SECTION 5.12: WATER SUPPLY			
File name: 507052_DSSR Section 5.12 Water Supply Rev 1_20210927			
Authors' declaration:	**I declare that appropriate diligence and quality assurance was applied in the compilation of this report. As such I am confident in the results here described and the conclusions drawn.**		
	Name: P Rosewarne *Pr Sci Nat MSc* Principal Hydrogeologist	SRK Consulting - Certified Electronic Signature srk consulting	**Date:** 28/09/2021
Project Manager Authorisation:	**Name:** D Holmes *Pr Eng MBA*	SRK Consulting - Certified Electronic Signature srk consulting	**Date:** 28/09/2021
Project Partner Authorisation:	**Name:** B Engelsman *Pr Eng Pr CPM*	SRK Consulting - Certified Electronic Signature srk consulting	**Date:** 28/09/2021
Eskom Nuclear Siting Studies Acceptance:	**Name:** I Saayman	IC Saayman	**Date:** 29/09/2021
pp	**Name:** F van Mosseveld		**Date:** 2021-09-29

EXECUTIVE SUMMARY

Average potable water use by the Koeberg Nuclear Power Station (KNPS), rated 5 550 MW_{th}, from municipal supply during the period 2010 to 2015 was 18.4 ℓ/s. Following water savings interventions, this has reduced to 10.8 ℓ/s and is unlikely to be reduced further. This supply source has met KNPS's requirements since commissioning in 1985 and on-site storage has served to mitigate any short-term supply disruptions. However, back-up in terms of a secure alternative supply has been established from the Aquarius Wellfield supplying groundwater to a desalination plant at KNPS. The Aquarius Wellfield resource is finite and this aquifer is also being used by the City of Cape Town and so it is not viable to also serve the new nuclear installation from this source. Desalination of seawater is therefore seen as the long-term secure supply option for the new nuclear installation(s), pending further feasibility studies and is also favoured by Eskom.

Requirements for the new nuclear installation(s) (maximum of 13 200 MW_{th}) assumed for this water supply assessment (excludes once-through cooling water), range between *c.*54 ℓ/s during site establishment, a maximum demand of 104 ℓ/s and *c.*23 ℓ/s during operations (excludes KNPS). Apart from some initial contributions, these quantities cannot be sourced or guaranteed from existing conventional water supply schemes (City of Cape Town) or from local groundwater resources at and around the site.

Securing a reliable water supply from other sources such as new surface water schemes, recycling of wastewater, site storm water run-off and/or water-trading is not considered to be viable for a number of reasons. These include the need for a new pipeline and competing with the City of Cape Town for wastewater, lack of storm water run-off due to the sandy nature of the site and time, logistical and legal constraints for water-trading. Desalination of seawater, and some local groundwater, offer the best short and long-term option for water supply to support the safe operation of the nuclear installation(s) with least environmental impact and highest assurance of supply, and is the preferred option.

Desalination plants will be established in phases, with a package plant and temporary reservoirs for the site establishment phase and several water treatment plants with permanent reservoirs established for the operational phase. All such infrastructure will be established within the enveloping footprint area.

Brine from the desalination process will be discharged beyond the surf zone during nuclear installation(s) construction and co-disposed with once-through cooling water discharge during nuclear installation operation to minimise impacts on the marine environment. Monitoring of brine discharge (and associated additives such as coagulants and biocides) into the sea will only be required during the construction phase as it will be virtually undetectable when co-disposed with the cooling water outfall during nuclear installation operation. Monitoring of the desalination plants intake(s) and management of mitigation measures will be required to prevent blockage by foreign bodies, e.g. jellyfish.

With desalination of seawater being the preferred option, there are no uncertainties associated with water supply, apart from security and adequacy of power supplies in

the event of a severe on-site accident, and possible concurrent loss of off-site grid power.

Uncertainties associated with conventional water supply, which will only require addressing should desalination of seawater not meet all requirements or need to be supplemented/replaced, are:

- effects of drought/climate change on security and availability of supply;
- quality of such supply;
- availability of sufficient supplies within City of Cape Town's supply system and their willingness/ability to provide such supply;
- viability of establishing a new pipeline(s) to convey treated wastewater from source to site;
- impact of groundwater abstraction on existing groundwater users, including the City of Cape Town, and sensitive ecological receptors, such as wetlands, although mitigation measures should minimise any such impact, and initial flow modelling has shown that this is unlikely to occur.

AMENDMENT RECORD			
Rev	**Draft**	**Date**	**Description**
0		04/06/2015	New chapter, replacing old KSSR Rev 1
1	1	07/12/2020	Update taking into account NNR comments on the TSSR, Chapter 1 (PPE), KNPS strategy for improving potable water resilience and data updates such as definition of droughts and wet periods. Re-ordering of some sections to improve presentation.
1	2	11/08/2021	Executive summary added. Drawing updated. Cross-referencing and cognisance of Sections 5.5, 5.8 and 5.11.
1	3	14/09/2021	Changes to include cooling water volume from Chapter 1.

CONTENTS

5.12 WATER SUPPLY 5.12-6
5.12.1 Introduction 5.12-6
5.12.2 Purpose and Scope 5.12-6
5.12.3 Regulatory Framework 5.12-7
5.12.4 Guidelines and Plans 5.12-7
5.12.5 Approach to Evaluation 5.12-8
5.12.6 Water Requirements and Quality 5.12-9
5.12.7 Climatic Considerations 5.12-11
5.12.8 Existing Water Supply 5.12-11
5.12.9 Potential Water Supply 5.12-14
5.12.10 Management of Uncertainties 5.12-22
5.12.11 Monitoring 5.12-23
5.12.12 Management System 5.12-24
5.12.13 Conclusions 5.12-27
5.12.14 References 5.12-30

TABLES

Table 5.12-1 Aquarius Wellfield Representative Groundwater Chemistry 5.12-16
Table 5.12-2 Groundwater Chemical Analyses 5.12-18
Table 5.12-3 Summary of Chemical Analysis of Local Surface Water and Groundwater 5.12-19
Table 5.12-4 Summary of Activities, Links and Quality Requirements 5.12-26
Table 5.12-5 Regulatory Compliance Matrix 5.12-27

DRAWINGS

Drawing 5.12.1: Water Supply 5.12-13

5.12 WATER SUPPLY

5.12.1 Introduction

The purpose of this section is to present the approach and results of the investigation and assessment of the potable (to differentiate from once-through cooling water supply) water supply in and around the site in terms of:

- existing and planned nuclear installations with thermal capacity of 13 200 MW_{th} (see Chapter 3, Overview of Planned Activities at the site), for pre-construction, construction, operation and decommissioning, raw-water and demineralised purposes;
- workers/employees associated with the planned nuclear installation(s).

