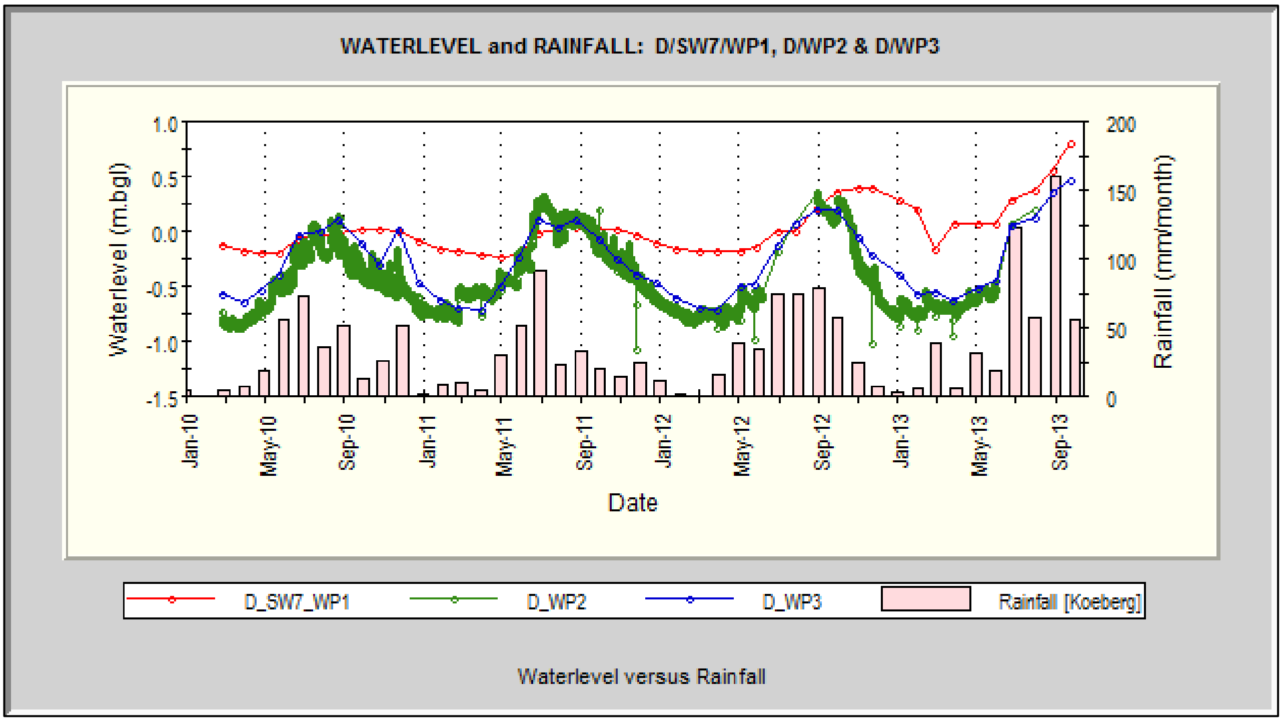
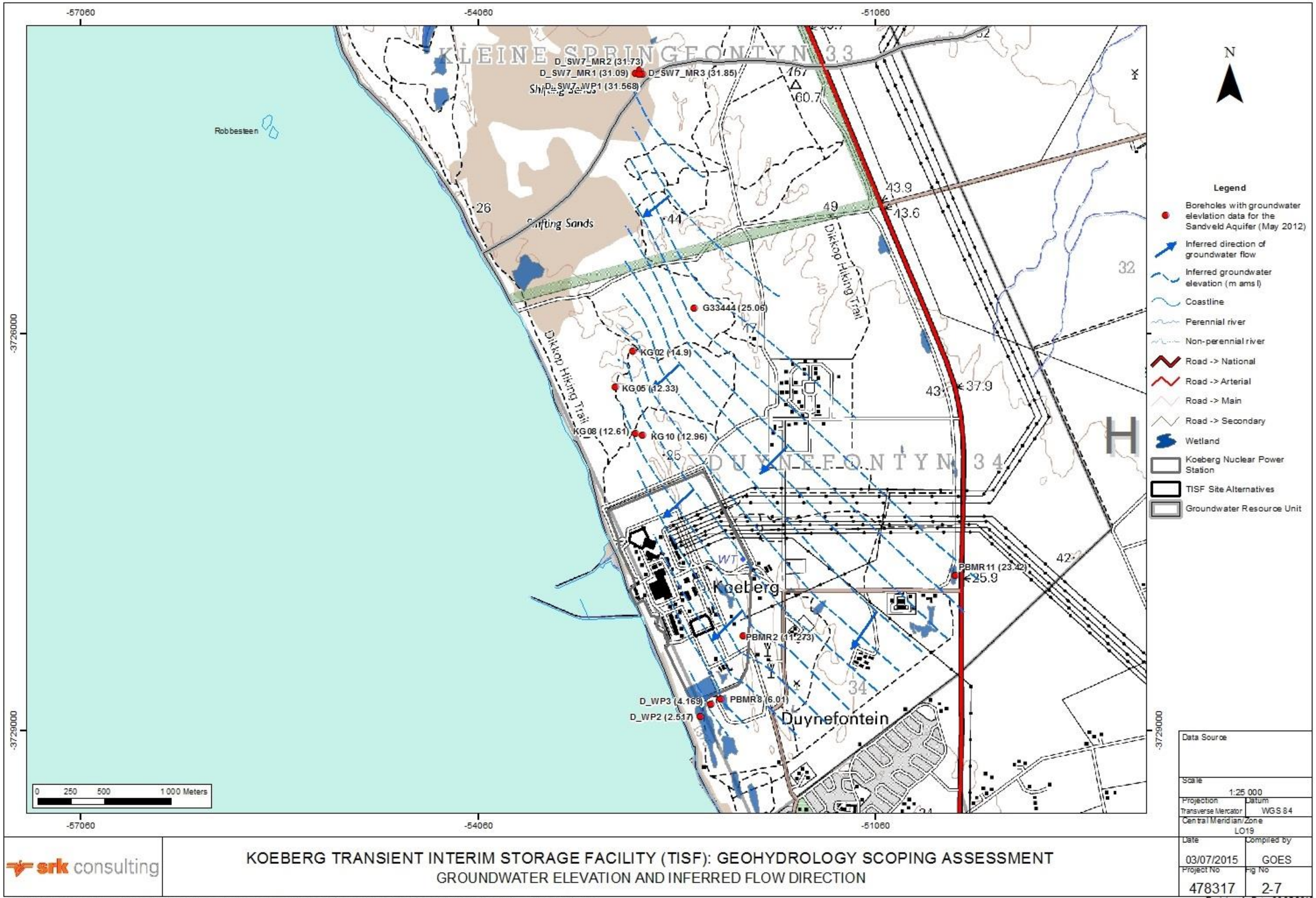


Figure 2-7: Groundwater Level Fluctuation in Monitoring Boreholes (top) and Piezometers (bottom) Installed into the Sandveld Aquifer around the KNPS site



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2.3.5 Aquifer Recharge

Estimates of recharge (as a percentage of rainfall) in the vicinity of the site have previously been made by Bredenkamp and Vandoolaeghe (1982), Vandoolaeghe and Bertram (1982), Bertram et al., (1984), Fleisher (1990) and Fleisher and Eskes (1992). Average recharge was estimated to be between 10 and 30 % of mean annual precipitation (MAP).

A recharge factor of 25 % of MAP was derived for the area surrounding the Silwerstroom Wellfield, by using a water-balance approach to analyse groundwater monitoring information collected between 1978 and 1982 (Bredenkamp and Vandoolaeghe, 1982).

Fleisher and Eskes (1992) determined natural recharge near the site to be 23 % for vegetated areas and 42 % for non-vegetated areas.

Significant tritium (^{3}H) concentrations (>1 TU) measured in the primary aquifer indicate a fairly dynamic system with groundwater in the aquifer being some 10 to 20 years old (SRK, 2014).

The Groundwater Resource Assessment Phase 2 Project's (DWAF, 2005) data-set provides an 'average' rainfall-recharge factor for the G21B quaternary catchment of 15.4 % using the Chloride Mass Balance approach. The recharge in the Duynefontein GRU was estimated to be 15 % of MAP (Woodford, 2007).

Due to the unconfined nature of the upper sediments, recharge takes place over the entire area (**Figure 2-9**). Following a review of all available recharge estimates for this assessment, a site recharge figure of 15 % is considered to be representative.

2.3.6 Borehole Yields and Groundwater Use

The Atlantis Aquifer is a highly productive aquifer with borehole yields of >10 L/s being obtained from production boreholes in the Witzand and Silwerstroom Wellfields, which are located >5 km north of the Project site (**Figure 2-10**). Borehole yields in the range of 0.5 to 5 L/s are common in the sands underlying the existing KNPS (SRK, 2014). Two boreholes drilled during 1991 by SRK along the northern boundary of the site yielded 1.7 and 4.2 L/s (Rosewarne, 1989 and Rosewarne, 1995). Ten boreholes drilled to depths of between 25 and 33 m along the Aquarius Wellfield yielded between 2 and 6 L/s (Jolly and Hartley, 1996). Maximum test pumping yields obtained for four boreholes drilled for the DSSR into the Sandveld Aquifer ranged from 5.1 to 7 L/s (**Table 2-3**).

The town of Atlantis has been largely dependent on groundwater for its water supply since 1976. Groundwater is abstracted from the aquifer at 40 boreholes in the Witzand and Silwerstroom Wellfields (**Figure 2-10**), softened at a water treatment plant and then distributed for domestic and industrial use (Flanagan and Parsons, 2005).

Two basins situated in the dunes to the south-west of Atlantis (**Figure 2-10**), which serve as final retention ponds for intermediate quality stormwater and treated domestic wastewater, provide for the artificial recharge of the aquifer some 500 m up-gradient of the Witzand Wellfield (Wright and Parsons, 1994).

Intermediate quality stormwater and treated domestic wastewater is discharged into Basin 7 (southern recharge basin), situated 4 km northeast of the Project site (**Figure 2-4**). High quality stormwater from Atlantis is diverted into Basin 12 (northern recharge basin). This artificial recharge counters the encroachment of naturally poorer quality groundwater (Tredoux et al., 1999). Poorer quality wastewater including treated industrial effluent is discharged into the coastal infiltration basins along the coastline, 3 km north of the site. This poorer quality water cannot be used for recharge into the aquifer and it does not meet the requirements of the DWAF general standard for discharge into the Donkergat River and is, therefore, disposed of as close to the coast as possible (Wright and

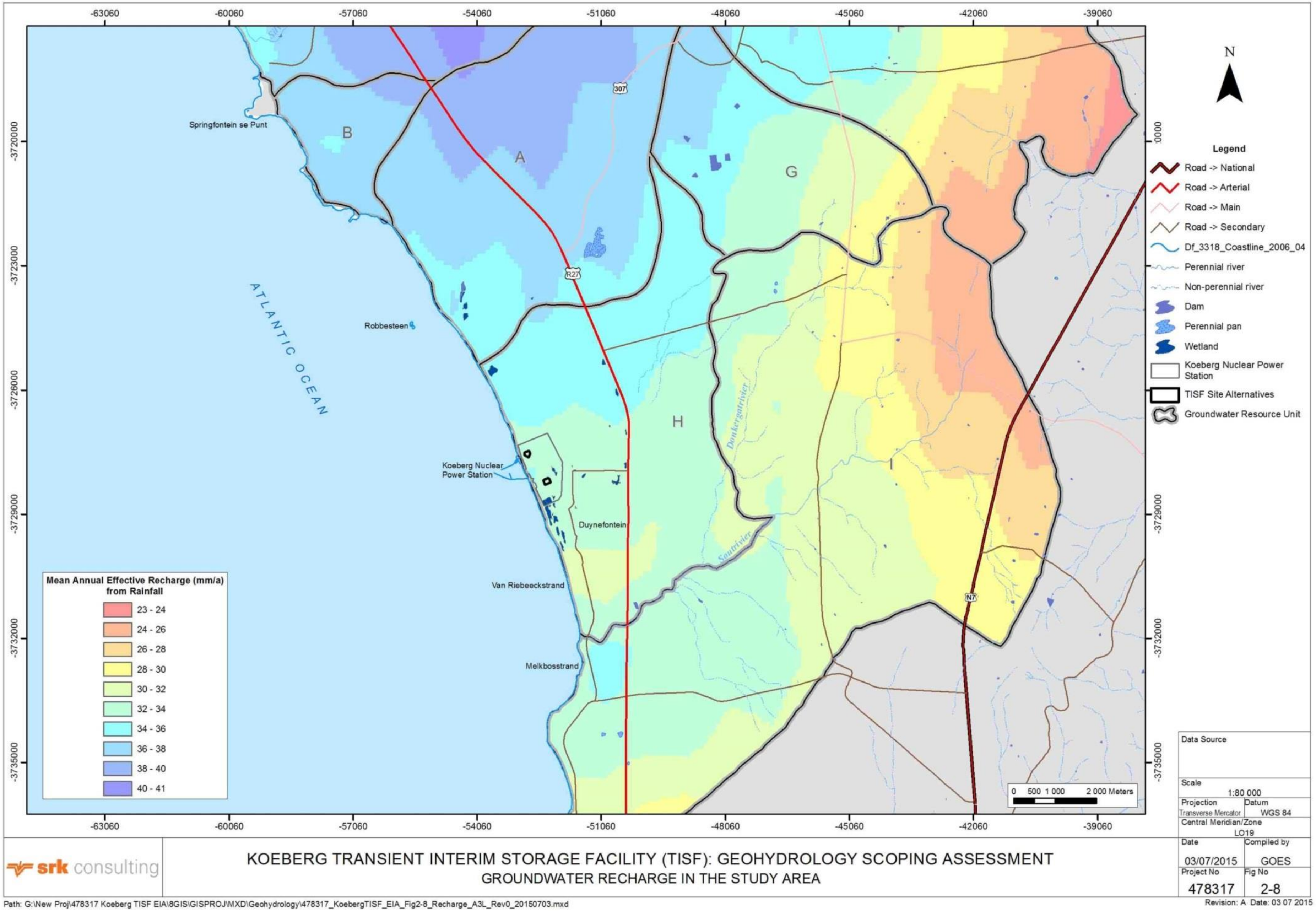
Parsons, 1994). Recharge into these coastal infiltration basins produces a subsurface hydraulic mound that acts as a barrier against seawater intrusion and increases the exploitable groundwater resource potential up-gradient at the Witzand Wellfield (Wright and Parsons 1994 and Tredoux et al., 1999).

