CHAPTER 4: SITE INVESTIGATION APPROACH

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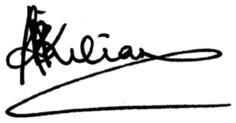
Author declaration:

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.



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I declare that this report has undergone independent peer review by myself, that comments were addressed to my satisfaction, and that as such, it is considered fit for publication.

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AMENDMENT RECORD			
Rev	**Draft**	**Date**	**Description**
0		04 June 2015	New chapter, replacing old KSSR Rev 0
1		29 September 2021	Chapter updated to reflect the latest information, address NNR comments on DSSR Rev 0 and to align with the latest template on structure and layout of Site Safety Reports.
1a		15 March 2024	Chapter updated to reflect the latest regulatory standards.

EXECUTIVE SUMMARY

This chapter presents a historical overview of how the Duynefontyn site was selected and the process that was followed to further characterise the site in support of the Periodic Safety Review and Long Term Operation of Koeberg Nuclear Power Station and to locate additional nuclear installation(s) for the purposes of generating electricity.

This chapter presents:

- a summary of the historical studies performed to select the site;
- motivation for the choice of the site to accommodate new nuclear installation(s);
- Studies performed to update the DSSR Rev 1 to address shortcomings identified by the NNR in their review of DSSR Rev 1 and in support of the Periodic Safety Review and Long Term Operation of Koeberg.

It covers the overall approach to the site investigation while the specific technical and detailed aspects on site characteristics (e.g. geology, seismology, demography) are presented in ***Chapter 5***.

A summary of the studies that culminated in the selection of the site for the Koeberg Nuclear Power Station is provided.

This chapter also describes the main activities that were carried out to reassess the site characteristics in support of the Periodic Safety Review and Long Term Operation of Koeberg and the expansion of the site for new nuclear installation(s).

Thus, the siting factors and criteria taken into consideration provided the necessary assurance that radiological doses and risks to the public and the environment will be acceptably low, that natural phenomena and man-made hazards can be appropriately accounted for and that the implementation of emergency plans and security measures are feasible.

CONTENTS

Page

TABLES

DRAWINGS

4 SITE INVESTIGATION APPROACH

4.1 Purpose

This chapter presents a historical overview of how the Duynefontyn site was selected and the process that was followed to further characterise the site in support of the Periodic Safety Review and Long Term Operation of Koeberg Nuclear Power Station (Koeberg) and to locate additional nuclear installations for the purposes of generating electricity.

The chapter presents:

- a summary of the historical studies performed to select the site;
- motivation for the choice of the site to accommodate new nuclear installation(s);
- Studies performed to update the DSSR Rev 0 (Eskom, 2016) to address shortcomings identified by the NNR during their review of the DSSR Rev 0 and in support of the Periodic Safety Review and Long Term Operation of Koeberg.

This chapter covers the overall approach to the site investigation while the specific technical and detailed aspects on site characteristics (e.g. geology, seismology, demography) are presented in ***Chapter 5***.

4.2 Regulatory Framework

The national legal and regulatory framework for the development of this SSR is presented in ***Chapter 2*** (Legal and Regulatory Basis). This chapter has been developed in line with the requirements as contained in The Regulations on Licensing Sites for New Nuclear Installations, R.927 (Department of Energy, 2011) published in terms of section 36 read with section 47 of The National Nuclear Regulator Act (Act No. 47 of 1999 (Republic of South Africa, 1999), viz:

“Regulation 5 (1) – A motivation for the choice of the site to ensure a low risk of public exposure from the operation of the nuclear installation(s);

“5 (3) The characteristics of the site relevant to the design assessment, risk and dose calculations, including inter alia:

(a) external events;

(b) meteorological data;

(c) land use;

(d) population demographics;

(e) regional development;

(f) projections of the above data commensurate with the design life of the nuclear installation(s)."

"5 (4) A source term analysis that is representative of the overall potential hazards posed to the public and the environment owing to the new nuclear installation(s). A representative scope of internal and external events enveloping the new nuclear installation(s) must be taken into consideration."

"5 (5) A Probabilistic Risk Assessment (PRA) using the site characteristics referred to in Regulation 5(3) and the source terms referred to in Regulation 5(4) to demonstrate compliance with the probabilistic risk limits. This analysis must include the impact of all nuclear installations and actions on the site, existing and proposed, for which authorizations have been granted by the Regulator."