This section complements the evaluation of water use by the population around the site, as discussed in ***Section 5.5*** (Land and Water Use), ***5.10*** (Hydrology and Hydraulics) and ***5.11*** (Geohydrology).

5.12.2 Purpose and Scope

The purpose of this section of this SSR is to present the approach to the activities and the results of the water supply investigation at and around the site in terms of:

- determining the water supply requirements at various development/operational stages of the nuclear installation(s);
- existing supply from municipal and community sources;
- quality of existing supplies;
- potential surplus allocation from existing sources;
- potential new sources of water supply and the preferred option;
- security of supply, including the effect of severe drought (see comments under ***5.12.5.2***);
- constraints on development of new supply sources.

The focus of the section is on identification and evaluation of a secure and adequate supply of water to the nuclear installation(s) and ancillary structures/activities for the planned generating capacity during construction, operation, shutdown and decommissioning, whilst also taking into account the public users and the environment.

5.12.3 Regulatory Framework

The key legislation in South Africa relevant to water supply and protection of water resources is the National Water Act, 1998, Act No. 36 of 26 August 1998, (Republic of South Africa, 1998). This Act is the principal legal instrument that applies to water resource management in South Africa and contains comprehensive provisions for the protection, use, development, conservation, management and control of the country's water resources. The provisions of the Act are implemented and monitored by the Department of Human Settlements, Water and Sanitation (DHSWS, formerly the Department of Water Affairs [DWAF] and more recently the Department of Water and Sanitation [DWS]). The key section that would be relevant to developing conventional water supplies for site use would be Section 21(a), *Taking water from a water source,* and a water use licence would have to be applied for. However, compliance with the above Act will only be required if a decision is made to develop such a source, e.g. on-site groundwater.

In addition, the management of water as a renewable resource is required to be carried out within the framework of the relevant environmental legislation, i.e. the National Environmental Management Act, 1998, Act No. 107 of 27 November 1998, (Republic of South Africa, 1998). Site work for this SSR, i.e. on-site drilling and testing of exploration boreholes, was carried out within the scope of this Act.

The Regulations on Licensing of Sites for New Nuclear Installations, (Department of Energy, 2011) are generally applicable and in particular Regulation 4(2): '*Factors considered in the evaluation of sites must include ... the proposed nuclear installation design(s) and the characteristics specific to the site...'*

5.12.4 Guidelines and Plans

National and international guidelines consulted in the preparation of this SSR included:

- National Nuclear Regulator (NNR), Regulatory Guide RG-0011 Interim Guidance for the Siting of Nuclear Facilities, Rev 0 (National Nuclear Regulator, 2016).
- South African National Standard Guidelines for Drinking Water No. 241-1-2015 of 2015, (South African Bureau of Standards, 2015) - This guideline and the one following are self-explanatory and provide recommended and upper screening limits for various key constituents of natural waters.
- the DWAF's Water Quality Guidelines of 1996, (Department of Water Affairs and Forestry, 1996).

- Eskom’s Strategy for Improving Potable Water Resilience at Koeberg Nuclear Power Station (Eskom, 2018).
- the Plant Parameter Envelope (PPE) information in ***Chapter 1*** (Introduction) of this SSR for a 13 200 MW_{th} nuclear installation.
- Electric Power Research Institute, Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide), (Electric Power Research Institute, 2015) - This guide discusses water availability and costing for a nuclear installation.

5.12.5 Approach to Evaluation

The approach to the site investigation included the following steps:

Desk Study

A desk study was carried out involving detailed review of the national legal and regulatory requirements and guidelines, national and international guidelines, review and collation of available information on water supply, liaison with the geohydrology, hydrology and land and water use SSR investigations.

Determination of Water Requirements

This was done by referencing the PPE and existing KNPS water use.

Field Work

The following field work activities were carried out specifically for ***Section 5.11*** but have relevance to this section in terms of groundwater supply and included:

- a hydrocensus in 2006/2007, updated in 2017 (approximate 5 km radius from the site centroid, but mainly centred on the suburb of Duynefontein – see ***Section 5.11***) and water use survey (up to 50 km radius from the site centroid – see ***Section 5.5***);
- drilling of 13 exploration, test and monitoring boreholes (10 for SSR purposes and three for wetlands monitoring) within the site;
- test pumping of selected higher yielding of the SSR boreholes to assess yield potential and obtain water samples for laboratory analysis.

Data Analysis

The following data analysis activities were carried out specifically for ***Section 5.11,*** but have relevance to this section and included:

- chemical analysis of water samples to check for suitability for various uses (biannually);
- determination of local and regional groundwater and surface water potential;
- numerical groundwater flow modelling to assist inter alia in assessing the water balance to determine an estimate of the exploitable groundwater potential and any impacts on local wetlands and existing groundwater users;
- comparison of the feasibility and environmental implications of the different supply options, including desalination of seawater - A comparison of costing of the different options has not been carried out in detail as the preferred option both environmentally and from an assurance of supply perspective is desalination of seawater. The environmental impacts and comparisons thereof have been evaluated in the Environmental Impact Report (Eskom, 2010b).

5.12.6 Water Requirements and Quality

The existing Koeberg Nuclear Power Station (KNPS, rated 5 550 MW_{th}) used an average of 18.4 ℓ/s of municipal water during the period 2010 to 2015, (Eskom, 2018), sourced from the local municipal supply (see below). This usage has been reduced to 10.8 ℓ/s by implementing water savings interventions and is unlikely to be reduced further (Eskom, 2018). Water is supplied directly to the power station, as described in ***Subsection 5.12.8***. It is proposed to augment this supply with the back-up of groundwater from the Aquarius Wellfield via a desalination plant, as discussed further in ***Subsection 5.12.7***. This is seen as an option for KNPS only (Eskom, 2018) as the Aquarius Wellfield resource is finite and is also being used by the City of Cape Town (CCT).