Groundwater demand from the Witzand and Silwerstroom wellfields was 0.43 Mm^3/a in 1977 (Dyke, 1992), 8.5 Mm^3/a in 1998/1999 (Parsons, 1999) and 3.2 Mm^3/a in 2005 solely from the Witzand Wellfield. Based on modelling results, the sustainable ‘fresh water’ yield of the Witzand Wellfield is 5.8 Mm^3/a (Fleisher and Eskes, 1992).

Based on data received from the CoCT, 2.6 Mm^3/a of groundwater was abstracted from the two wellfields in 2007, significantly less than what was estimated during 1998/1999 (SRK, 2014). The reduced yields and the overall significantly reduced abstraction productivity of the two wellfields is a result of iron-related clogging. The CoCT is planning to rehabilitate and clean the boreholes to increase the borehole yields back to their initially determined sustainable yields (SRK, 2014). There are no visible signs of any negative impacts caused by groundwater abstraction from the Atlantis Aquifer, and the Silwerstroom spring is still flowing in spite of continued groundwater abstraction from the Silwerstroom Wellfield (Parsons, 1999). The discharge rate of the Silwerstroom spring was estimated to be 0.5 Mm^3/a during 1992 (Fleisher and Eskes, 1992). The Atlantis Aquifer is fully allocated and no further development or increased abstraction (other than rehabilitating the existing boreholes) will be allowed (Van der Berg et al., 2007).

A number of hydrocensuses have been conducted in the vicinity of the site; during September 1999, August 2004, November 2004, and September 2007 (Parsons and Flanagan, 2006; Levin, 2000; Flanagan and Parsons, 2005 and Bugan and Parsons, 2007). Where possible, the coordinates, depth, groundwater level, use, and yield were obtained, and a groundwater sample collected for chemical analysis. The January 2008 hydrocensus for the DSSR investigation was carried out in areas where little or no data were available (SRK, 2014).

Apart from the water supply abstraction mentioned earlier groundwater is also used in the vicinity of the site as a source of water for smallholdings, brickmaking and sand mining (SRK, 2014). Groundwater is predominantly used for small-scale vegetable farming, water for horses and irrigation of commercial lawn. Reticulated municipal water is available to most smallholdings from a pipeline constructed during 2002, but municipal water is only used to a limited extent due to the relatively high cost. Groundwater is still the preferred choice for water supply (Parsons and Flanagan, 2006).


Springfontein se Punt
A
B
G
H
I
ATLANTIC OCEAN
Robbesteen
Koeberg Nuclear Power Station
Duynefontein
Van Riebeeckstrand
Melkbosstrand
Donkergatrivier
Soutrivier
R27
307
N7
Legend
Road -> National
Road -> Arterial
Road -> Main
Road -> Secondary
Df_3318_Coastline_2006_04
Perennial river
Non-perennial river
Dam
Perennial pan
Wetland
Koeberg Nuclear Power Station
TISF Site Alternatives
Groundwater Resource Unit
Mean Annual Effective Recharge (mm/a) from Rainfall
23 - 24
24 - 26
26 - 28
28 - 30
30 - 32
32 - 34
34 - 36
36 - 38
38 - 40
40 - 41
0 500 1 000 2 000 Meters
Data Source
Scale 1:80 000
Projection Transverse Mercator
Datum WGS 84
Central Meridian/Zone LO19
Date 03/07/2015
Compiled by GOES
Project No 478317
Fig No 2-8
srk consulting
KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
GROUNDWATER RECHARGE IN THE STUDY AREA
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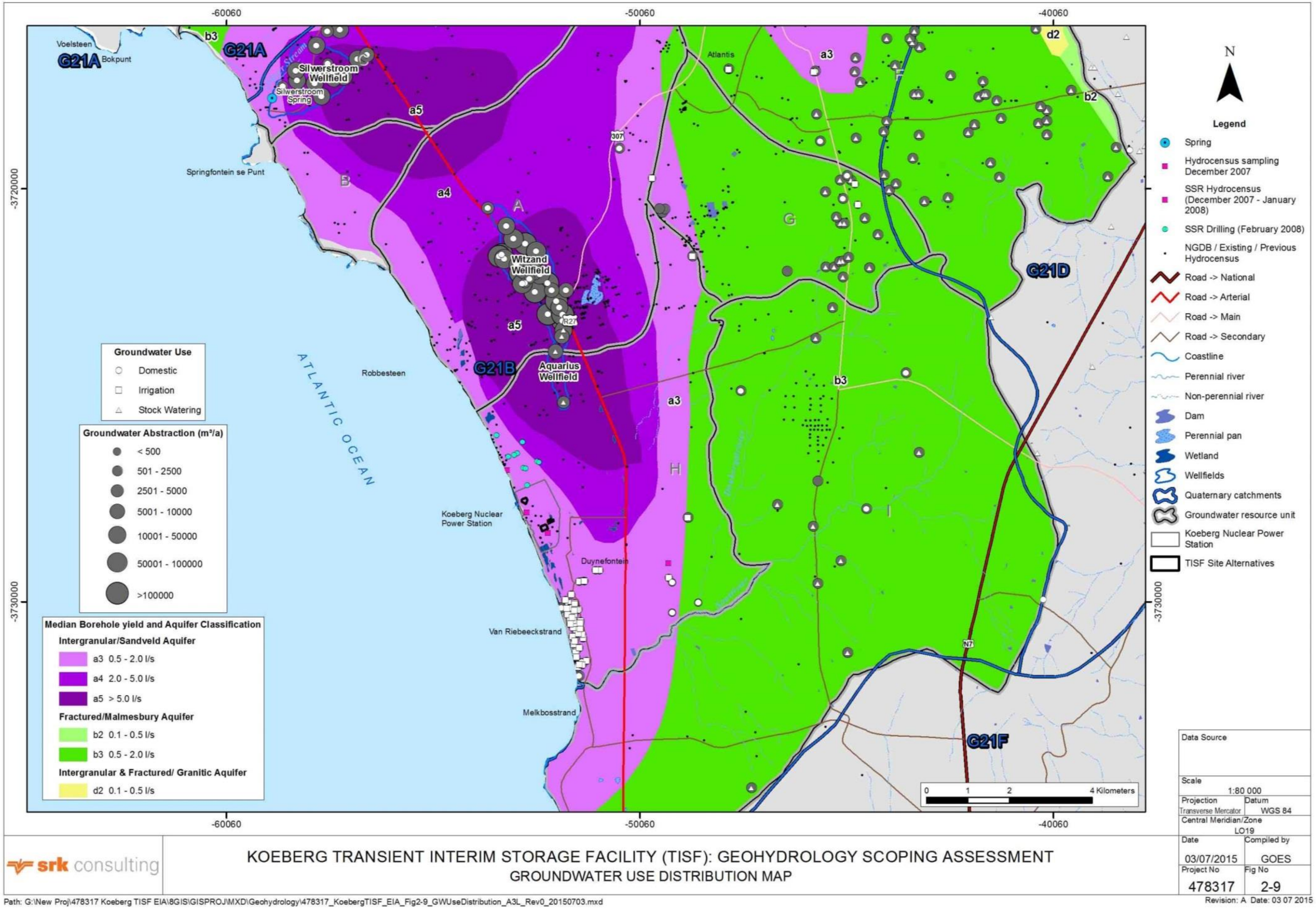
Revision: A Date: 03 07 2015

There are approximately 1 000 erven in Duynefontein, of which about 75 % have wellpoints installed for garden irrigation purposes (SRK, 2014). Duynefontein is considered a high income group area and typical water demand is estimated to be 1 800 litres per day per household (i.e. 450 litres per person per day for a four person household) (SAICE, 1995). The estimated breakdown of domestic water usage indicates that 35 % of water is used for garden irrigation (SAICE 1995). Therefore, an average of some 230 m^3/a of groundwater per erf is abstracted via wellpoints from the primary aquifer, assuming gardens are irrigated each day. This equates to *c*.173 000 m^3/a of groundwater being abstracted from the area south of the KNPS. Based on data collected during the January 2008 DSSR hydrocensus (SRK, 2014), some 30 000 m^3/a of groundwater is abstracted from four boreholes along the Aquarius Wellfield (GCS1, GCS7, GCS9 and GCS10). The groundwater from these boreholes is currently used for stock watering and irrigation purposes, as well as to supply the dam at the conservation offices at the existing KNPS. These boreholes were initially drilled to supply water to KNPS. However, as the groundwater is relatively high in salinity, the use of these boreholes was temporarily abandoned as desalination by reverse osmosis was not cost-effective (Eskom, 2006a). It was previously estimated that 0.5 Mm^3/a of groundwater was abstracted from the Aquarius Wellfield (Parsons, 1999). The four boreholes were re commissioned at the beginning of 2007.

Five monitoring boreholes are situated around the reactors at the KNPS (TW1 to TW5). These boreholes are presently solely used for groundwater monitoring purposes (Hön et al., 2007 and Hön and Engelbrecht, 2007). A further six monitoring boreholes have also been recently drilled at the PBMR DPP site (PBMR1 to PBMR6) to monitor groundwater levels, macro chemistry and ^3H concentrations in both the primary aquifer and underlying Malmesbury Group Aquifer (Flanagan, 2008b). This monitoring programme commenced during February 2008 (Flanagan and Burgers, 2008), and was stopped in March 2010 when the PBMR project was terminated. The DSSR monitoring programme was subsequently (from March 2010) expanded to include an additional 15 monitoring boreholes, which include an old Department of Water Affairs borehole and four of the PBMR boreholes (SRK,2013). Also included are three piezometers installed in some of the wetlands on site. This brings the total number of groundwater monitoring points to 17 boreholes and three piezometers. See **Figure 2-5** for the localities of these monitoring points.

On-site Groundwater Abstraction

Groundwater is presently not used at the Project site (SRK, 2014). The nearest abstraction points are from boreholes at the Aquarius and Witzand Wellfields. The six boreholes drilled on-site into the Malmesbury Group Aquifer during the work for the DSSR assessment yielded between 2 and 12 L/s (SRK, 2014). The Malmesbury Group Aquifer is presently not utilised in the area.