"5 (6) An analysis of the Impact on the public due to normal operations of the new nuclear installation(s)…"

"5 (7) The identification and determination of emergency planning zones using the characteristics of the site, source term analysis and PRA established in accordance with Regulations 5(3), 5(4) and 5(5) respectively…"

"5 (8) An analysis to demonstrate the viability of an emergency plan taking into account relevant data established in accordance with Regulations 5 (3), 5 (4), and 5 (5), including disaster management infrastructure…"

"5 (9) An assessment on the suitability of the site, from a nuclear security perspective as determined by the NNR."

Further aspects considered in the development of this chapter and the SSR are contained in RG-0011, Interim Guidance on the Siting of Nuclear Installations (National Nuclear Regulator, 2016). In addition to the above-mentioned requirements, other aspects to be addressed include:

(a) Public and Environmental Analyses;

(b) Proposed arrangements for control of developments around a nuclear installation(s) site;

(c) Provision for the protection of non-human species; and

(d) Monitoring of site conditions.

4.3 International Guides

The following guides and other documentation were also consulted to provide useful points of reference:

Electric Power Research Institute Siting Guide on Site Selection and Evaluation Criteria for an Early Site Permit Application (Electric Power Research Institute, 2022);

United States Nuclear Regulatory Commission, General Site Suitability Criteria for Nuclear Power Stations, Regulatory Guide 4.7 (United States Nuclear Regulatory Commission, 2024);

United States Nuclear Regulatory Commission, Guide NUREG-1844 on Safety Evaluation Report for an Early Site Permit (ESP) at Exelon Generation Company. Example of a review of an ESP application to a nuclear regulator (United States Nuclear Regulatory Commission, 2006).

International Atomic Energy Agency (IAEA) Specific Safety Requirements SSR-1, Site Evaluation for Nuclear Installations (International Atomic Energy Agency, 2019).

International Atomic Energy Agency Nuclear Energy Series No. NG-T-3.7, Managing Siting Activities for Nuclear Power Plants (2012) (International Atomic Energy Agency, 2022);

International Atomic Energy Agency Safety Standards, Specific Safety Guide No. SSG-35, Site Survey and Site Selection for Nuclear Installations (International Atomic Energy Agency, 2015);

Electric Power Research Institute Siting Guide on Site Selection and Evaluation Criteria for an Early Site Permit Application (Electric Power Research Institute, 2022) and IAEA SSG-35 (International Atomic Energy Agency, 2015) establishes requirements for the siting process. It provides recommendations and guidance on establishing a systematic process for site survey and site selection for a number of preferred candidate sites, from which one could be selected for the construction and operation of a nuclear installation.

IAEA SSR-1 (International Atomic Energy Agency, 2019) establishes requirements for site evaluation for nuclear installations, in order to meet the fundamental safety objective.

In accordance with SSR-1, the safety objective in site evaluation for nuclear installations shall be to characterise the natural and human induced external hazards that might affect the safety of the nuclear installation, in order to provide adequate input for demonstration of protection of people and the environment from harmful effects of ionising radiation. The scope of site evaluation encompass factors relating to the site and factors relating to the interaction between the site and the installation(s), for all operational states and accident conditions, including accidents that could warrant emergency response actions. In determining the scope of site evaluation, a graded approach is applied commensurate with the radiation risk posed to people and the environment.

4.4 Approach Adopted for the Motivation of the Site and the Demonstration of Site Suitability

The two processes relating to the safety considerations for a site of a nuclear installation(s) are the siting process and the site evaluation process.

Siting is the process of surveying and selecting a suitable site for a nuclear installation(s). The selection of a suitable site is one of the elements of the concept of defence in depth for preventing and mitigating accidents as stated in principle 8 of IAEA Safety Fundamental Principles, SF-1 (International Atomic Energy Agency, 2006) that “All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.”

The siting process for a nuclear installation is divided into two stages:

- Site survey, in which candidate sites are identified after the investigation of a large region and the rejection of unsuitable sites;
- Site selection, in which the candidate sites are assessed by screening, evaluation, comparison and ranking on the basis of safety and other considerations to select one or more preferred candidate sites.

In South Africa, the siting process is not regulated and no nuclear installation licence is required but it is conducted in consultation and with input from the relevant stakeholders which include regulatory authorities, government departments and local authorities.