According to the PPE, water requirements for nuclear installation(s), based on a likely phased approach to installation of units with 13 200 MW_{th} capacity, are estimated to be:

- site establishment: *c*.54 ℓ/s;
- early site activities: *c*.70 ℓ/s;
- early construction activities: *c*.73 ℓ/s;
- construction: *c*.63 ℓ/s;
- maximum demand: 104 ℓ/s (maximum short-term rate of withdrawal from water source for potable and sanitary waste systems);
- operation: *c*.23 ℓ/s.

Based on the water savings achieved at KNPS it is likely that the operational water use can be reduced.

Temporary employees will require 46 ℓ/s of potable water initially, reducing to 12 ℓ/s for permanent staff after construction. This water requirement will be supplied by the CCT to employees in residential areas through the existing infrastructure. The majority of these employees may already live in the area and the additional water requirement is likely to be less than stated.

The following temporary reservoirs/storage capacity will need to be established on the site (Eskom PPE) for the excavation and construction phases of each new installation (13 200 MW_{th}):

- seawater reservoir (pre-desalination): 1 x 9 000 m^3;
- desalinated peak construction water (two days standby): 12 620 m^3.

The following permanent reservoirs (Eskom PPE) will be required for each new installation (13 200 MW_{th}) operational phase:

- demineralised water: 1 x 1 035 m^3;
- 2 x site water tanks: 37 492 m^3;
- 2 x feedwater tanks: 6 210 $m^{3;}$
- 1 x condensate feedwater tank: 3 312 m^3;
- 2 x demineralised primary make-up water tanks: 35 190 m^3;
- 1 x borated refuelling water tank: 6 624 m^3.

These reservoirs will be located around the nuclear installation within the EIA Corridor (shown in ***Drawing 5.12.1)***. Reservoirs are required for the new nuclear installation(s) because water will be derived from a non-mains desalination source (see discussion in ***Subsection 5.12.7***) and sufficient storage needs to be maintained on-site. The KNPS is mains-supplied by the CCT and so can call on immediate and sustained supplies. Further, when KNPS was conceived of and commissioned, there was no water supply deficit in the province nor was there a heightened risk of recurring severe droughts facing the Greater Cape Town Metropolitan Area, as was recently experienced. The latter has been illustrated by the record low rainfall for Cape Town and the surrounding catchment areas for the period 2015 to 2018.

Water for potable use must meet the SANS-241-1-2015 Guidelines for Drinking Water (as per the PPE). These are referenced under ***Subsection 5.12.9***. Make-up water will need to be desalinated to remove harmful constituents such as iron and bicarbonate.

Of direct influence, i.e. putting possible constraints on water allocations and on any decisions regarding use of local water resources for supply to the site, are local DHSWS and municipal strategic initiatives/actions. These include any water licenses and allocations that have been allocated through these agencies. Such allocations have been considered in the evaluation of the potential supply of water to the new nuclear installation(s) proposed at the site. This evaluation was also performed taking into account the PPE that is presented in ***Chapter 1*** of this SSR.

5.12.7 Climatic Considerations

The site has a Mediterranean climate characterised by warm, dry summers and mild, moist winters. The mean annual precipitation measured at the Koeberg weather station from 1980 to 2019 is 372.1 mm. Maximum rainfall occurs during June (65 mm), July (68 mm) and August (53 mm), while the lowest rainfall occurs during January (10 mm) and February (8 mm). Extreme values for the site, as referenced from ***Section 5.8***, Meteorology are defined as follows:

- 'High' rainfall - 23.7 mm/h, 70.0 mm/24 h and 162.4 mm/month. On this basis, 1986 to 1988 and 2013 to 2014 were 'wet' periods, with 1987, 1988 and 2014 being 'very wet';
- a drought is traditionally defined in South Africa as a year in which the rainfall is 75 per cent or less than the average taken over a 30-year period. However, the South African Weather Services use the internationally accepted Standardised Precipitation Index or SPI. A drought occurs when the SPI is continuously negative and reaches an intensity of -1.0 or less. On this basis, the frequency of a moderate drought is 15.8 per cent, a severe drought 6.8 per cent and an extreme drought 2.8 per cent. Also, on this basis, 2015 to 2018 can be described as a drought, with 2016 to 2017 being a severe drought.

It is noted that climate change predictions include a reduction in rainfall for the Duynefontyn area (Airshed, 2020). This is discussed in detail in ***Section 5.8***.