Voelsteen
G21A
Bokpunt
Silwerstroom Wellfield
Silwerstroom Spring
Springfontein se Punt
Atlantis
Witzand Wellfield
Aquarius Wellfield
Robbesteen
ATLANTIC OCEAN
G21B
G21D
G21F
Koeberg Nuclear Power Station
Duynefontein
Van Riebeeckstrand
Melkbosstrand
Groundwater Use
Domestic
Irrigation
Stock Watering
Groundwater Abstraction (m³/a)
< 500
501 - 2500
2501 - 5000
5001 - 10000
10001 - 50000
50001 - 100000
>100000
Median Borehole yield and Aquifer Classification
Intergranular/Sandveld Aquifer
a3 0.5 - 2.0 l/s
a4 2.0 - 5.0 l/s
a5 > 5.0 l/s
Fractured/Malmesbury Aquifer
b2 0.1 - 0.5 l/s
b3 0.5 - 2.0 l/s
Intergranular & Fractured/ Granitic Aquifer
d2 0.1 - 0.5 l/s
Legend
Spring
Hydrocensus sampling December 2007
SSR Hydrocensus (December 2007 - January 2008)
SSR Drilling (February 2008)
NGDB / Existing / Previous Hydrocensus
Road -> National
Road -> Arterial
Road -> Main
Road -> Secondary
Coastline
Perennial river
Non-perennial river
Dam
Perennial pan
Wetland
Wellfields
Quaternary catchments
Groundwater resource unit
Koeberg Nuclear Power Station
TISF Site Alternatives
0 1 2 4 Kilometers
-60060
-50060
-40060
-3720000
-3730000
Data Source
Scale 1:80 000
Projection Transverse Mercator
Datum WGS 84
Central Meridian/Zone LO19
Date 03/07/2015
Compiled by GOES
Project No 478317
Fig No 2-9
srk consulting
KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
GROUNDWATER USE DISTRIBUTION MAP
Path: G:\New Proj\478317 Koeberg TISF EIA\8GIS\GISPROJ\MXD\Geohydrology\478317_KoebergTISF_EIA_Fig2-9_GWUseDistribution_A3L_Rev0_20150703.mxd
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Ecosystem Water Use and Interaction with Surface Water

The only area in the vicinity of the site where the terrain is sufficiently low-lying to support significant areas of wetland habitat is found 1.5 km south of the site (SRK, 2014). The slack areas between a series of low lying east-west oriented dunes give rise to a mosaic system of alkaline dune-slack wetlands (Day, 2007a). No other natural freshwater systems or springs are known to occur at the site.

These dune wetlands are fed primarily by the seasonal fluctuations in the water table, forming pools of shallow, brackish water during winter. These wetlands are dry in summer when the water table drops. These pools provide a breeding habitat for frogs as well as numerous aquatic and semi-aquatic invertebrates including crustacean fauna that occur in seasonal wetland habitats. Wet season salinities in the wetlands are probably elevated, as a result of marine influences such as sea mists and off-shore winds. The wetlands are considered of high local and regional importance, although their similarity to other wetlands north of the site has not yet been established (Day, 2007a).

A series of coastal infiltration basins (see **Figure 2-5** for localities), which has been excavated between the dunes 3 km north of the site for disposal of wastewater including treated industrial effluent, may be linked to an increase in seepage and deterioration of the limestone cliffs along a section of nearby coastal shoreline (Day, 2007a and Day, 2007b). The coastal infiltration basins are highly artificial habitats, comprising deep, permanent, open water bodies, vegetated by species that thrive under conditions of nutrient enrichment (Day, 2007a and Day, 2007b). The coastal infiltration basins provide permanent habitat to a variety of swimming waterfowl, but are of limited value to wading birds. Fish have been introduced to the ponds, primarily to provide an early warning of water quality problems. The coastal infiltration basins are unnatural water features of low quality, but locally rare, permanent freshwater habitat, artificially contributing to plant and animal diversity in the area. They play an important role in terms of providing a hydraulic barrier for the protection of the Atlantis Aquifer from seawater intrusion (Day, 2007a).

Several short, perennial streams flow directly towards the Atlantic Ocean in the vicinity of the site. Most of these streams disappear into the flat areas near the coast or cannot maintain open river channels across the coastal dunes (Mawatsan, 2006). No rivers flow through the site and the closest significant drainage channel is the Sout River (5 km south of the site) and its largest tributary, the Donkergat River, which discharges into the ocean at Melkbosstrand (Day, 2007a).

2.3.7 Aquifer Classification and Vulnerability

The Atlantis part of the Sandveld Aquifer is classified as a Sole Source aquifer system (Parsons 1995 and Parsons and Conrad, 1998). Although smallholdings in the vicinity of the site are dependent on groundwater, a reticulated pipeline was constructed during 2002. The primary aquifer system towards the east of the site is therefore classified as a Major Aquifer system with high vulnerability to anthropogenic impacts (Parsons and Flanagan, 2006). Its vulnerability is mainly due to its shallow unconfined water table and high permeability. The Sandveld Aquifer beneath the Project site similarly has a high vulnerability due to its shallow water table and high permeability.

2.3.8 Groundwater Quality

Regional groundwater quality of the Atlantis Aquifer was discussed in detail by Fleisher (1990). The groundwater of this aquifer was classified as Class A type (EC <70 mS/m) (Vandoolaeghe and Bertram, 1982). The groundwater is generally of a sodium (Na) - chloride (Cl) type, but younger groundwater in the vicinity of the site shows a calcium (Ca) - bicarbonate (HCO_3) character (Parsons, 1999). Interpretation of groundwater quality data collected at the site of the PBMR DPP site confirms that groundwater quality in the vicinity of the site has a Na-Cl character, as is typical of groundwater in coastal environments. Based on monitoring data and previous investigations, groundwater in close proximity to the site also shows a magnesium (Mg) - sulfate (SO_4) and MgCl character, as shown in the Durov diagram below (**Figure 2-11**).

Samples have been collected from early 2010 for chemical analysis as part of the extended monitoring programme (SRK, 2014) and at KNPS since 2007 (Hön, *et al*, 2007 to 2015). The results of these analyses are plotted in Piper diagrams in **Figure 2-12**. Also see **Appendix 2** for Tables summarising the analysis results. The groundwater samples for the Sandveld Aquifer near the dune slack wetland (D SW7 MR1 to MR3) show a stagnant signature (enriched in SO_4 and/or CaCl) due to evaporation of the shallow groundwater in the vegetated wetland. The wetland water samples at D/WP2 & 3, which are near the coast, all show a NaCl-type water whilst the water from the dune-slack wetland at D/WP1 shows a stagnant signature similar to the nearby boreholes (SRK, 2014).

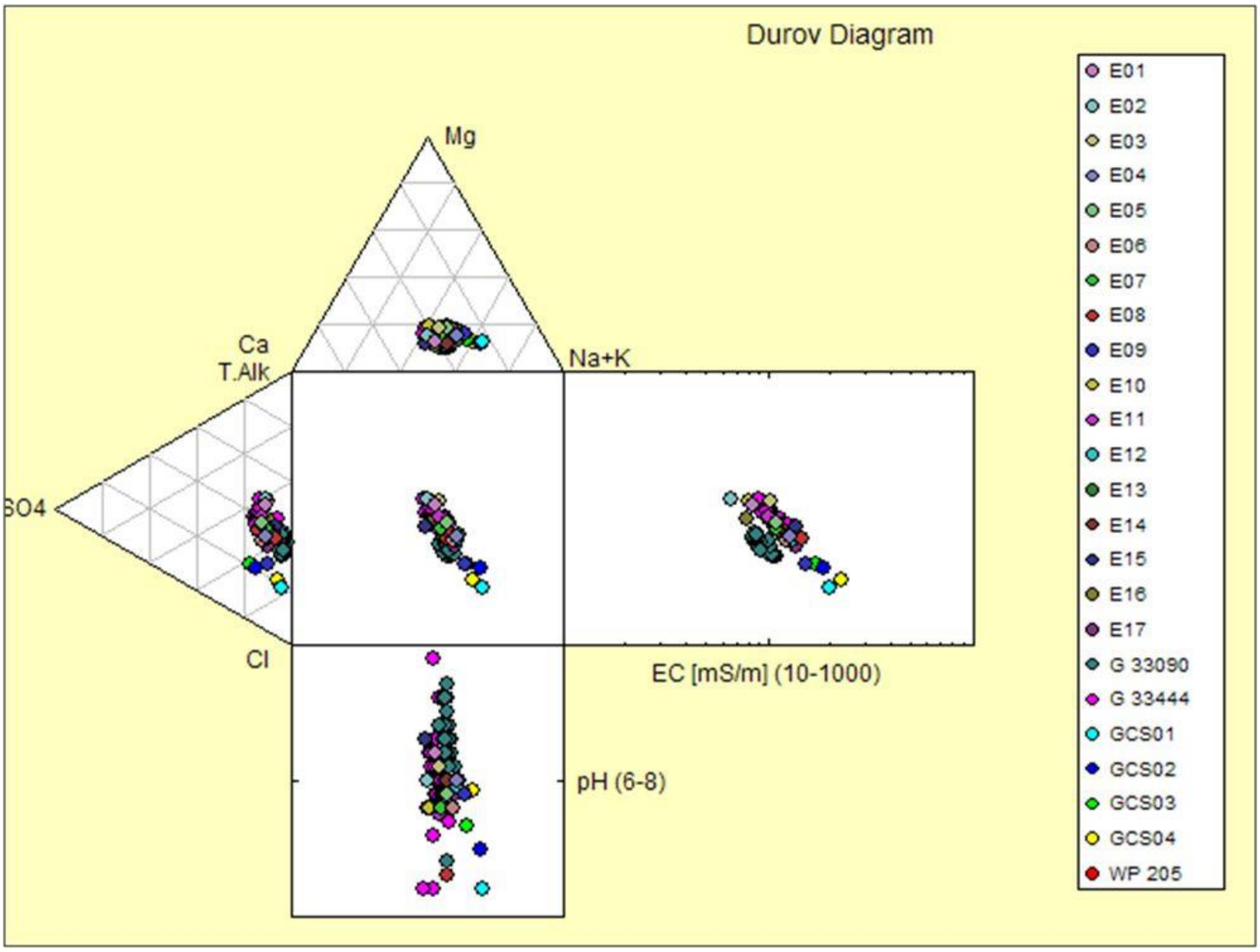


Figure 2-11: Durov Diagram Indicating the Hydrochemical Character of Groundwater near to the Duynefontein Site (borehole names in legend)

Based on field measurements, EC at the site ranges between 85 and 215 mS/m, while at the Aquarius Wellfield, it ranges from 135 to 200 mS/m (Jolly and Hartley, 1996). Some 18 wellpoints were previously installed along the coastline (along the western boundary of the site), and groundwater EC levels at these wellpoints ranged from 65 to 150 mS/m (Fleisher, 1993). Groundwater samples from four boreholes and wellpoints (E08, GCS1, PBMR-BH and TW2) were collected in close proximity to the site during the DSSR hydrocensus, and EC levels in these samples ranged from 100 to 250 mS/m (SRK, 2014). Groundwater quality monitoring data available for the Witzand Wellfield indicates that EC levels vary between 50 and 250 mS/m in the vicinity of the site (**Figure 2-13**).

Monitored EC values of groundwater from Sandveld Aquifer boreholes near the Project site are indicated in **Figure 2-14**. These EC values range from *c*.110 mS/m at borehole KG02 north of the Project site to *c*.550 mS/m at borehole PBMR11 east of the Project site. EC values over time shows little variation (SRK, 2013). EC values for groundwater from the KNPS monitoring boreholes are indicated in **Figure 2-15**. These EC values range from *c*.50 mS/m in TW4 to *c*.700 mS/m in TW3. EC values at borehole P2a, which is closest to the preferred Alternative 1, range from *c*.280 to 339 mS/m.

The groundwater salinity (indicated as EC in mS/m) across the study area is indicated in **Figure 2-16**.

The quality of the groundwater is a direct result of the closeness of these aquifers to the ocean, i.e. at the end of the flow path and influence of frontal rainfall recharge and sea-spray / aerosols.

There is no indication of the freshwater-saline water interface zone that should theoretically be present at the coast as none of the existing boreholes have been drilled deep enough (SRK, 2014). The fresh/saline water interface in an aquifer can be estimated by using the Ghyben Herzberg relationship (Verrjuit, 1968), which states that the depth of the interface (in m) is equal to the height of water level in mamsl x 40. This interface may be shifted by groundwater control measures and sea level rise.