Following the siting process, the suitability of the site is then confirmed in the site evaluation process through detailed investigations and studies resulting in the characterisation and derivation of site related design bases for the nuclear installation(s).

Site evaluation continues throughout the operating lifetime of the installation, to take into account changes in site characteristics, the availability of information, operational records, regulatory approaches, evaluation methodologies and safety standards. If the site related design parameters are changed during the operational stage, re-evaluation of and upgrades to the installation during operation may consequently be necessary.

The site evaluation studies and investigations as well as the results are reported in the DSSR (***Chapters 5***, ***6***, ***7***, ***8*** and ***9***), which, in accordance with Regulation on Licensing of Sites (Department of Energy, 2011), is submitted to the National Nuclear Regulator (NNR) in support of a Nuclear Installation Site Licence. In accordance with RG-0011 (National Nuclear Regulator, 2016), the DSSR also forms part of the safety case that is submitted to the NNR in support of Koeberg's Periodic Safety Review and Long Term Operation Application.

4.4.1 Motivation for the Choice of the Duynefontyn site – Investigated Areas

Studies for the selection and qualification of a suitable nuclear site in the Western Cape were carried out in the 1960s and 1970s (Eskom, 1966). The Western Cape was prioritised at that time since 88 per cent of South Africa's power was generated in Mpumulanga close to the coalfields, necessitating long and vulnerable transmission lines to the coast resulting in the loss of approximately 30 per cent of the power transported. This, coupled to the large amounts of cold cooling water required by nuclear power stations made the west coast an obvious choice for siting a nuclear power station.

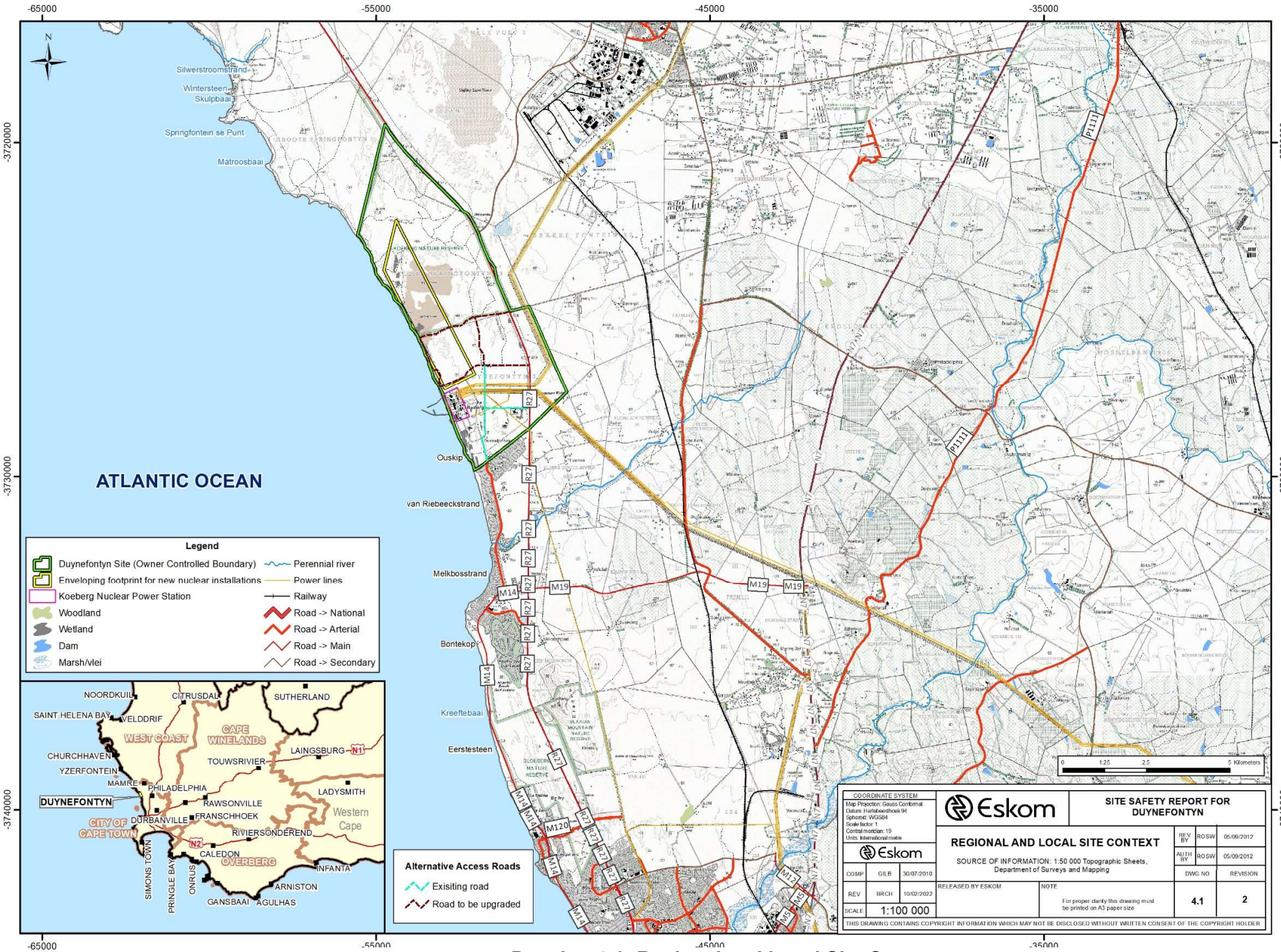
A number of areas along the west coast, north of Cape Town were considered which culminated in the selection of the Duynefontyn (previously known as Koeberg) site for the Koeberg Nuclear Power Station. Key drivers in the original site selection were:

- the geological stability of the Duynefontein area;
- accessibility of cold cooling water from the Atlantic Ocean;
- proximity to Cape Town for easy access to transport and harbour facilities for the delivery of heavy equipment, materials and nuclear fuel;
- availability of local labour;
- ease of integration into the national grid;
- the site appeared to fit well into the schemes of the Department of Planning and the Cape Divisional Council at that time;
- economic considerations;
- close to load centre;
- seismology;
- safety considerations (Electricity Supply Commission, 1973)
    - Population distribution
    - Radiation dose

  The Atomic Energy Board (AEB), currently the South African Nuclear Energy Corporation (Necsa), provided guidance in the form of exclusion and population centre distances at that time. It also defined the allowable population distributions in terms of the magnitudes of the likely radioactivity releases in reactor accidents and their estimated probabilities of occurrence. A staged licensing approach was followed and the granting of each stage was conditional upon prior satisfactory review by the AEB of relevant information (Atomic Energy Board, 1971).

A licence application for the use of the site was done under the South African Nuclear Installations (Licensing and Security) Act, 1963 (Act No. 43 of 1963) (Republic of South Africa, 1963), later replaced by the Atomic Energy Act, 1967 (Act No. 90 of 1967) (Republic of South Africa, 1967), which stated that no site may be “used” for a nuclear installation without a licence issued by the AEB. Hence, the ultimate criterion for site acceptability was AEB approval.

A permit to produce nuclear energy was issued under Section 3 of the Atomic Energy Act (Atomic Energy Board, 1977). Construction started in 1979 and Unit 1 was commissioned in April 1984 and Unit 2 in July 1985. The history of safe operation of the Koeberg since 1984 provides unique supporting evidence in respect of site suitability. The regional and local site context is shown in **Drawing 4-1**.



Drawing 4-1: Regional and Local Site Context

4.4.2 Investigated Areas and Characteristics

In accordance with IAEA SSR-1 (International Atomic Energy Agency, 2019), the suitability of a site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation. This SSR is for the reassessment of the suitability of the site.

The main stages followed in the development of this SSR include:

- evaluation of the safety requirements and criteria for siting of nuclear installations at national level applicable to a proposed site (see ***Section 4.4.1*** above);
- collection and analysis of existing available information for the proposed site - This included key historical information which was reviewed, analysed and taken into consideration in the preparation of this SSR, including:
    - report on preliminary site investigations (Eskom, 1966);
    - the DSSR Rev. 0 (Eskom, 2016);
- performance of complementary measurements, studies, monitoring and analysis;
- identification of uncertainties and further work required in support of the Periodic Safety Review and Long Term Operation of Koeberg and prior to or during construction and operation of a new nuclear installation(s).