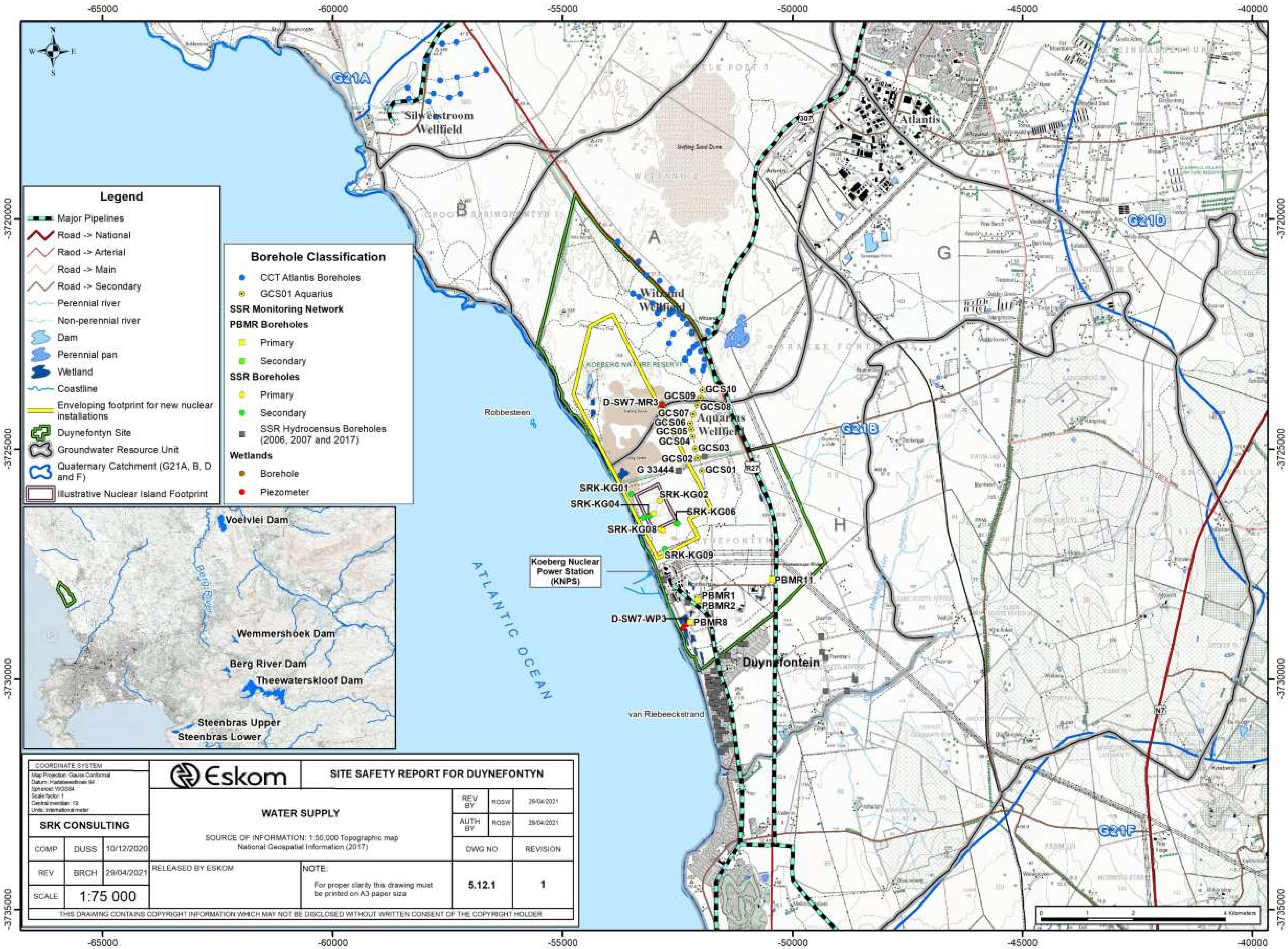
5.12.8 Existing Water Supply

The site falls within the Berg Water Management Area (WMA). The relevant water sources are shown on the inset map on ***Drawing 5.12.1***.

According to water requirement projections in Appendix D of the National Water Resource Strategy (Department of Water Affairs and Forestry, 2004), there is no allowance for water requirements for power generation in this WMA. The site receives the bulk of its water via the local authority, the CCT. In 2017, boreholes comprising the Aquarius Wellfield (***Drawing 5.12-1***), which is discussed further under ***Subsection 5.12.9***, were rehabilitated and this water could be fed into the proposed desalination plant at KNPS to assist with a reduction in reliance on and supplement use of municipal water supplies.

The CCT augments the water supply to the greater metropolitan area from Voëlvlei Dam situated approximately 12.5 km southwest of Tulbagh. At the dam, water is treated and pumped to the Plattekloof Reservoir. A head meter is located approximately 8 km north of the reservoir, on the Voëlvlei Dam/Plattekloof Reservoir pipeline from where it feeds the 40 000 m^3 capacity Melkbos Reservoir, located on the farm Blaauwberg. The Melkbos Reservoir supplies the Melkbosstrand/Blaauwberg area with water. The water gravitates along a pipeline to a valve chamber northeast of the Melkbosstrand/M14 intersection and supplies KNPS with water. The local authority supplies the required water to the residential areas of Bloubergstrand, Melkbosstrand, Van Riebeeckstrand and Duynefontein.

A pipeline supplying Atlantis runs along the R27 (***Drawing 5.12.1***). Currently, supply to the KNPS is dependent on draw-down on the Melkbos Reservoir and on-site reservoir storage is needed to regulate this supply. The site is near the end of the supply network and the CCT's priority is to supply Atlantis and KNPS, the latter due to its National Key Point status. The CCT is therefore unable to give a definite undertaking to guarantee supply for any additional nuclear installations on the site. This stance could change if the whole site is declared a National Key Point as is the current situation with the KNPS. However, given the impacts of drought conditions, such as those experienced in 2017/2018, reliance on municipal water supply cannot be guaranteed.



Path: \\CTN-SVR0.ctn.za.srk.ad\vol1\Root\Proj\New Proj\507052_SSR UPDATE\8GIS\GISPROJ\MXD\Duynefontyn\Chapter 5\Section 12\507052_DWG_5-12-1_DSSR UPDATE_WaterSupply_A3L_Rev1_20210429.mxd

5.12.9 Potential Water Supply

Supply sources for water for the new nuclear installation include:

- surface water from existing dams/pipeline or construction of a new supply dam(s);
- groundwater – Aquarius Wellfield; Atlantis Aquifer; Malmesbury Aquifer;
- treated wastewater;
- buying out of existing water use licenses;
- storm water run-off from the site;
- desalination of sea water.

Surface water

There are no rivers crossing the site and no perennial rivers occur within the site vicinity (16 km radius). The soils at the site are also very sandy and unsuitable for dam construction. Development of a surface water supply by Eskom is therefore not considered further.

Groundwater

Prior to the drought conditions of 2017/2018, the unconstrained average daily water demand for the CCT was 1 346 Mℓ/day (City of Cape Town, 2018), reducing to 500 Mℓ/day by January 2018 with restrictions in place. An augmentation programme was initiated by the CCT in 2017 which included the following, with projected/sustainable yields in brackets (City of Cape Town, 2019):

- groundwater:
  - Atlantis Aquifer (116 ℓ/s);
  - Cape Flats Aquifer (CFA, 521 ℓ/s);
  - CFA managed aquifer recharge (810 ℓ/s);
  - Table Mountain Group Aquifer (TMGA, 579 ℓ/s).
- wastewater re-use (810 ℓ/s);
- desalination phase 1 (579 ℓ/s);
- additional surface water (694 ℓ/s).

The Aquarius Wellfield of 10 boreholes was installed in 1996, tapping the Sandveld Aquifer, designed to supply 15 ℓ/s, but boreholes became in need of rehabilitation because of construction problems and clogging with iron bacteria. The raw water quality is also substandard for nuclear installation water requirements in terms of e.g. bicarbonate and iron. Borehole rehabilitation was carried out in August and September 2017, and a new wellfield sustainable supply established (Advisian, 2018) for supply to the proposed KNPS desalination plant. The following yields have been determined (units as used by Advisian):

- Group A GCS01, GCS08 & GCS10: 436.32 m^3/day (*c*.5 ℓ/s);
- Group B GCS02, GCS07, GCS09: 485.4 m^3/day (*c*.5.6 ℓ/s);
- Group C GCS03 & GCS06: 198.9 m^3/day (*c*.2.3 ℓ/);
- Group D GCS05: 143.68 m^3/day (*c*.1.6 ℓ/s ;
- Total: 1 264.3 m^3/day (*c*.14.5 ℓ/s).