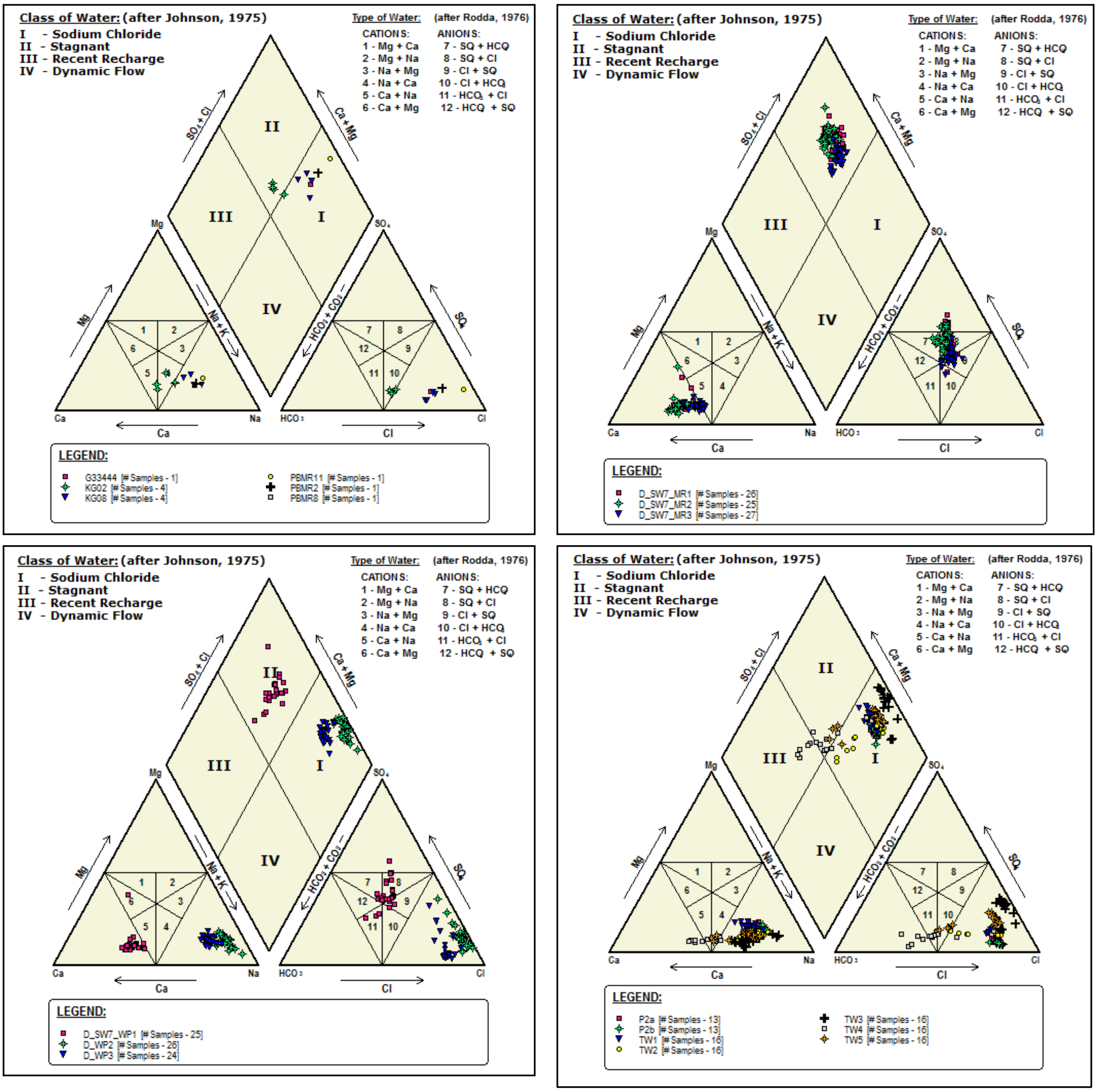


Figure 2-12: Piper Diagrams Indicating the Hydrochemical Character of Groundwater from Sandveld Aquifer Boreholes (top left), the Sandveld Aquifer Wetland Boreholes (top right), Wetland Piezometers (bottom left) and KNPS Monitoring Borehole (bottom right

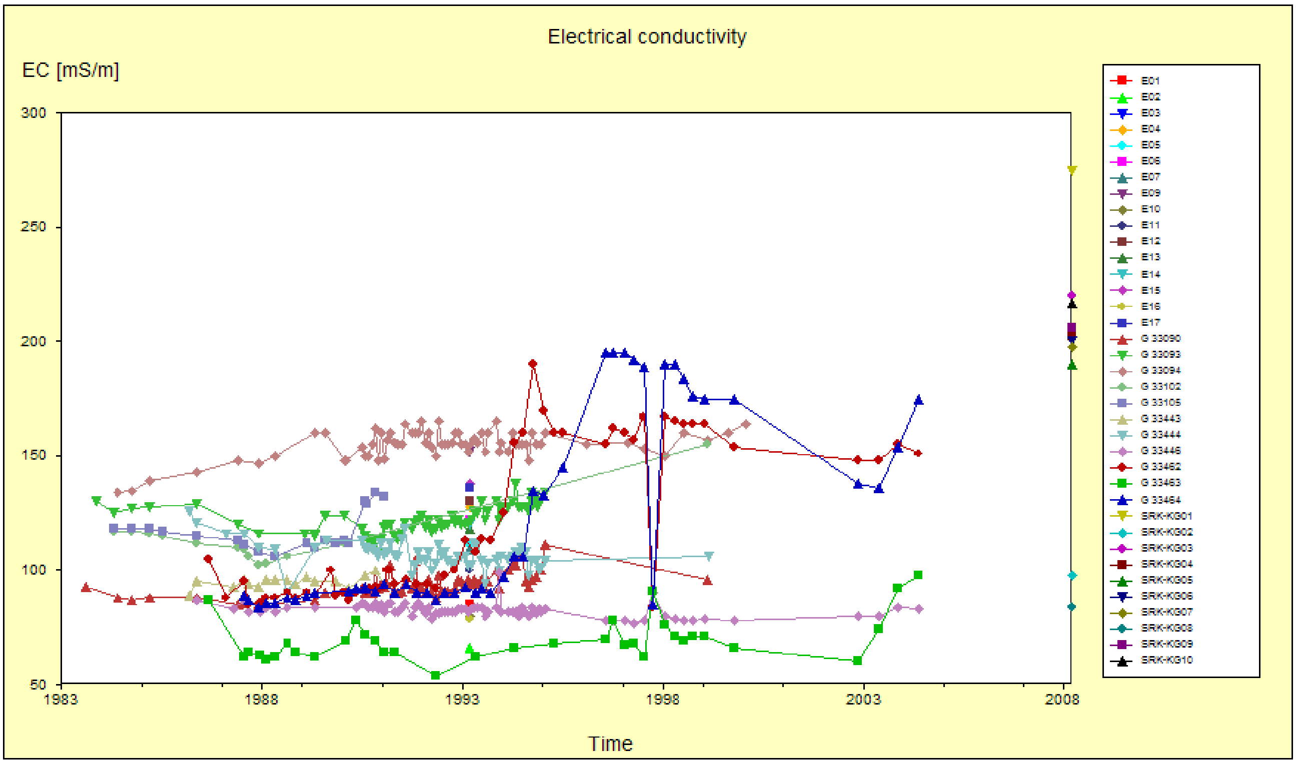


Figure 2-13: Monitored Groundwater EC Data Since 1983 (borehole names in legend)

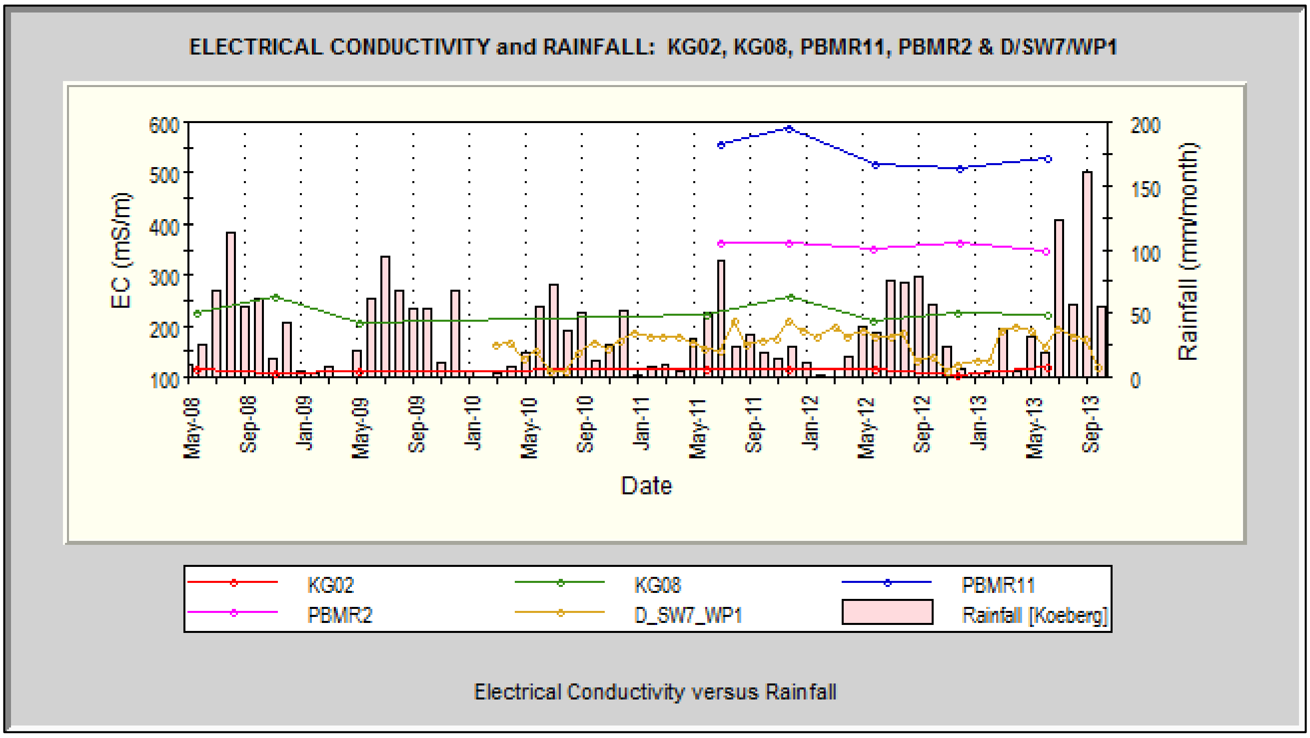


Figure 2-14: Monitored EC of Groundwater from Sandveld Aquifer Boreholes around the KNPS