The main activities carried out to reassess site characteristics in support of the Periodic Safety Review and Long Term Operation of Koeberg and the expansion of the site for new nuclear installation(s) included the following:

- update of the baseline ecological studies of the site and immediate surrounds (***Chapter 5.3***);
- updated surveys of the demography, land and water use, adjacent sea use and nearby transportation, industrial and military facilities within an 80 km radius of the site centroid (see ***Chapters 5.4***, ***5.5***, ***5.6*** and ***5.7***);
- update of meteorological information incorporating the extended meteorological monitoring programme (see ***Chapter 5.8***);

- update of the oceanographic information with additional oceanographic measurements and detailed numerical modelling studies and a conceptual engineering design for new nuclear installation(s), including an updated and expanded Tsunami Hazard Analysis (THA) (see ***Chapter 5.9***);

- update of the baseline hydrological studies of the site and surrounding quaternary catchments to assess storm water, hydraulics and flood lines (see ***Chapter 5.10***);

- update of geohydrological data incorporating the additional testing and monitoring programmes (see ***Chapter 5.11***);

- updated evaluation of local and regional water resources and desalination of sea water for freshwater supply to the site (see ***Chapter 5.12***);

- geological mapping and seismic monitoring of the site and the surrounding area (see ***Chapters 5.13*** and ***5.14***) at the site region (≤320 km), site vicinity (≤40 km), site area (≤8 km) and site location (≤1 km) scale; characterisation of the seismic hazard for the site, that follows an enhanced Senior Seismic Hazard Analysis Committee (SSHAC) Level 2 process, which cover geological investigations aimed at providing input data to the PSHA study;

- In addition to the geotechnical characterisation that was done in support of DSSR Rev 0, additional intrusive investigations, extending the geotechnical model across the Nuclear-1 footprint and obtaining soil samples for density testing (new and old core) to update the geotechnical characterisation, concentrating on identifying geotechnical hazards, such as landslides, ground collapse, differential settlement and soil liquefaction potential. Other data to be obtained from the Duynefontyn PSHA SSHAC team include Multi-Channel Analysis of Surface Waves (MASW) and downhole/cross hole Vs measurements, and seismic refraction and reflection surveys (onshore and offshore) which have been included (see ***Chapter 5.15***).

- analysis of the above data to show that the site meets the requirements of sections 5 (3), (4), (5), (6), (7), (8) and (9) of the Regulations on Licensing of Sites (Department of Energy, 2011) including applying a graded approach to sections 6.6.3, 7, 8, 9, 10 and 11 of RG-0011 (National Nuclear Regulator, 2016);

- performance of ongoing measurements/monitoring and analyses

that will continue in the future for confirmatory or other purposes. These measures include monitoring of parameters related to the following (see ***Section 5.2*** of this SSR):

- groundwater;
- seismology;
- oceanography;
- meteorology;
- corrosion.

- conclusions on compliance with the safety requirements and criteria for siting of nuclear installations.

On the basis of the results of the above investigations and analyses for the site performed to date, the following has been identified and presented in this SSR:

- the site characteristics (and any evolution of such over time) that support the Koeberg Periodic Safety Review, Long Term Operation and expansion for the establishment of a new nuclear installation(s) (***Chapter 5***);
- critical/important features and characteristics and identification of actions needed prior to and post-construction of a new nuclear installation(s), e.g. additional monitoring;
- a probabilistic risk assessment of external events and their importance to safety, e.g. flooding (inter alia storm surges, tsunamis, sea level rise) and seismic hazard (***Chapter 6***);
- potential radiological impact on the public and the environment (***Chapter 7***);
- feasibility of emergency planning (***Chapter 8***);
- physical protection and security (***Chapter 9***);
- areas of uncertainty that can be addressed with additional design measures (all chapters/sections and ***Chapter 11***).

Details of the approaches followed and the results for each field of study are contained in ***Chapters 5*** to ***9*** of this SSR.

4.4.3 Environmental Authorisations

Eskom envisages the construction of a new nuclear installation(s) at the Duynefontyn site. In 2006 an environmental impact assessment (EIA) process was initiated to identify a suitable site for the new nuclear installation(s), called Nuclear-1 with a nominal capacity of 4 GWe. Five possible sites were identified (Bantamsklip, Brazil, Duynefontyn, Schulpfontein and Thyspunt) with three (Bantamsklip, Duynefontyn and Thyspunt) being studied in more detail. In 2017, Eskom was granted an Environmental Authorisation by the Department of Environmental Affairs for the Dynefontyn site, subject to appeals (Department of Environmental Affairs, 2017).