Test pumping showed that there was no interference of drawdown between adjacent boreholes. Water levels measured in 2017 were also very similar to those when the wellfield was established in 1996 (Advisian, 2018). The local groundwater therefore appears to show a 'buffering' against the effects of drought, probably due to the high storage capacity of the sandy aquifer. It is therefore unlikely that abstraction from the Aquarius Wellfield would impact on the CCT abstraction from the Witzand or Silwerstroom wellfields. Modelling results from ***Section 5.11*** confirm this statement.

Groundwater quality

Some examples of the groundwater quality from these boreholes for selected water quality indicators, sampled in November 2017, are given in ***Table 5.12-1*** (Advisian, 2018). A clear trend emerges of groundwater quality improving along the line of boreholes from GCS1 (poorer quality) to GCS10 (better quality), i.e. from nearer the coast to further inland.

Table 5.12-1
Aquarius Wellfield Representative Groundwater Chemistry

Site ID					
Determinand	**Units**	**SANS-241-1-2015 Standards**	**GCS1**	**GCS6**	**GCS10**
EC	mS/m	≤170	291	170	100.2
pH	pH units	>5-<9.7	7.3	7.01	7.28
K	mg/ℓ	-	1.2	1.1	1.0
Na	mg/ℓ	≤200	414.4	178.2	112.1
Ca	mg/ℓ	-	126.8	136.7	71.4
Mg	mg/ℓ	-	47.1	32.5	19.4
SO_4	mg/ℓ	≤250	123.2	264.6	41.9
Cl	mg/ℓ	≤300	750.3	292.2	155.1
TAL (as $CaCO_3$)	mg/ℓ	-	188	156	224
NO_3 (as N)	mg/ℓ	≤11	BDL*	0.43	BDL
F	mg/ℓ	≤1.5	0.4	0.4	0.5
Fe	mg/ℓ	≤0.3	1.243	1.258	1.261

*below detection limits

The Atlantis Primary Aquifer System (APAS) is the most important groundwater resource in the study area. The APAS was capable of yielding a minimum of about 127 ℓ/s (4 Mm^3/a) of groundwater on a sustainable basis, prior to implementation of the CCT augmentation scheme. The abstraction of the wellfields dropped-off markedly from 1999 due to a combination of limited water treatment capacity, biofouling of boreholes limiting yields and vandalism of infrastructure (pers comm. C Lasher-Scheepers, April 2020).

The CCT has recently carried out the re-drilling of 22 boreholes and the rehabilitation of a further 12 boreholes, associated with the Witzand Wellfield. The design yield from the upgraded wellfield is 237 ℓ/s, slightly more than quoted in CCT, 2018. The drilling of new production boreholes has not started yet, but it is planned to obtain an additional 127 to 162 ℓ/s (pers. comm. C Lasher-Scheepers, April 2020).

Drilling and yield testing of the Malmesbury Aquifer at the site during the

SSR investigation has shown that this aquifer has potential for limited supply to the site, only suited to site establishment requirements in terms of quantity and quality.

The location of the sources described above is shown in ***Drawing 5.12.1***.

A summary of results of selected water quality indicators from the chemical analyses from October 2020 of the groundwater from the site (SSR geohydrological monitoring) is shown in ***Table 5.12.2*** over page. The sample locations are shown in ***Drawing 5.12.1***. The groundwater is slightly alkaline (T ALK) with moderate salt content, as indicated by the electrical conductivity (EC), and is of a sodium chloride type, typical of a coastal environment in the Western Cape.

Table 5.12-2
Groundwater Chemical Analyses

Site ID		**SANS**	**SRK-KG1***	**SRK-KG2****	**PBMR1***	**PBMR11****	**SRK-KG8****	**SRK-KG9***
Determinand	**Units**							
EC#	mS/m	≤170	347.1	120.0	283.0	460	213.9	247.0
pH	pH units	≥5-≤9.7	7.93	8.04	7.84	7.58	7.79	7.81
K	mg/ℓ	-	4.7	3.8	4.1	6.3	4.9	2.9
Na	mg/ℓ	≤200	441.1	110.8	362.1	651.3	244.5	345.4
Ca	mg/ℓ	-	168.2	84.8	127.1	135.6	110.6	92.6
Mg	mg/ℓ	-	43.9	24.9	38.3	90.2	42.7	35.4
SO_4	mg/ℓ	≤250	2.2	54.5	10.0	137.2	70.8	68
Cl	mg/ℓ	≤300	900.0	199.0	695.6	1 253	485.4	588.5
T ALK (as $CaCO_3$)	mg/ℓ	-	212	220	212	164	248	236
NO_3 (as NO_3)	mg/ℓ	≤11 (as N)	<0.2	3.1	<0.2	<0.2	<0.2	<0.2
F	mg/ℓ	≤1.5	<0.3	<0.3	<0.3	0.3	<0.3	<0.3
Fe	mg/ℓ	≤0.3	0.862	<0.020	0.837	4.926	0.416	0.540

*Malmesbury Aquifer

**Sandveld Aquifer

#values taken directly from the analytical reports by Element Materials Technology

Surface water quality

The surface water originating from supply dams, e.g. Wemmershoek, Steenbras and Voëlvlei dams (see inset map on ***Drawing 5.12.1***), on the inland TMG catchments, is of better quality, i.e. at the lower end of the EC range. A summary of representative chemical analyses of the local surface water, represented by the raw water intake at the Voëlvlei Water Treatment Works, for the period 1 July 2016 to 30 June 2017 is shown in ***Table 5.12.3*** (City of Cape Town, 2017). Groundwater quality from the Witzand Wellfield is also included for comparison (1 May 2009 to 30 April 2012).