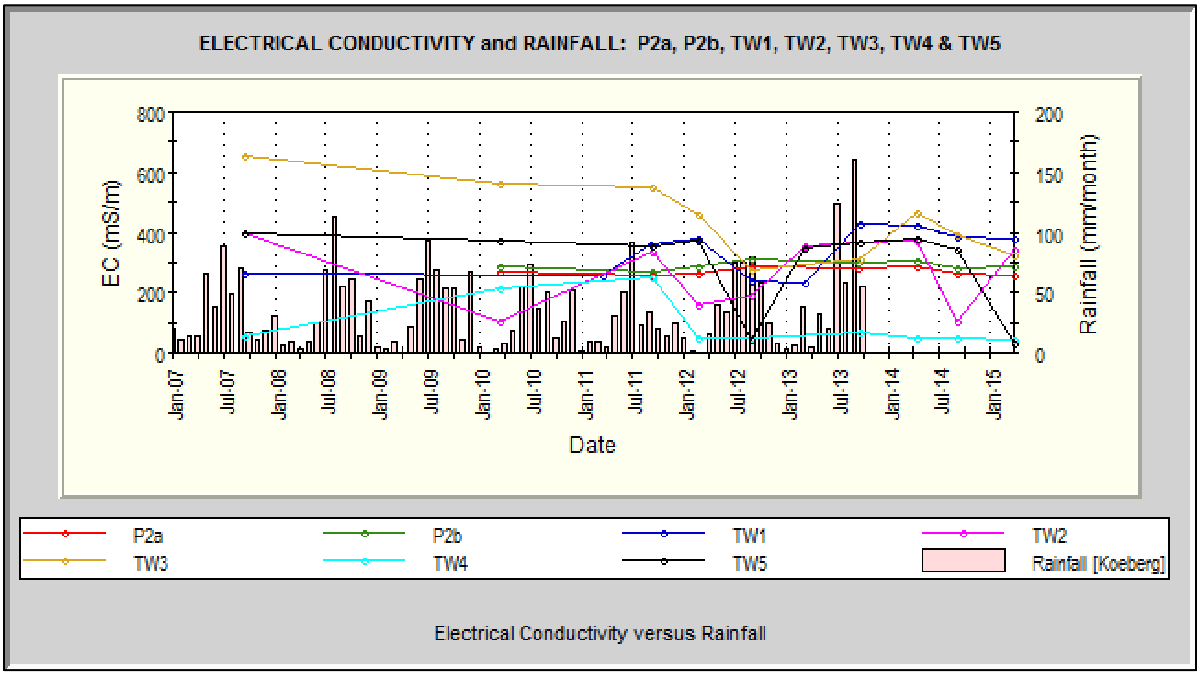
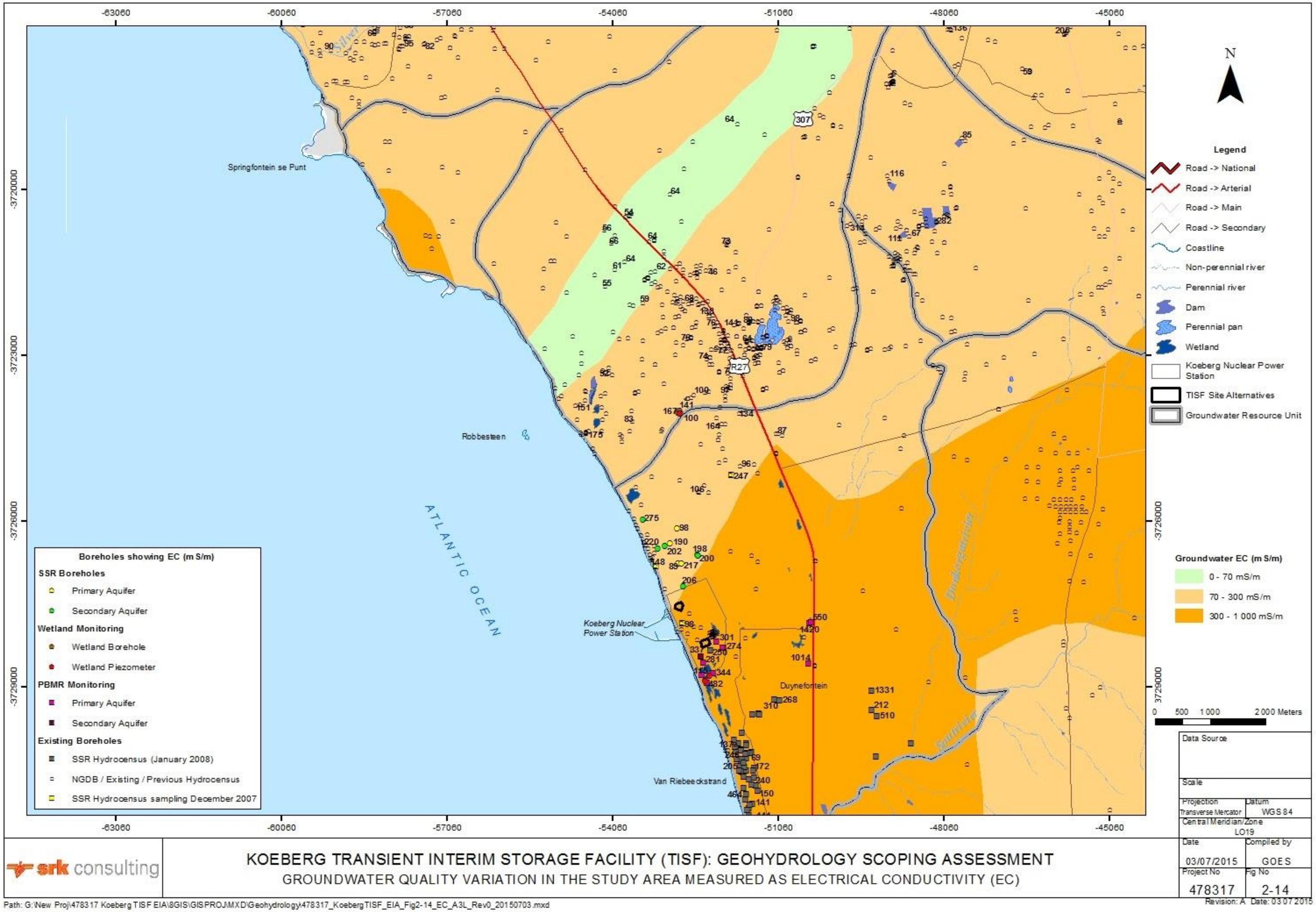


Figure 2-15: Monitored EC of Groundwater from Sandveld Aquifer Monitoring Boreholes at the KNPS


Legend
Road -> National
Road -> Arterial
Road -> Main
Road -> Secondary
Coastline
Non-perennial river
Perennial river
Dam
Perennial pan
Wetland
Koeberg Nuclear Power Station
TISF Site Alternatives
Groundwater Resource Unit
Groundwater EC (m S/m)
0 - 70 mS/m
70 - 300 mS/m
300 - 1 000 mS/m
Boreholes showing EC (m S/m)
SSR Boreholes
Primary Aquifer
Secondary Aquifer
Wetland Monitoring
Wetland Borehole
Wetland Piezometer
PBMR Monitoring
Primary Aquifer
Secondary Aquifer
Existing Boreholes
SSR Hydrocensus (January 2008)
NGDB / Existing / Previous Hydrocensus
SSR Hydrocensus sampling December 2007
ATLANTIC OCEAN
Springfontein se Punt
Robbesteen
Koeberg Nuclear Power Station
Duynefontein
Van Riebeeckstrand
0 500 1 000 2 000 Meters
Data Source
Scale
Projection Transverse Mercator
Datum WGS 84
Central Meridian/Zone LO19
Date 03/07/2015
Compiled by GOES
Project No 478317
Fig No 2-14
Revision: A Date: 03 07 2015
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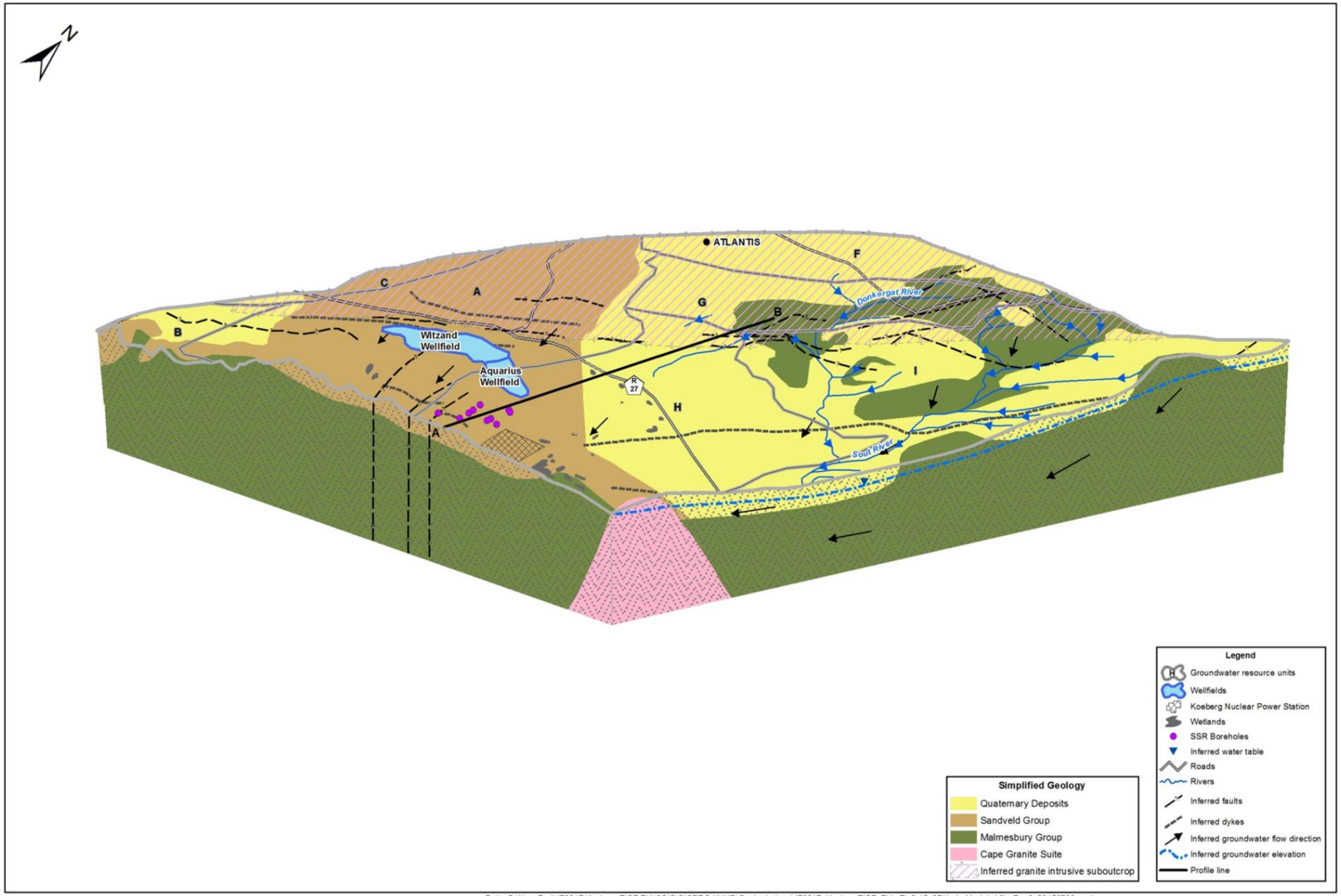
KOEBERG TRANSIENT INTERIM STORAGE FACILITY (TISF): GEOHYDROLOGY SCOPING ASSESSMENT
GROUNDWATER QUALITY VARIATION IN THE STUDY AREA MEASURED AS ELECTRICAL CONDUCTIVITY (EC)
Path: G:\New Proj\478317 Koeberg TISF EIA\8GIS\GISPROJ\MXD\Geohydrology\478317_KoebergTISF_EIA_Fig2-14_EC_A3L_Rev0_20150703.mxd

2.4 Conceptual Geohydrological Model

A conceptual geohydrological model is a descriptive representation of a groundwater system that incorporates an interpretation of the geological and hydrological conditions. It consolidates the current understanding of the key processes of the groundwater system, including the influence of stresses, and assists in the understanding of possible future changes. **Figure 2-17** presents a schematic representation of the geohydrological profile at the site. The main concepts were introduced in the **Subsections 2.3.1** to **2.3.8** above, and are summarised below:

- There is no downstream use of groundwater.
- Groundwater at the site is near/at the end of its flow path.
- Depth to the groundwater table at the Project site ranges between 3 and 4 mbgl, which is deeper than the proposed TISF excavation depth of 2 m, hence dewatering of groundwater will probably not be required during construction.
- The receiving environment/downstream receptor of any contamination will be the shore zone/sea.
- There is a two aquifer system present, with an upper intergranular aquifer (Sandveld Aquifer) and a lower fractured rock aquifer (Malmesbury Aquifer).
- For this assessment, only the upper Sandveld Aquifer may potentially be impacted by the Project.
- Local direct recharge only affects the Sandveld Aquifer - the Malmesbury Aquifer is recharged inland, far from the Project site. There may be upward leakage of groundwater from the Malmesbury Aquifer into the Sandveld Aquifer (and vice versa) depending on relative groundwater heads in each aquifer.
- Groundwater flow is from inland, across the Project site, in a south-westerly direction towards the coast, where it discharges into the ocean.
- Hydraulic conductivity values of the Sandveld Aquifer at and around the Project site range from 0.9 to 5.6 m/d.
- The hydraulic gradient across the site is *c*.0.0125 rising to *c*.0.025 closer to the coast. Groundwater therefore flows under a relatively low gradient at a calculated flow rate of *c*.2.6 m/d, which indicates a relatively quick migration across the Project site, towards the coastline.
- There is an inferred interface between 'fresh' groundwater from inland and saline groundwater in the shore-zone - This interface may be shifted by groundwater control measures and sea level rise. However, down-hole salinity probing did not detect this zone and so it is unlikely to be a significant boundary at the site in terms of establishing the TISF. This is to be expected given the height of the water table above sea level (z) and the Ghyben-Herzberg relationship (interface = 40z), as previously described in Subsection 2.3.8. The interface is therefore below the base of the Sandveld Aquifer and proposed excavation and will have no effect on the proposed Project.
- Natural groundwater quality is marginally saline and of a mixed sodium chloride (NaCl) and calcium bicarbonate ($Ca(HCO_3)_2$) character.