4.5 Operating Experience

On 11 March 2011, a 9 magnitude earthquake, followed by a 15 m tsunami, heavily damaged the nuclear power reactors at Japan's Fukushima Daiichi facility. Following this accident, regulators required significant enhancements to nuclear power plants. These included: adding capabilities to maintain key plant safety functions following a large-scale natural disaster; new equipment to better handle potential reactor core damage events; strengthening emergency preparedness capabilities and in the case of site evaluations, updating evaluations on the potential impact from seismic and flooding events. Internationally licensees (operators) were requested to reanalyse potential flooding and seismic effects based on advances in the knowledge and understanding of seismic and flooding hazards. These re-evaluations used updated information and methodologies to inform plant operators of potential impacts to their sites. As such Koeberg has changed the approach used to update the tsunami hazard analysis (THA) and the seismic hazard analysis for the site, the details of which are given in ***Chapters 5.9*** and ***5.14*** of this SSR.

Other changes to requirements included consideration of the credible combinations of natural and human induced external events that could affect the safety of nuclear installations on the same site or on adjacent and nearby sites, the details of which are given in ***Chapter 6*** of this SSR.

4.6 Management System

The site investigation approach undertaken for this SSR entailed the following:

- desk studies;
- site reconnaissance;
- detailed site investigations;
- data analysis, computer-based modelling and reporting;
- peer reviews.

A quality assurance programme was established to control the effectiveness of the evaluation and the formulation of conclusions on the site selection. This conforms to the overall management system for this SSR, which is described in detail in ***Chapter 10*** (Management System), siting regulations, NNR requirements documents and international guidelines (***Sections 4.2*** and ***4.3***) and relevant Eskom classification procedures.

All studies carried out and reports produced for this SSR have been rigorously reviewed by selected peer reviewers who are leading experts in their fields. Further reviews have been carried out by a technical writer who has extensive nuclear licensing experience.

Electronic records of the work carried out are stored in a secure central repository with regular off-site back-up procedures. The overall quality management system complied with that set out in ***Chapter 10***. All references cited are saved on the central repository.

Compliance with regulatory requirements is indicated in ***Table 4-1*** below. This is for the overall SSR as compliance per se is not demonstrated within this chapter.

Table 4-1: Regulatory Compliance Matrix

Act/Regulation	Regulation	Issue	Chapter/Section in this SSR where covered
Regulations on Licensing of Sites (Department of Energy, 2011)	5 (1)	A motivation for the choice of the site	4
	5 (3)	Characteristics of the site relevant to design assessment, risk and dose calculations	5, 6, 7 and 8
	5 (4)	Source term analysis	7 and 8
	5 (5)	Probabilistic risk assessment	6
	5 (6)	Impact on the public	7
	5 (7)	Emergency planning zones	8
	5 (8)	Viability of emergency plan	8
	5 (9)	Site security	9
Regulatory Guide RG-0011, Interim Guidance on the Siting of Nuclear Facilities (National Nuclear Regulator, 2016)	Attachment B: Typical Content and Structure of a Site Safety Report	4. Site Investigation Approach	4
		4. Site Investigation Approach • monitoring programme	5.2

4.7 Conclusions

In conclusion, it can be stated that the site selection and investigation approach for this SSR has been carried out in accordance with the requirements of the Regulations on Siting of New Nuclear Installations (Department of Energy, 2011) and the Interim Guide on Siting of Nuclear Installations (National Nuclear Regulator, 2016). It has been carried out to the required level of detail and quality by suitably qualified experts and has been thoroughly peer reviewed, both internally and externally. The approach adopted indicates compliance with the regulatory requirements and international best practice.

Key site characteristics are covered in ***Chapter 5***, external events in ***Chapter 6***, potential radiological impact on the public and environment in ***Chapter 7***, emergency planning in ***Chapter 8***, physical protection and security in ***Chapter 9***, with conclusions and management of uncertainties and any open items in ***Chapter 11***. This work supports the Periodic Safety Review and Long Term Operation of Koeberg and the extension of the site for additional nuclear installations to be built, increasing the capacity from the currently licensed 2 200 MWe (KNPS) to the proposed maximum of 6 200 MWe (KNPS + New Nuclear Installation(s)). There are no known planned future developments in the surrounding area that might impact negatively on the site.

The siting factors and criteria that were taken into consideration thus provide the necessary assurance that the radiological doses and risks to the public and the environment will be acceptably low, that natural phenomena and man-made hazards can be appropriately accounted for and that implementation of emergency plans is feasible (Department of Energy, 2011).

4.8 References

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