Table 5.12-3
Summary of Chemical Analysis of Local Surface Water and Groundwater

Determinand	Units	SANS	Source Voëlvlei	Source Witzand Wellfield
pH	pH units	≥5-≤9.7	8.7	7.7
EC	(mS/m)	≤170	18	30
Ca	mg/ℓ	-	15	27
Mg	mg/ℓ	-	2.8	3.6
Na	mg/ℓ	≤200	13	22
K	mg/ℓ		0.9	1.2
SO_4	mg/ℓ	≤250	23	29
Cl	mg/ℓ	≤300.0	26	42
Total Alkalinity (as aCO_3)	mg/ℓ	-	21	15
F	mg/ℓ	≤1.5	0.1	0.1
Fe (total)	mg/ℓ	≤0.3	0.104	0.065
Mn (total)	mg/ℓ	≤0.1	<0.006	0.009

The quality of these ground and surface waters all fall within the SANS-241-1-2015 recommended limits for drinking water and would therefore be suitable for most on-site uses, apart from those requiring demineralised quality. The surface water is of better quality because it is sourced further inland and from a predominantly sandstone catchment area, whereas the local groundwater is subject to coastal sea spray salts and dissolution of calcrete within the sand aquifer. Comparison of the EC of the Voëlvlei surface water above, which is for a period of severe drought, as described in ***Subsection 5.12.7***, and results for 2014 for a wet period, shows no significant change, with the former being 18 mS/m and the latter 15.6 mS/m (City of Cape Town, 2014).

Other sources

Other potential sources of water include construction of a new dam(s), buying out and consolidation of existing water use licenses/allocations, treated wastewater and storm water run-off from the site. However, none of these options are considered to be viable in terms of securing a sufficient and reliable source of supply because:

- There are a limited number of feasible new dam sites available in the site region for further water resource development. Only one is being considered by the CCT, namely on the Molenaars River on the Worcester side of the Huguenot Tunnel (*c.*10 km due north of Wemmershoek Dam), (City of Cape Town, 2018) which is of no consequence for site supply.
- Buying out of existing water use licences (water trading) would be very challenging and take considerable time, be fraught with potential obstacles and uncertainties and would be unlikely to realise the supply quantities required.
- The severe drought (see ***Subsection 5.12.7***) of *c.*2015 to 2018 affecting Cape Town and the surrounding catchment areas showed the adverse effects of climate change on surface water resources in the area, and also the potential unreliability of such sources in the long-term. The so-called "Day-Zero', when the CCT would basically have run out of dam-supplied and piped surface water, was only narrowly averted by timely rainfall and austere/punitive restrictions.
- Quantities of site wastewater and storm water run-off would be too small to meet demand (see ***Section 5.10***). Opportunities exist for additional use of reclaimed wastewater in the WMA, as listed under the CCT augmentation programme earlier in this subsection. However, these sources are earmarked for use by the CCT. Additionally, getting this water to the site would entail installation of a new pipeline(s) with accompanying issues of access, servitudes and environmental authorisation, plus the supply from such a source(s) is likely to fluctuate according to water use by contributing communities in response to wet or dry climatic conditions.

Desalination of seawater

The only other viable supply option is use of desalinated seawater. There is a ready supply of seawater at the site and there is an existing supply of power to the site for KNPS (possibly for 20 years from c.2021). In terms of nuclear installation safety and assurance of supply, which are paramount considerations for this SSR and licensing, desalination (reverse osmosis) is an attractive option to provide the necessary reliable long-term water supply to the site (Eskom, 2010a), given:

- the periodic droughts that affect the site area and region and uncertainty pertaining to climate change effects exacerbating drought conditions;
- the already scarce water supply situation;
- concerns over environmental impacts of groundwater abstraction;
- potential impacts of global warming, i.e. severe droughts;
- ready availability of tried and tested desalination technology/equipment.

Seawater desalination plants (reverse osmosis) will be used for the main water supply to the new nuclear installation(s) and will be deployed in phases during the lifecycle of the project, typically as follows (see ***Chapter 3*** of this SSR):

- Phase 1: Site establishment – local groundwater, CCT supply and/or desalinated seawater will be used.
- Phase 2: Construction - 3 x 35 ℓ/s desalination systems during the excavation phase, with the seawater intake from beach wells, installed in a permanent building of approximately 1 700 m^2;
- Phase 3: Operation - two of the above-mentioned desalination units, with one back-up unit/on preventative maintenance. All desalination plant infrastructure will be located within the enveloping footprint area as shown in ***Drawing 5.12.1***.

Back-up power supplies need to be sufficient to take into account the requirements to run the desalination plant under accident conditions.

The seawater requirements and brine discharge throughout the stages of the new nuclear installation lifecycle, assuming the figures quoted in ***Subsection 5.12.5.2*** and a conservative 40 per cent water recovery, would be approximately:

- construction: 157.5 ℓ/s input and 94.5 ℓ/s brine;
- maximum demand (construction/commissioning): 260 ℓ/s input and 156 ℓ/s brine;
- normal operation (13 200 MW_{th} capacity): 57.5 ℓ/s input and 34.5 ℓ/s brine.

During construction, the estimated maximum brine discharge will be 156 ℓ/s (assumes a maximum water use of 104 ℓ/s), for which a number of discharge options exist (Eskom, 2010a):

- through a pipe located on the upper beach profile;
- from a pipe located beyond the surf zone at a suitable depth.

Disposal of the brine in the turbulent surf zone would improve mixing and reduce the risk of the brine forming a density current which could transport the brine along the seabed without undergoing significant mixing/dilution. However, this is discouraged by the DHSWS (Department of Water Affairs and Forestry, 2004) due to the sensitivity of this environment. Disposal beyond the surf zone along the sandy seabed at sufficient velocities to enhance vertical mixing of the brine is thus recommended. Construction is also likely to take about seven years (Eskom, 2017) and baseline monitoring and modelling of plume dispersion will be required to ensure that any environmental impacts are within predicted ranges and as approved by the regulatory authority. The brine is also likely to contain biocides, coagulants and neutralising agents which will need to be taken into account in the impact modelling and monitoring. A coastal water discharge permit will be required for this activity.

During operation, the brine will be mixed with the very large volumes of cooling water discharged from the nuclear installation(s) (about 76 000 ℓ/s per unit according to the PPE) to minimise such impacts.

5.12.10 Management of Uncertainties

The costs linked to obtaining water from the various sources discussed above varies considerably, and uncertainties exist in calculation of such costs. However, to give an indication of the quantum and variability, CCT figures (City of Cape Town, 2018) suggest about R5.20 per kℓ for surface water, R5 per kℓ for groundwater to about R9 per kℓ for desalination. It must be pointed out that the latter figure applies to commercial developments at e.g. The Waterfront and Cape Flats and may be different to the unit cost of a desalination plant developed adjacent to the KNPS or the new nuclear installation(s).