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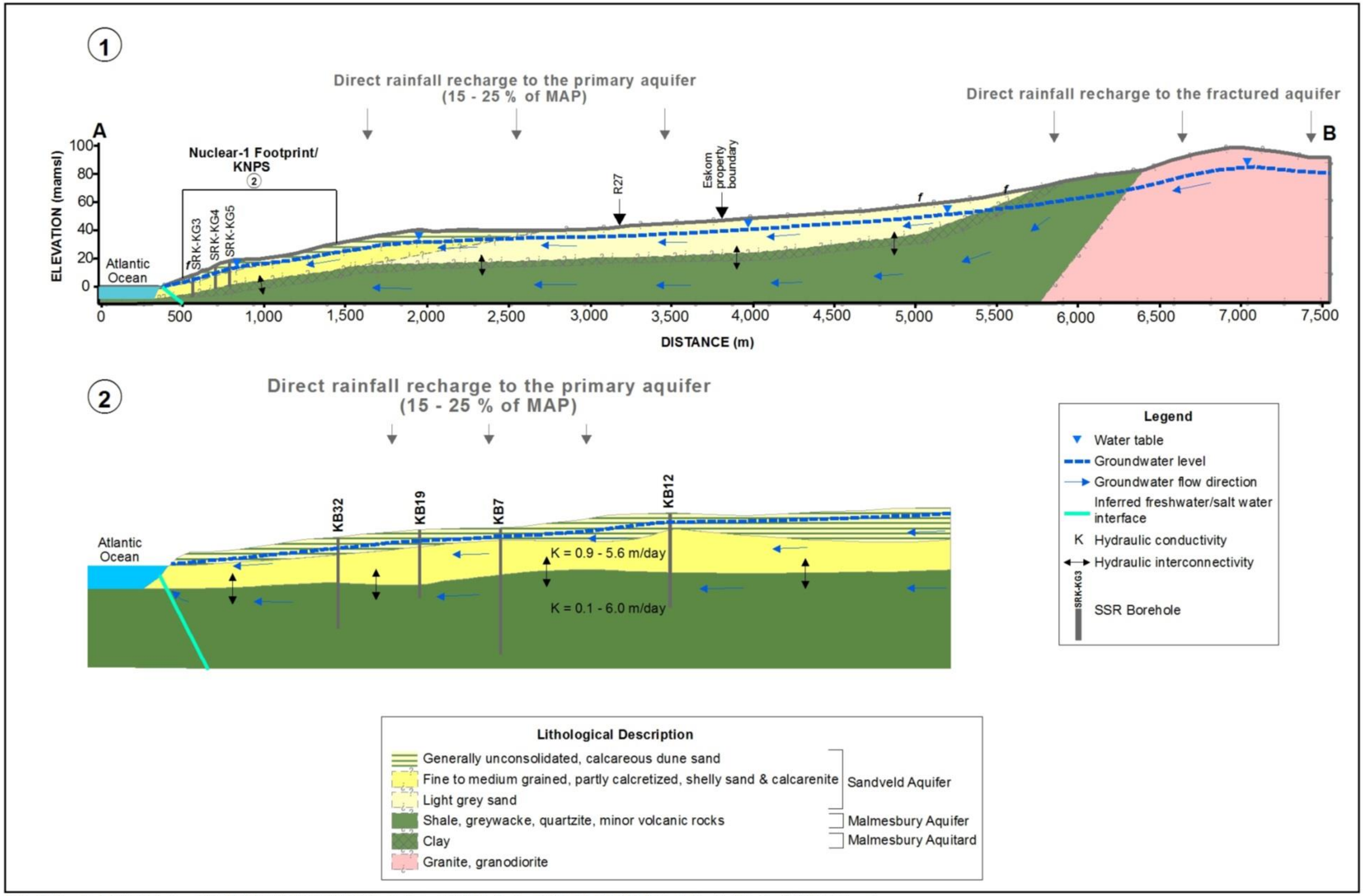
ESKOM KOEBERG TISF GEOHYDROLOGICAL ASSESSMENT
CONCEPTUAL 3D GEOHYDROLOGICAL MODEL

Project No.
478317

Figure 2-17: Conceptual 3D Geohydrological Model



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ESKOM KOEBERG TISF GEOHYDROLOGICAL ASSESSMENT
CONCEPTUAL 2D GEOHYDROLOGICAL MODEL

Project No.
478317

Figure 2-18: Conceptual 2D Geohydrological Model

3 Impact Identification, Assessment and Mitigation

The assessment of potential impacts on the groundwater resources discussed below is relevant to both site alternatives.

3.1 Construction Phase

During the construction phase of the proposed facility, the groundwater resources underlying the site may potentially be impacted as follows:

1. Hydrocarbon contamination: Downward migration of leaked and / or spilled fuel, oil and grease into the underlying aquifer system;
2. Hazardous waste/chemicals contamination: Downward migration of contaminants from on-site waste storage areas and /or chemical storage areas into the underlying aquifer system;
3. Organic and bacterial (microbiological) contamination: Downward migration of contaminants from leaking and / or spilling temporary on-site sewage facilities into the underlying aquifer system.

With respect to hydrocarbon, hazardous waste, chemicals and organic and bacterial (microbiological) contamination of the aquifer, the intensity is assessed to be low, as the natural quality of groundwater at the sites should not be notably degraded. It is presently not known what types of hazardous substances may be, stored, transported or disposed of, or otherwise managed, at the site during construction. However, typical examples of such potential contaminants are paints and solvents, vehicle wastes (e.g. used motor oil, etc.), mercury-containing wastes (e.g. thermometers, switches, fluorescent lighting, etc.), caustics and cleaning agents and batteries.

It is expected that without mitigation, the quantity of potential contaminants used and / or stored, and spilled and / or leaked at the sites, will be insufficient to extensively contaminate the primary aquifer. With mitigation, the intensity reduces to insignificant. The water quality analyses from boreholes drilled at the Duynefontein site show no indications of degradation of quality due to construction of the KNPS and the impacts are thus expected to be of a short-term nature.

The significance of the impact is assessed to be of ***very low*** significance and with the implementation of mitigation is reduced to ***insignificant*** (**Table 3-1** over page).

Table 3-1: Potential groundwater contamination caused by construction activities

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>Low
1</td><td>Short-term
1</td><td>Very Low
3</td><td>Probable</td><td>VERY LOW</td><td>– ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:
• Place drip trays under stationary machinery, only re-fuel machines at the temporary fuelling station, install temporary structures to trap fuel spills at the temporary fuelling station.
• Immediately clean oil and fuel spills and dispose of contaminated material (soil, etc.) at licensed sites only.
• Equip the site with sufficient ablution facilities. Secure chemical toilets to ensure that they do not blow over in windy conditions.
• Do not release any pollutants, including sediment, sewage, cement, fuel, oil, chemicals, hazardous substances, waste water, etc., into the environment.
• Compile a procedure for the storage, handling and transport of different hazardous materials and ensure that it is strictly adhered to.
• Ensure vehicles and equipment are in good working order and drivers and operators are trained with respect to actions to be taken in the case of a fuel spill or leak.
• Ensure that good housekeeping rules are applied.</td></tr>
<tr><td>With mitigation</td><td>Local
1</td><td>Low
1</td><td>Short-term
1</td><td>Very Low
3</td><td>Possible</td><td>INSIGNIFICANT</td><td>– ve</td><td>High</td></tr>
</table>

3.2 Operations Phase

The potential impacts during the operational phase are as follows:

1. Fuel and oil leaks from the vehicle transporting the storage casks.
2. Breached storage casks resulting in the dispersion of radioactive spent fuel particles and release of radioactive aerosols (e.g. Cesium-137) at the site, which could percolate into the groundwater resources in the vicinity of the site through rainfall recharge.

However, under normal design operational conditions, such releases are highly unlikely. This has been demonstrated by cask storage operations at the KNPS over the past 30 years. The results of the 2010 environmental surveillance programme at this site do not indicate any significant adverse effects on the environment. There are also no significant increases in the levels of radioactivity in environmental samples over pre-operational levels, with the exception of marine and sewage sludge samples (Eskom, 2011). The casks will also be designed to contain any accidental releases. Impacts of such accident scenarios are therefore not considered here.

Leakage of radioactivity into the underlying aquifer is highly unlikely and will not directly affect any existing groundwater users, but if such an incident were to occur, the receiving environment will be affected. Taking cognisance that an impermeable containment structure (concrete slab) will be constructed for the TISF, any contaminants emanating from this source will be contained on the concrete slab. In the highly unlikely event of such a cask breach, the monitoring system will detect this and remediation actions will be taken.

It is expected that without mitigation, the quantity of potential non-radioactive contaminants used and / or stored, and spilled and / or leaked at the sites, will be insufficient to extensively contaminate the primary aquifers. With mitigation, the intensity is reduced to insignificant. The impact will be of a short-term nature. For example, the water quality analyses from boreholes drilled at the Duynefontein site show no indications of degradation due to operation of the KNPS.

The significance of the impact is assessed to be of ***very low*** and, with the implementation of mitigation, is reduced to ***insignificant*** (**Table 3-2** over page).

Table 3-2: Potential groundwater contamination caused by operational activities

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>Low
1</td><td>Short-term
1</td><td>Very Low
3</td><td>Probable</td><td>VERY LOW</td><td>– ve</td><td>High</td></tr>
<tr><td colspan="9">Essential mitigation measures:

Cask monitoring system must be implemented to monitor for radioactive emissions.
Breaches in dry casks can be temporarily plugged with radiation absorbing materials (e.g. lead, heavy concrete) until permanent fixes or replacement can be made and the cask storage pad decontaminated.
Immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only.
Use existing ablution and waste water treatment facilities at the KNPS.
Do not release any pollutants, including, radioactive substances, sewage, fuel, oil, chemicals, hazardous substances, waste water, etc., into the environment.
Ensure vehicles and equipment are in good working order and drivers and operators are trained.
Ensure that good housekeeping rules are applied.
</td></tr>
<tr><td>With mitigation</td><td>Local
1</td><td>Low
1</td><td>Short-term
1</td><td>Very Low
3</td><td>Possible</td><td>INSIGNIFICANT</td><td>– ve</td><td>High</td></tr>
</table>

3.3 Fatal Flaws (Statement of Acceptability)

The geohydrological specialist study indicates that there are no groundwater related fatal flaws with respect to establishing a TISF at either of the two proposed alternative sites. This assumes normal operation of the TISF.

3.4 No Go Option

In case the proposed TISF is not developed, the existing used fuel storage status quo will continue with no change in groundwater contamination risk.

3.5 Groundwater Monitoring

Groundwater monitoring at the TISF is not required as no contamination of the underlying aquifer by the proposed site activities is foreseen.

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Bruce Engelsman Pr Eng Pr CPM.
Partner

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

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Appendices

Appendix 1: Rainfall Data

Koeberg Rainfall - Long term Monthly Totals														
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	***% LT Ave***
1980	22.4	5.8	0.8	31.4	62.2	61.4	25.6	54.2	10.4	7.8	52.4	18.2	352.6	***92.3***
1981	67.6	0.0	34.4	34.8	11.4	39.6	87.8	63.0	41.2	11.6	8.2	16.0	415.6	***108.8***
1982	13.0	8.0	5.4	28.8	35.8	61.8	46.2	63.4	16.8	19.6	13.0	28.4	340.2	***89.0***
1983	3.8	29.6	23.4	8.8	68.0	84.0	33.4	21.0	30.0	6.4	6.2	10.4	325.0	***85.1***
1984	2.0	2.4	27.8	22.0	82.4	25.8	40.2	28.2	75.0	43.6	1.0	32.8	383.2	***100.3***
1985	11.6	8.8	48.4	39.2	35.2	59.4	113.0	62.0	50.8	6.0	1.0	2.4	437.8	***114.6***
1986	11.2	4.0	30.2	21.2	31.2	112.8	94.4	68.2	27.8	15.8	15.2	8.6	440.6	***115.3***
1987	12.4	8.0	10.8	35.0	98.2	110.4	147.2	134.4	41.4	15.0	2.8	24.8	640.4	***167.6***
1988	1.0	0.2	39.2	86.4	18.0	24.9	48.7	88.5	27.8	9.6	3.9	3.0	351.2	***91.9***
1989	2.0	14.7	18.3	40.4	32.0	36.0	65.5	58.4	53.7	19.4	20.0	1.8	362.2	***94.8***
1990	6.9	8.9	0.0	82.3	44.6	77.8	90.6	12.8	12.4	1.4	7.2	15.4	360.3	***94.3***
1991	5.8	2.6	5.6	10.9	52.6	65.9	102.2	19.9	45.7	24.9	11.4	5.0	352.5	***92.3***
1992	1.4	13.7	9.8	29.0	38.9	80.1	55.1	30.2	21.7	25.2	0.5	3.8	309.4	***81.0***
1993	2.3	30.5	7.2	107.8	88.4	34.1	68.5	31.8	2.5	0.6	1.2	14.0	388.9	***101.8***
1994	0.2	0.0	9.2	13.6	25.2	157.4	81.0	17.6	31.6	7.2	17.4	4.6	365.0	***95.5***
1995	3.0	2.6	3.2	11.4	39.8	75.0	74.7	37.8	27.6	36.4	4.4	30.6	346.5	***90.7***
1996	5.2	42.0	16.4	16.2	33.6	110.4	48.4	37.6	65.2	40.8	22.0	20.6	458.4	***120.0***
1997	4.4	1.2	0.6	20.4	61.8	67.4	24.8	44.2	8.0	2.8	27.0	11.8	274.4	***71.8***
1998	3.2	0.0	8.8	17.6	86.0	43.0	40.2	24.8	15.2	5.4	37.6	16.6	298.4	***78.1***
1999	0.0	0.0	0.0	31.2	40.8	44.4	57.8	105.4	74.4	1.2	15.6	7.0	377.8	***98.9***
2000	8.4	0.0	1.2	2.8	21.8	59.6	43.2	39.2	46.6	3.0	14.6	2.0	242.4	***63.4***
2001	7.6	5.6	0.0	18.8	70.6	44.6	162.4	85.2	37.0	23.2	5.8	6.6	467.4	***122.3***
2002	55.5	12.2	8.6	31.6	25.6	53.4	52.8	62.2	29.4	30.8	12.0	27.6	401.7	***105.1***
2003	2.2	4.4	25.6	10.2	26.2	12.0	33.6	90.4	49.0	11.4	0.4	14.2	279.6	***73.2***
2004	8.0	0.8	7.0	56.0	1.3	81.6	63.1	38.0	17.4	114.8	3.8	2.0	393.8	***103.1***
2005	17.6	1.6	4.0	65.8	50.4	76.0	22.8	67.8	31.1	9.7	6.7	0.3	353.8	***92.6***
2006	0.0	5.5	3.5	30.3	92.5	32.2	55.6	55.3	10.0	28.2	15.0	19.9	348.0	***91.1***
2007	10.7	14.3	14.3	65.5	38.5	88.2	49.5	69.6	16.5	11.0	18.7	30.2	427.0	***111.8***