The other main uncertainties for conventional water supply to the site are:

- source of long-term supply to the site;
- effects of drought and global warming on security of supply;
- impact of groundwater abstraction on existing users and wetlands, although mitigation measures should minimise any such impact - Such

mitigation measures will include modelling of the extent and depth of pumping drawdown prior to commissioning of any supply boreholes and ongoing monitoring of water levels and water quality as per the annual SSR geohydrological monitoring programme. Initial modelling for this SSR (see ***Section 5.11***) indicates that, with suitably sited boreholes and sustainable pumping rates, such impacts will not occur, e.g. CCT abstraction from the Witzand and Silwerstroom wellfields will not be affected.

However, based on the scarcity of conventional local and regional water supplies in the site region and environmental concerns, it is proposed to use desalination as the means to secure a reliable long-term water supply for the new nuclear installation(s). Assuming that desalination does form the long-term supply source, the above uncertainties will fall away, but sufficiency of power supplies during accident or other downtime conditions will need to be addressed. Uncertainties regarding power include when the new nuclear installation(s) will be built as power from KNPS will only be available for about 20 years from 2021. Variations in water demand during the nuclear installation life cycle will be covered by on-site storage capacity. There are also uncertainties regarding permitting of groundwater abstraction and discharge of brine into the sea.

Other uncertainties that will require attention are the effect of large-scale oil spillage from ships that could be drawn into the intake zone and contamination by micro-organisms/jellyfish on the seawater feed. Incidents of jellyfish clogging of the KNPS seawater intake occurred in February 1997, June 1999, May 2005 and March 2020, (Pisces Environmental Services, 2020) with the latter resulting in the shutting-down of one unit of KNPS. An increase in jellyfish blooms can be expected in the future and relevant mitigation measures and management will be required, which are beyond the scope of this section.

5.12.11 Monitoring

A groundwater monitoring programme has been compiled for the Aquarius Wellfield (Advisian, 2018) which covers frequency of measurements/sampling, parameters and reporting. This will support the proposed KNPS back-up water supply.

With water supply being sourced from the desalination of seawater, the only monitoring required is salinity and other quality (e.g. coagulants, neutralisers, biocides) measurements in the discharge plume area, assessment of seabed erosion during construction and regular inspection of the intake(s) of the desalination plant to ensure that it/they do not get blocked by foreign matter, e.g. oil, jellyfish, micro-organisms.

During operation, the influence of the brine discharge will be virtually undetectable in the cooling water outfall (Eskom, 2010b) and specific monitoring will therefore not be required during the operational phase of the new nuclear installation(s).

A long-term (13 years so far, with some interruptions, and continuing) programme of groundwater level and quality monitoring at the site is in place as part of this SSR. This will provide sufficient data in the event that use of the site aquifers is ever considered.

5.12.12 Management System

Water supply at the site has been classified as a level D activity according to Eskom's safety classification methodology. This is based on desalination of seawater being the preferred supply source for the new nuclear installation(s) and the assured supply to the KNPS from municipal and groundwater sources, with sufficient on-site storage back-up. A level D classification means that an Eskom approved quality management system must be followed for execution of this work and this requirement was implemented, as briefly described below and covered in detail in ***Chapter 10*** (Management System).

Detailed records of the work carried out and databases established were kept by the consultant, e.g. hydrocensus, water quality analyses and geohydrological monitoring. These records were obtained from ***Section 5.11*** of this SSR and data validated by means of reference to the management system implemented for that section. Chemical analysis records obtained from the CCT for the Voëlvlei Water Treatment Works are produced by their Scientific Services laboratory. This laboratory is SANAS ISO/IEC 17025 accredited. Duplicate samples are taken during the weekly sampling runs for QA/QC purposes. However, the absolute accuracy of these analytical data is not crucial to this SSR Section as the water sources analysed are not being considered for supply to the site.

Electronic records have been stored in a secure central repository with regular off-site back-up procedures and subject to Eskom's approval. All references cited are saved on the central repository. Although the preferred water supply source is desalination of seawater, all relevant data are presented as back-up documentation in the form of appendices to ***Section 5.11*** of this SSR, i.e. hydrocensus, certificates of chemical analyses and monitoring.

Table 5.12.4 lists the activities carried out, the links to other SSR sections/chapters and the relevant quality control requirements.

Table 5.12.4
Summary of Activities, Links and Quality Requirements

Activity	Links		Quality Requirements
	Inputs	Outputs	
Hydrocensus	Position of all water points such as boreholes, springs, dams from ***Section 5.11***	***Section 5.5*** and ***Section 5.10***; Information on existing groundwater use from boreholes and springs (additional to the Geohydrology hydrocensus area) will provide essential input into the Land Use and Hydrology sections, mainly on quantities used and quality.	Check methodologies used, Project Quality Plan, method statement of supplying organisation(s) to ensure valid data are acquired
Water quality	Chemical analyses from selected laboratories and municipal water treatment works, ***Section 5.11***	***Section 5.5*** and ***Section 5.10;*** Water quality data will be used as input to the Land Use and Hydrology sections	Municipal laboratory SANAS ISO/IEC 17025 accredited.
Development of new sources	Integrated study including comparison of costs and environmental issues	Source location and status. Assured supply	NA
Desalination	***Chapter 1*** (PPE for cooling water discharge volume).	***Section 5.3*** (Ecology). Brine discharge quantities, temperature and quality. Accuracy of actual with predicted brine dispersion and environmental impacts.	NA
Monitoring	From ***Section 5.10*** and ***Section 5.11***		Check monitoring protocols used by supplying organisation(s)

A regulatory compliance summary is given in ***Table 5.12.5*** to show what

Acts/regulations are relevant to water supply and where in this SSR they have been dealt with.

Table 5.12.5
Regulatory Compliance Matrix

Act/Regulation	Regulation	Issue	Section where covered
National Water Act, 1998 (Republic of South Africa, 1998)	Section 21(a) 38(i)	Water use licence Coastal water discharge	5.12.4 5.12.9
National Nuclear Regulator (National Nuclear Regulator, 2016) RG-0011	8.2	Land and water use in the region	5.12.8
RG-0011	8.4.2	Hydrological considerations	5.12.6; 5.12.7
Regulations on Licensing of Sites for New Nuclear Installations (Department of Energy, 2011)	4	Site characteristics	5.12.5; 5.12.6

5.12.13 Conclusions

The main conclusions regarding water supply at the site are the following:

- Average potable water use by the KNPS (rated 5 550 MW_{th}) from municipal supply has reduced from 18.4 ℓ/s to 10.8 ℓ/s following water saving interventions. This is scheduled to be augmented by a back-up system of groundwater from the Aquarius Wellfield supplying a desalination plant at KNPS.
- Groundwater levels in the Aquarius Wellfield in August/September 2017 were very similar to those when it was originally installed in 1996,

indicating that the local Sandveld Aquifer is ‘buffered’ against the effects of drought, at least in the short-term.