Koeberg Rainfall - Long term Monthly Totals														
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	***% LT Ave***
2008	5.9	9.0	3.5	9.4	24.6	68.5	113.4	55.7	60.8	13.4	42.5	4.0	410.7	***107.5***
2009	3.5	8.5	0.7	20.8	61.5	93.8	63.4	53.8	54.0	10.5	67.8	4.0	442.3	***115.8***
2010	0.3	3.8	7.1	18.3	55.3	72.6	36.2	50.8	12.7	25.3	51.8	1.1	335.3	***87.8***
2011	8.6	9.6	4.0	30.0	50.8	91.6	23.3	33.2	19.3	14.5	24.0	10.5	319.4	***83.6***
2012	1.3	0.6	15.1	39.1	34.2	74.9	74.5	79.1	57.3	23.9	6.9	3.5	410.4	***107.4***
2013	5.5	38.0	5.3	32.1	19.1	123.5	57.3	160.7	55.3	16.3	30.0	4.1	547.2	***143.2***
2014	40.9	0.9	43.0	16.5	37.9	124.3	62.5	54.1	16.0	3.4	13.8	0.6	413.9	***108.3***
2015	15.7	0.4	1.0	4.9	24.7									
LT Average	10.2	8.5	12.6	32.4	45.6	70.5	64.5	57.1	34.0	18.3	16.6	11.6	382.1	
Minimum	0.0	0.0	0.0	2.8	1.3	12.0	22.8	12.8	2.5	0.6	0.4	0.3	242.4	
Maximum	67.6	42.0	48.4	107.8	98.2	157.4	162.4	160.7	75.0	114.8	67.8	32.8	640.4	
Median	5.5	5.5	7.2	29.0	38.9	68.5	57.3	54.2	30.0	13.4	13.0	8.6	365.0	

Appendix 2: Groundwater Chemistry Data

Chemistry of Groundwater from the Sandveld Aquifer Boreholes

Borehole No.	Determinand														
	Ca	Mg	Na	K	Alkalinity ($CaCO_3$)	Cl	SO_4	NO_3 (N)	F	NH_4 (N)	PO_4 (P)	Fe	Mn	pH	EC
May-08															
SRK-KG2	98	21	107	4	236	205	58	<0.1	0.3	<0.1	9.1	<0.001	<0.001	7.6	116
SRK-KG8	115	46	245	7.1	289	515	58	0.8	0.3	<0.1	15.5	<0.001	<0.001	7.8	226
Nov-08															
SRK-KG2	87	14.9	95	9.1	222	179	49	0.8	0.4	<0.0	1.9	<0.001	<0.001	8.0	109
SRK-KG8	108	39	295	9.2	244	598	73	2.3	0.3	<0.1	1.7	1.8	0.01	7.8	257
May-09															
SRK-KG2	73	27	99	6.2	220	187	44	0.4	0.3	<0.1	<0.12	0.05	0.002	7.7	113
SRK-KG8	104	55	277	9.1	246	582	70	3.2	0.3	<0.1	0.41	0.46	0.02	6.7	208
May-11															
SRK-KG2	77	22	128	7	213	198	61	0.4	0.2	<0.1	NA	<0.1	<0.02	7.9	112
SRK-KG8	99	41	335	13.8	288	537	66	<0.1	0.2	0.1	NA	<0.1	0.14	7.5	231
Nov-11															
SRK-KG2	88	16.7	84	2.5	201	187	55	1.9	0.7	<0.1	0.5	0.29	0.034	6.0	105
SRK-KG8	113	41	216	4.9	266	628	70	<0.1	0.4	<0.1	0.59	0.18	0.02	7.1	224
May-12															
SRK-KG2	79	24	118	5.2	226	191	85	3.1	0.3	<0.1	0.27	<0.015	<0.001	7.7	113
SRK-KG8	113	42	292	7.8	287	453	74	0.7	0.3	0.1	0.13	0.03	<0.001	7.6	210
Nov-12															
SRK-KG2	77	13.9	102	3.8	209	148	38	5.1	0.5	<0.1	0.12	0.03	0.001	7.7	93.4
SRK-KG8	106	39	289	6.5	270	443	63	<0.1	0.2	0.1	0.14	0.04	0.01	7.6	204
May-13															
SRK-KG2	86	18.5	109	4	210	229	41	6.8	0.2	0.5	0.12	0.01	0.009	6.6	115
SRK-KG8	107	38	294	5.5	296	516	43	<0.1	0.2	0.4	<0.12	0.18	0.02	7.1	214
All concentrations in mg/L except for EC = mS/m and pH = no unit NL= No Limit															

Chemistry of Groundwater from the Sandveld Aquifer Boreholes at KNPS

Borehole No	DATE	SAMPLER	LAB	PH_LAB	PH_SAT	EC	TDS	Na	Ca	Mg	Cl	K	SO_4	Nitrate + Nitrite as N	Ammonia as N	Alkalinity as $CaCO_3$
P2a	09/11/2008	CSIR	CSIR	7.6		290	1856	447	106	47	738	17	108	-999.00	0.10	254
P2a	02/24/2009	CSIR	CSIR	7.6		290	1856	458	104	47	769	18	117	-0.10	0.10	248
P2a	09/11/2009	CSIR	CSIR	8.3		300	1920	397	102	45	699	6	73	-0.10	0.10	256
P2a	03/11/2010	CSIR	CSIR	7.2		285	1824	436	110	62	810	10	83	-0.10	0.10	242
P2a	09/09/2010	CSIR	CSIR	7.4		279	2090	384	108	46	741	4	84	0.23	0.37	240
P2a	03/16/2011	CSIR	CSIR	8.4		339	2530	342	119	53	758	7	107	0.35	0.15	260
P2a	09/06/2011	CSIR	CSIR	8.0		339	1975	372	109	50	755	11	103	0.35	0.89	237
P2a	02/22/2012	CSIR	CSIR	7.6		300	1920	451	128	46	808	8	101	-0.10	0.10	249
P2a	08/28/2012	CSIR	CSIR	7.6		300	1920	375	103	48	692	9	93	-0.10	0.10	269
P2a	03/06/2013	CSIR	CSIR	7.3		295	1888	414	103	46	721	6	93	-0.10	0.12	262
P2a	09/17/2013	CSIR	CSIR	7.5		290	1856	431	101	47	706	6	100	-0.10	0.13	262
P2a	04/09/2014	CSIR	CSIR	7.6		280	1660	437	107	48	669	6	102	-0.10	0.13	255
P2a	03/24/2015	CSIR	CSIR	7.3		280	1606	393	104	42	730	5	91	-0.10	0.16	263
P2b	09/11/2008	CSIR	CSIR	7.5		310	1984	492	108	46	828	16	74	-999.00	0.13	255
P2b	02/24/2009	CSIR	CSIR	7.5		300	1920	491	100	45	788	18	87	-0.10	-0.10	328
P2b	09/11/2009	CSIR	CSIR	7.8		300	1920	455	107	43	824	4	63	-0.05	0.10	254
P2b	03/11/2010	CSIR	CSIR	7.2		260	1664	467	106	58	850	9	63	0.05	0.10	242
P2b	09/09/2010	CSIR	CSIR	7.3		296	2220	416	110	43	809	4	65	0.09	0.22	234
P2b	03/16/2011	CSIR	CSIR	8.4		351	2620	367	111	48	818	6	76	0.31	0.14	278
P2b	09/06/2011	CSIR	CSIR	8.0		351	2040	402	107	47	798	11	79	0.34	1.01	253
P2b	02/22/2012	CSIR	CSIR	7.6		310	1984	487	126	43	872	7	77	-0.10	0.20	244
P2b	08/28/2012	CSIR	CSIR	7.6		315	2016	463	133	52	772	13	84	-0.10	0.20	266
P2b	03/06/2013	CSIR	CSIR	7.5		310	1984	476	106	45	805	6	75	-0.10	0.16	244
P2b	09/17/2013	CSIR	CSIR	7.7		310	1984	452	95	45	732	6	73	-0.10	0.15	259
P2b	04/09/2014	CSIR	CSIR	8.1		300	1744	482	110	48	758	6	81	-0.10	0.18	254
P2b	03/24/2015	CSIR	CSIR	7.3		290	1716	430	107	41	797	4	74	-0.10	0.21	254
TW1	03/28/2007	CSIR	CSIR	7.7		260	1664	377	116	42	645	10	125	0.49	0.00	217
TW1	09/11/2007	CSIR	CSIR	7.9		260	1664	446	105	45	625	11	134	0.00	0.20	219

Borehole No	DATE	SAMPLER	LAB	PH_LAB	PH_SAT	EC	TDS	Na	Ca	Mg	Cl	K	SO_4	Nitrate + Nitrite as N	Ammonia as N	Alkalinity as $CaCO_3$
TW1	03/14/2008	CSIR	CSIR	7.5		286	1830	445	122	50	732	16	173	0.80	0.50	250
TW1	09/11/2008	CSIR	CSIR	7.6		300	1920	433	155	59	763	19	179	0.00	1.09	288
TW1	02/24/2009	CSIR	CSIR	7.6		320	2048	432	161	60	808	27	203	0.00	1.00	290
TW1	09/11/2009	CSIR	CSIR	7.7		350	2240	457	161	58	871	12	166	0.00	1.00	314
TW1	03/11/2010	CSIR	CSIR	7.4		350	2240	511	182	81	970	18	169	0.05	1.10	302
TW1	09/09/2010	CSIR	CSIR	7.6		364	2720	432	182	62	962	8	166	0.20	0.55	276
TW1	03/16/2011	CSIR	CSIR	8.5		448	3320	413	208	72	987	13	203	0.61	0.49	381
TW1	09/06/2011	CSIR	CSIR	8.1		446	2710	450	194	76	1040	20	201	0.57	1.15	299
TW1	02/22/2012	CSIR	CSIR	7.5		415	2656	592	225	68	1160	10	186	-0.10	1.00	326
TW1	08/28/2012	CSIR	CSIR	8.3		245	1568	285	111	39	567	13	118	0.40	-0.10	242
TW1	03/06/2013	CSIR	CSIR	8.3		240	1536	352	109	41	572	14	128	0.40	-0.10	228
TW1	09/17/2013	CSIR	CSIR	7.7		430	2752	601	191	75	1070	11	185	-0.10	1.00	324
TW1	04/09/2014	CSIR	CSIR	7.4		445	2724	573	165	79	1050	11	187	-0.10	0.90	331
TW1	03/24/2015	CSIR	CSIR	7.4		405	2560	531	163	63	1060	9	158	-0.10	0.82	324
TW2	03/28/2007	CSIR	CSIR	7.9		395	2528	607	125	53	1000	10	217	-0.10	-999.00	281
TW2	09/11/2007	CSIR	CSIR	8.0		390	2496	710	171	53	1177	12	237	0.00	0.50	279
TW2	03/14/2008	CSIR	CSIR	8.6		104	666	101	74	8	156	43	47	3.33	-0.10	223
TW2	09/11/2008	CSIR	CSIR	7.8		390	2496	610	162	48	966	21	216	-999.00	0.62	279
TW2	02/24/2009	CSIR	CSIR	8.8		130	832	145	83	12	233	44	66	3.30	-0.10	242
TW2	09/11/2009	CSIR	CSIR	8.8		148	947	179	91	12	278	39	70	1.94	-0.10	240
TW2	03/11/2010	CSIR	CSIR	7.7		365	2336	585	160	61	1015	17	179	0.05	0.60	268
TW2	09/09/2010	CSIR	CSIR	7.8		358	2680	464	155	45	945	8	170	0.10	0.29	250
TW2	03/16/2011	CSIR	CSIR	9.3		130	975	136	91	10	195	53	47	4.48	0.14	279
TW2	09/06/2011	CSIR	CSIR	8.4		130	2490	455	156	50	949	19	199	0.39	1.10	293
TW2	02/22/2012	CSIR	CSIR	8.4		175	1120	203	110	14	340	28	77	1.00	-0.10	244
TW2	08/28/2012	CSIR	CSIR	8.3		190	1216	198	100	18	368	33	80	1.80	-0.10	257
TW2	03/06/2013	CSIR	CSIR	8.0		365	2336	581	161	50	948	11	186	-0.10	0.70	291
TW2	09/17/2013	CSIR	CSIR	8.0		390	2496	566	155	50	932	11	182	-0.10	0.65	271
TW2	04/09/2014	CSIR	CSIR	8.1		375	2335	556	155	54	909	11	180	-0.10	0.65	282