- Nuclear New Build water requirements (excluding once-through cooling water) range between *c*.54 ℓ/s during site establishment to a maximum demand of 104 ℓ/s and *c*.23 ℓ/s for operation for the new nuclear installation(s) (excludes KNPS).
- Apart from some contribution to site establishment requirements, these quantities cannot be sourced or guaranteed from existing conventional water supply schemes or from groundwater resources at and around the site.
- Water supply for site establishment purposes could be sourced from local groundwater or derived from the CCT’s piped supply to the site.
- Securing a reliable water supply from other sources such as new schemes, re-use of wastewater, site storm water run-off and/or water trading is not considered to be viable.
- Desalination of seawater, plus some site groundwater, offers the best short and long-term option for water supply to support the safe operation of the new nuclear installation(s) with least environmental impact and highest assurance of supply, and is the preferred option.
- Desalination plants will be established in phases with a package plant and temporary reservoirs for the site establishment phase and several desalination plants with permanent reservoirs established for the operational phase.
- Desalination plants, reservoirs and intake/discharge structures will all be established within the EIA Corridor area.
- Brine from the desalination process will be discharged beyond the surf zone during nuclear installation(s) construction (81 to 156 ℓ/s) and co-disposed with cooling water discharge (76 000 ℓ/s per unit) during nuclear installation operation (34.5 ℓ/s) to minimise impacts on the marine environment.
- Monitoring of brine discharge (and associated additives such as coagulants and biocides) into the sea will only be required during the construction phase as it will be virtually undetectable when co-disposed with the cooling water outfall during nuclear installation operation.
- Monitoring of the desalination plants intake(s) and management of mitigation measures will be required to prevent blockage by foreign bodies, e.g. jellyfish.
- With desalination of seawater being the preferred supply option, the uncertainties associated with water supply reduce to security and adequacy of power supplies in the event of i) a severe on-site accident,

ii) a concurrent loss of off-site grid power, iii) permitting of groundwater abstraction and iv) brine discharge into the sea.

- Uncertainties associated with conventional water supply, which will only require addressing should desalination of seawater not meet all requirements or need to be supplemented/replaced, are:
  - effects of drought/climate change on security and availability of supply;
  - quality of such supply;
  - availability of sufficient supplies within CCT's supply system and their willingness/ability to provide such supply;
  - viability of establishing a new pipeline(s) to convey treated wastewater to the site;
  - impact of groundwater abstraction on existing groundwater users and sensitive ecological receptors, such as wetlands - Mitigation measures should minimise any such impact and initial flow modelling has shown that such impacts are unlikely, i.e. CCT groundwater abstraction will not be affected.

5.12.14 References

1. Advisian, 2018. *Koeberg Desalination Wellfield Groundwater Monitoring Programme,* Cape Town: Advisian.

2. Airshed, 2020. *Proposed Methodology for Including Climate Change Forecasts into the Duynefontyn Site Safety Report. Draft.* Johannesburg: Airshed.

3. City of Cape Town, 2014. *City of Cape Town Analytical Data and Approximte Distribution for Cape Town,* Cape Town: City of Cape Town.

4. City of Cape Town, 2017. *Analytical Data and Approximate Distribution for Cape Town Drinking Water,* Cape Town: City of Cape Town.

5. City of Cape Town, 2018. *Water Outlook 2018 Report. Rev 25.,* Cape Town: City of Cape Town.

6. City of Cape Town, 2019. *Our Shared Water Future: Cape Town's Water Strategy,* Cape Town: City of Cape Town.

7. Department of Energy, 2011. *R.927: The Regulations on Licensing Sites for New Nuclear Intsallations.* Pretoria: Department of Energy.

8. Department of Water Affairs and Forestry, 1996. *Water Quality Guidelines,* Pretoria: Department of Water Affairs and Forestry.

9. Department of Water Affairs and Forestry, 2004. *Operational Policy for the Disposal of Land Derived Water Containing Waste to the Marine Environment in South Africa,* Pretoria: Department of Water Affairs.

10. Electric Power Research Institute, 2015. *Advanced Nuclear Technology:Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (Siting Guide).,* Concord: Electric Power Research Institute.

11. Eskom, 2010a. *Environmental Impact Assessment for the Proposed Nuclear Power Station ('Nuclear-1') and Associated Infrastructure. Freshwater Supply Specialist Report,* Johannesburg: Eskom.

12. Eskom, 2010b. *Environmental Impact Assessment for the Proposed Nuclear Power Station ('Nuclear-1') and Associated Infrastructure: Oceanography Specialist Report,* Johannesburg: Eskom.

13. Eskom, 2017. *Water Resources Plan for Nuclear Facilities at Thyspunt,* Johannesburg: Eskom.

14. Eskom, 2018. *Strategy for Improving Potable Water Resiliance at Koeberg Nuclear Power Station,* Cape Town: Eskom.

15. National Nuclear Regulator, 2016. *RG-0011: Interim Guidance for the Siting of Nuclear Facilities,* Centurion: National Nuclear Regulator.

16. Pisces Environmental Services, 2020. *Updated Baseline Status of Kelp and Jellyfish Along the South Western Cape Coast; Update of the Site Safety Report fro the Duynefontyn Site.* Cape Town: Pisces.

17. Republic of South Africa, 1998. *National Water Act, Act No. 36 of 26 August 1998,* Pretoria: Republic of South Africa.

18. South African Bureau of Standards, 2015. *South African National Standard for Drinking Water SANS 241-1-2015, Edition 2.,* Pretoria: South African Bureau of Standards.

19. SRK Consulting (South Africa), 2020. *Duynefontyn Site Safety Report Update, NSIP03858, Geohydrological Monitoring Annual Report March 2020.,* Cape Town: SRK Consulting (South Africa).

20. US Environmental Protection Agency, 2009. *Primary Drinking Water Standards for Bacteriological and Chemical Requirements,* Washington: EPA.