Borehole No	DATE	SAMPLER	LAB	PH_LAB	PH_SAT	EC	TDS	Na	Ca	Mg	Cl	K	SO_4	Nitrate + Nitrite as N	Ammonia as N	Alkalinity as $CaCO_3$
TW2	03/24/2015	CSIR	CSIR	8.0		330	2396	543	158	48	977	10	177	-0.10	0.65	292
TW3	03/28/2007	CSIR	CSIR	8.3		700	4480	1059	464	28	1900	72	763	-0.10	-999.00	59
TW3	09/11/2007	CSIR	CSIR	8.2		580	3712	953	445	30	1625	77	864	0.20	4.50	89
TW3	03/14/2008	CSIR	CSIR	8.0		540	2456	842	303	43	1359	73	736	-0.50	4.70	127
TW3	09/11/2008	CSIR	CSIR	8.3		600	3840	982	179	76	1707	87	469	-999.00	2.23	110
TW3	02/24/2009	CSIR	CSIR	7.8		600	3840	842	330	63	1493	90	708	-0.10	3.40	130
TW3	09/11/2009	CSIR	CSIR	8.2		600	3840	830	334	56	1410	59	777	-0.05	3.50	139
TW3	03/11/2010	CSIR	CSIR	7.5		495	3168	875	413	60	1435	86	863	-0.05	3.80	119
TW3	09/09/2010	CSIR	CSIR	76.0		593	4430	720	401	42	1521	45	840	0.28	2.70	103
TW3	03/16/2011	CSIR	CSIR	8.5		708	5290	678	402	45	1529	57	882	0.91	1.70	138
TW3	09/06/2011	CSIR	CSIR	8.2		708	4170	657	367	37	1579	85	819	0.33	4.05	115
TW3	02/22/2012	CSIR	CSIR	7.9		600	3840	862	412	37	1560	52	805	-0.10	3.90	128
TW3	08/28/2012	CSIR	CSIR	7.3		365	2336	521	156	34	824	54	323	-0.10	3.80	199
TW3	03/06/2013	CSIR	CSIR	8.5		330	2112	500	72	35	770	50	182	-0.10	4.90	171
TW3	09/17/2013	CSIR	CSIR	8.6		320	2048	505	83	32	767	53	191	-0.10	4.80	185
TW3	04/09/2014	CSIR	CSIR	7.8		470	3273	649	298	32	1050	47	664	-0.10	3.80	104
TW3	03/24/2015	CSIR	CSIR	8.0		380	2492	548	219	30	874	46	516	-0.10	3.60	137
TW4	03/28/2007	CSIR	CSIR	9.1		62	397	59	53	6	94	9	33	0.40	-999.00	122
TW4	09/11/2007	CSIR	CSIR	9.0		56	358	52	51	5	97	10	29	0.30	0.10	133
TW4	03/14/2008	CSIR	CSIR	8.9		55	352	57	53	4	85	11	22	0.32	-0.10	133
TW4	09/11/2008	CSIR	CSIR	9.2		52	333	56	49	4	84	10	25	-999.00	-0.05	127
TW4	02/24/2009	CSIR	CSIR	9.4		64	410	67	53	5	101	12	31	0.39	-0.10	140
TW4	09/11/2009	CSIR	CSIR	9.3		54	346	43	51	4	77	8	20	0.82	-0.10	130
TW4	03/11/2010	CSIR	CSIR	9.1		71	454	82	64	9	155	11	29	0.84	-0.10	145
TW4	09/09/2010	CSIR	CSIR	9.3		49	366	41	57	4	74	6	19	1.03	0.33	120
TW4	03/16/2011	CSIR	CSIR	9.4		263	1968	267	115	29	582	10	117	0.40	0.13	212
TW4	09/06/2011	CSIR	CSIR	9.7		263	1858	360	131	36	692	17	154	0.46	1.06	228
TW4	02/22/2012	CSIR	CSIR	9.1		58	371	46	62	4	77	7	19	-0.10	0.10	146
TW4	08/28/2012	CSIR	CSIR	7.5		52	333	36	50	4	45	7	19	1.10	-0.10	143

Borehole No	DATE	SAMPLER	LAB	PH_LAB	PH_SAT	EC	TDS	Na	Ca	Mg	Cl	K	SO_4	Nitrate + Nitrite as N	Ammonia as N	Alkalinity as $CaCO_3$
TW4	03/06/2013	CSIR	CSIR	8.7		54	346	42	56	4	65	6	20	0.90	-0.05	141
TW4	09/17/2013	CSIR	CSIR	8.7		66	422	61	62	6	96	7	27	0.70	-0.05	156
TW4	04/09/2014	CSIR	CSIR	8.0		58	337	36	53	4	58	6	7	-0.10	0.19	149
TW4	03/24/2015	CSIR	CSIR	9.2		44	263	35	54	4	60	5	10	-0.10	0.21	144
TW5	03/28/2007	CSIR	CSIR	7.8		420	2688	622	217	53	1014	23	378	0.25	-999.00	240
TW5	09/11/2007	CSIR	CSIR	7.7		225	1440	360	118	24	575	12	217	0.00	0.50	141
TW5	03/14/2008	CSIR	CSIR	7.8		419	2682	681	212	49	1058	25	389	0.80	1.50	255
TW5	09/11/2008	CSIR	CSIR	7.4		30	192	36	24	3	52	6	20	-999.00	-0.05	57
TW5	02/24/2009	CSIR	CSIR	8.0		400	2560	645	186	46	1045	37	331	-0.10	1.90	230
TW5	09/11/2009	CSIR	CSIR	7.8		30	192	25	21	3	41	3	15	0.13	-0.10	55
TW5	03/11/2010	CSIR	CSIR	8.1		250	1600	367	132	38	645	17	189	-0.05	1.40	192
TW5	09/09/2010	CSIR	CSIR	8.1		376	2800	490	184	43	958	13	287	0.33	0.66	279
TW5	03/16/2011	CSIR	CSIR	8.7		471	3530	468	197	49	1004	18	313	0.34	0.18	264
TW5	09/06/2011	CSIR	CSIR	8.5		471	2690	481	186	48	998	30	333	0.39	1.84	232
TW5	02/22/2012	CSIR	CSIR	7.9		410	2624	634	222	44	1100	18	343	-0.10	108.00	243
TW5	08/28/2012	CSIR	CSIR	6.4		44	282	39	36	4	69	4	25	0.60	-0.10	78
TW5	03/06/2013	CSIR	CSIR	7.8		370	2368	547	230	47	952	18	445	-0.10	1.90	258
TW5	09/17/2013	CSIR	CSIR	7.9		370	2368	537	180	43	863	17	340	-0.10	1.70	245
TW5	04/09/2014	CSIR	CSIR	8.1		380	2445	544	206	47	840	17	402	-0.10	1.90	251
TW5	03/24/2015	CSIR	CSIR	9.1		35	193	34	30	3	60	3	23	0.60	0.01	59

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9 September 2016

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INDEPENDENT REVIEW OF REPORT NUMBER 478317-42A/DRAFT 4: SPECIALIST GEOHYDROLOGY IMPACT ASSESSMENT FOR THE TRANSIENT INTERIM STORAGE FACILITY AT KOEBERG

1. Introduction

The Koeberg Operating Unit of Eskom Holdings SOC Limited (Eskom) appointed SRK Consulting (South Africa) (Pty) Ltd (SRK) to undertake an Environmental Impact Assessment (EIA) and associated authorisation processes in support of applications for Environmental Authorisation, and Water Use Authorisation for the Transient Interim Storage Facility (TSIF) at Koeberg Nuclear Power Station (KNPS). The Specialist Geohydrology Impact Assessment for the TSIF was completed by SRK in September 2016.

The independent Geohydrological Specialist (Karen Burgers) for the Environmental & Society Service Line of Advisian, was requested to review and comment on the Specialist Geohydrology Impact Assessment Report. Comment supplied to SRK included comments from Advisian and the client, Eskom.

2. Terms of Reference

The terms of reference for the Geohydrology Specialist review are as follows:

- Determine if the scope of work and methodology required have been adequately addressed in the Geohydrology Impact Assessment Report;
- Review the report for context, recent and accurate scientific data; and
- Conduct an independent and objective review of the Geohydrology Impact Assessment Report and confirm the scientific accuracy of information contained therein.

3. Methodology

The methodology for the review is as follows:

- Read through the document to determine if any grammatical, spelling or language errors occur;

- Assess the scientific accuracy and completeness of the report including context and recent data inclusion; and
- Give specific comments and suggestions on the report document about layout, format, information, assessment, language, methodology, impact assessment, results, conclusion for the Geohydrological Impact Assessment Report for the TSIF by SRK Consulting.

4. Findings

Table 1 lists the comments, corrections and suggestions made by the specialist for finalisation of the report and the resolution.

Table 1: Corrections, comments and suggestions for the TSIF Geohydrology Impact Assessment Report

No.	Comment / Correction	Location	Resolution
1	Add CISF to list of abbreviations	Section 1.1 paragraph 2	Corrected
2	Add NRWDI to list of abbreviations	Section 1.1 paragraph 2	Removed
3	Add ‘for’ to ‘spent fuel for the 4 (four) metal casks in the …’	Section 1.1 paragraph 2	Corrected
4	Remove ‘to’ in ‘spent fuel to be removed …’	Section 1.1 paragraph 6	Corrected
5	Change EIAR to EIR	Section 1.4 point 3	Changed to ‘Scoping Report’
6	Change Thes to These in ‘Thes tributaries are generally ……’	Section 2.1 paragraph 4	Corrected
7	Change Aguifer to Aquifer	Table 2-3	Corrected
8	Minor grammatical corrections to whole para graph and quantify distance to boreholes	Section 2.2.3 2nd paragraph	Corrected
9	Move ‘respectively’ to the end of the sentence	Section 2.2.3 6th paragraph	Corrected
10	Reference ‘as described previously’	Section 2.4 bullet 11	Corrected
11	There is very little monitoring information included for the actual KNPS site itself and it is only up to 2007. As the TSIF alternative’s proposed are on the KNPS site itself the recent monitoring data for KNPS should have been included in the report.	Overall comment	KNPS monitoring data forwarded and included in the assessment
12	The initial baseline assessment did not include an impact identification, assessment and mitigation section.	Overall comment	This has been rectified and included in the final draft as Section 3
13	Any radiological monitoring is subject to the NNR licensing process. The radiological monitoring requirements of the radiological study is not aligned with the geohydrological study. The radiological assessment report does not require ground water	Section 3.5	This has been rectified regards the recommendations for monitoring

	monitoring; and **The IAEA Safety Standards: Storage of Spent Nuclear Fuel for protecting people and the environment, SSG-15 Specific Safety Guide only requires ground water monitoring for wet storage facilities and not for dry storage facilities.**		

5. Conclusions

The comments, corrections and suggestions for finalisation of the Geohydrology Impact Assessment for the TSIF were, satisfactorily addressed. The scope of the work has been adequately addressed and the methodology followed. The baseline groundwater, geology, physiographic and climatic context locally and regionally has been adequately described. The risks during the construction and operational phases have been assessed, mitigation proposed and risks rated with and without mitigation. The conclusions contained in the report are appropriate and have addressed the risks to the groundwater regime for the proposed TSIF locations and the preferred location.

Yours faithfully

KBurgers

Karen Burgers
Geohydrology Specialist

SSA Environment & Society (RI)

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

EIA for the Proposed Used Nuclear Fuel Transient Interim Storage Facility at Koeberg Nuclear Power Station

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E-mail:	sjones@srk.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Karen Burgers, declare that --

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Advisian (WorleyParsons)

Name of company (if applicable):

16/08/2016

Date: