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Revisions

This document has been revised according to the following schedule:

Revision	Date Approved	Nature of Revision	Prepared by
00	17 April 2020	First Issue	E Raubenheimer
01	2 March 2023	Document number changed from NLM-PRO-00154 to NLM-PRO-00171. Addressed NNR comments in NIL04B0180	L Hordijk
02	See title page	Reviewed based on detail design and latest SAR. Addressed NNR comments in NIL04B0189 (updated Table 1)	L Hordijk

Contents:

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide the general public with background information in order for the National Nuclear Regulator (NNR) to determine the necessity to hold a Public Hearing for the planned second extension of the Necsa Pipestore Facility (TPS) on Thabana. Thabana is a licenced storage facility (NIL-04, Variation 0) for radioactive waste and includes chambers, bunkers, trenches, drum stores and also the TPS. The purpose of the Public Information Document (PID) is to provide members of the public with sufficient information regarding the application for authorization to enable meaningful public participation in the NNR authorization process. The distribution of the PID also presents the NNR with an opportunity to demonstrate its role in the radiological protection of the public and the environment. This document has been prepared based on the NNR document RD-013 [2] which prescribes a PID for new authorisations.

1.2 DEFINITIONS AND ABBREVIATIONS

1.2.1 DEFINITIONS

SAFARI-1 spent fuel:	For the purpose of this document, referring to SAFARI-1 spent fuel includes both spent fuel elements and spent control rod assemblies.
Thabana:	The crest of a hill at Necsa containing various licenced facilities for the storage of a range of radioactive waste types.
NTP U residue	Residue containing uranium and aluminium resulting from the production of the medical isotopes at NTP, when the target plates are dissolved. This material is packaged inside a LTS container. This material is also referred to as NTP Uraniferous Waste.

1.2.2 ABBREVIATIONS

ALARA:	As Low as Reasonably Achievable
BEVA:	BEVA site is part of the Pelindaba West Site (fuel fabrication area)
Bq:	Becquerel - Unit of radioactivity
COHWHS:	Cradle of Humankind World Heritage Site
DFFE:	Department of Forestry, Fisheries and Environment,
DMRE:	Department of Mineral Resources and Energy
DPTE:	Double Porte pour Transfer Etaché
ECC:	Emergency Control Centre
EIA:	Environmental Impact Assessment
EIR:	Environmental Impact Report (or specialist study report)

EPZ:	Emergency Planning Zone
Fuel	SAFARI-1 spent fuel and fuel elements
g:	The acceleration of gravity - 9.8 (m/s^2)
GDF:	Geological Disposal Facility
HCC:	Hot Cell Complex
I&AP's:	Interested and Affected Parties
IAEA:	International Atomic Energy Agency
IBR:	Inverted Box Rib (roof sheeting)
IMS:	Integrated Management System
LS&A:	Licensing Services and Analysis
LTS:	Long Term Storage
mSv:	MilliSievert - one thousandth of a Sv
MTR:	Materials Testing Reactor
NECSA:	South African Nuclear Energy Corporation Limited
NLM:	Nuclear Liabilities Management department (now WM)
NNE:	North-North-East
NNR:	National Nuclear Regulator
NNW:	North-North-West
NTP:	Nuclear Technology Products
OHS:	Occupational Health and Safety
OTIA:	Oliver Tambo International Airport
OTS:	Operating Technical Specification
PDO:	Predisposal Operations
PGA:	Peak Ground Acceleration
PPE:	Personal Protective Equipment
PWR	Pressure Water Reactor
QA:	Quality Assurance
QC:	Quality Control
QMS:	Quality Management System
RP:	Radiation Protection
RPO:	Radiation Protection Officer
RS:	Richter Scale (measurement of earthquake magnitude)
SABC:	South African Broadcasting Corporation
SAFARI-1:	Research Reactor at Necsa
SAR:	Safety Assessment Report
SHEQ:	Safety, Health, Environment and Quality
SHEQ-INS:	SHEQ-Instruction documents
Sv:	Sievert (radiation dose unit)
TPS:	Thabana Pipe Store
µSv:	MicroSievert- one millionth of a Sv
WM	Waste Management department (previously NLM)

1.3 General Background Information

The TPS facility is currently used for the interim storage of spent nuclear fuel (intermediate to high level radioactive material) from the SAFARI-1 research reactor. This facility is NNR authorised for the: acceptance, dry storage, internal handling and transfer, and transfer to other authorised facilities of SAFARI-1 spent fuel [1]. The TPS became operational in 1997 and was already extended in 2007 to accommodate more storage pipes for SAFARI-1 spent fuel. This NNR authorisation request will therefore be for the second extension of the facility. The TPS stores the SAFARI-1 spent fuel elements and the intention is to retrieve and remove the spent fuel sometime in the future when the final option for disposal or further storage at a centralized national facility has become a reality.

The current allocated storage space for the SAFARI-1 spent fuel was exhausted in 2022. Other spent fuel is currently, as per SAFARI-1 Nuclear Installation License, stored in the reactor pool. Further storage space at the Thabana Pipestore is therefore required, which will require an extension of the storage capacity for the continuous operation of the SAFARI-1 research reactor. Without this extension SAFARI-1 will not be able to continue normal operations e.g. for the production of medical isotopes, research and training within the nuclear energy field. Necsa supplies a wide range of innovative hi-technology products and services to South Africa and the foreign market sectors with the SAFARI-1 reactor as the cornerstone of the NTP commercial isotope production market. NTP produces Molybdenum-99 and Iodine-131 isotopes required for over 100 000 different medical procedures e.g. used to detect cancer and other diseases. For this reason, Necsa intends to extend the facility to accommodate 48 additional storage pipes for SAFARI-1 spent fuel and also now 36 storage pipes for uranium residue from the Hot Cell Complex (HCC) at Nuclear Technology Products (NTP). This additional storage capacity will provide sufficient storage capacity for all the fuel elements and uranium residue which is foreseen to be generated when the SAFARI-1 reactor is at least operated until 2035.

The existing facility will be extended by a maximum of 11.84 m x 12.49 m (W x L) to the north of the site (HCC waste pipes) and by 11.84 m x 15.78 m (W x L) to the south of the site (SAFARI-1 waste pipes). The overall development footprint will be approximately 335 m^2.

An option study [3] showed that the extension of the facility would be the most suitable option for the further management of the SAFARI-1 spent fuel and uraniferous material. Another study [4] concluded that to extend the facility to the north and south, as described above would optimize the extension according to the various optimization criteria that has been used.

An official Environmental Impact Assessment (EIA) process was registered with the Department of Forestry, Fisheries and Environment (DFFE) for the TPS extension. The public participation process had commenced in October 2019 with invitations to the public and existing Necsa stakeholders to register as Interested and Affected Parties (I&AP's) for the EIA process. This process has been completed and DFFE issued Necsa with an Environmental Authorisation for the extension of the Necsa Pipe Storage Facility for SAFARI-1 Spent Fuel and NTP Uraniferous Waste [14].

Some of the most important documents relevant to this report are listed in Section 9.0 (References).

1.4 SUMMARY OF THE TPS AND ITS INTENDED EXTENSION

The TPS was commissioned in 1997 and is currently composed of two sections, one section for the SAFARI-1 spent fuel, and the other for waste from the HCC (historic Necsa PWR fuel testing program). The section for waste originating from the fuel testing program (HCC) was never used, and never authorised by the NNR for use. Necsa does not intend to use these storage pipes. Additional and new storage pipes will now be installed to accommodate for the storage of additional SAFARI-1 spent fuel and uraniferous material from NTP for the first time, respectively.

The Thabana Pipestore is located within the Thabana Complex at Pelindaba East, and is a dry storage facility for spent fuel from SAFARI-1 research reactor. The facility basically consists of storage pipes (pipes below ground level) and the facility building above ground (Figure 1). The primary function of the building is to provide protection and shelter for the storage pipes. It protects the storage pipes and auxiliary systems against adverse weather and environmental conditions.

A storage pipe consists of a borehole casing and a leak proof stainless steel storage vessel of 125 mm inside diameter (SAFARI-1 spent fuel) and 250 mm inside diameter (NTP uraniferous material) which positions vertically inside a borehole of just deeper than 17 m. The borehole casing consists of mild steel and it provides the cylindrical space for the storage vessel to fit into. Fibre cement linings between the casing and the storage vessels neutralize the possible formation of nitric acid that could be formed by radiolysis.

The current section of the store currently used for the storage of SAFARI-1 spent fuel consists of 60 storage pipes, of which each pipe can hold 20 spent fuel assemblies. Of the 60 storage pipes 30 were commissioned in 1997 and another 30 was commissioned in 2007 during the first extension of the facility. An additional 48 storage pipes will be installed for the storage of additional SAFARI-1 spent fuel. The 36 storage pipes, which will now be prepared for the NTP uraniferous material will each, hold 32 LTS (Long Term Storage) containers.

The items are stored in a corrosion neutral atmosphere, by ensuring that the storage vessel is filled with an inert gas atmosphere (helium/argon mixture). The construction and installation of the 36 pipes to store NTP Long Term Storage (LTS) containers (containing the uraniferous material) have the same original design and configuration as for the existing SAFARI-1 storage pipes, only having a larger internal diameter to accommodate the storage vessel.

The whole facility and content is under nuclear safeguards control. Thus close control is applied by the Nuclear Safeguards department and the International Atomic Energy Agency (IAEA) to ensure no items are added or removed from the facility in an uncontrolled fashion.

Figure 1, Figure 2 and Figure 3 are photos of the TPS during and after the first extension in 2007 (an exposed SAFARI-1 storage vessel and its emplacement into a borehole).

Figure 1: The completed TPS after the 2007 extension. Light green is the original facility and dark green is the 2007 extension

Figure 2: Emplacement of a new SAFARI-1 storage vessel into a borehole during 2006/7 extension

Figure 3: A new SAFARI-1 storage vessel being lowered into a borehole during the 2006/7 extension

1.5 *INTERNATIONAL TRENDS IN STORAGE OF SPENT RESEARCH REACTOR FUEL*

According to research conducted by the IAEA [5] and earlier IAEA publications it has become clear that storage expansion and or auxiliary interim storage construction is an important step to keep many research reactors in operation. Currently, the only final options for this type of spent fuel is either reprocessing or direct disposal in a deep Geological Disposal Facility (GDF). None of these options are yet available in South Africa. The majority of fuel and uranium residue to be stored at TPS would be low enriched material. The IAEA also recognises that sending spent fuel abroad for reprocessing will be technically difficult (due to stringent transport regulations) and prohibitively expensive.

Many countries with research reactors have in the past sent their spent fuel back to the countries where the fuel originated from which were mostly the USA and the former Soviet Union. However, this window of opportunity has now mostly been closed and a country without nuclear power programmes has to address this themselves.

Wet storage of fuel in at-reactor pools is the most commonly used storage option for the IAEA member states. However, for long term storage of aluminium clad MTR fuels (such as SAFARI-1) for periods exceeding 30 to 40 years, dry storage is considered preferable due to the known instability of aluminium in water. The IAEA's experience with dry storage of spent fuel from research reactors include facilities such as dry-wells, vaults, hot-cells, concrete channels, vertical concrete canisters and various casks. Inert gas atmospheres (such as with the TPS) has been used in some of these designs.

The TPS has been safely and securely operated for more than 20 years and the option study [3] confirmed that the extension of the TPS will be the most suitable storage option for new SAFARI-1 spent fuel and uraniferous material produced by Necsa.

2.0 APPLICANTS INFORMATION

Name:	The South African Nuclear Energy Corporation Limited
Physical Address:	Elias Motsoaledi Street (Church Street West Extension)
	R104 Pelindaba, Madibeng District, North West, 0240
Company Registration no:	2000/003735/06
Date of incorporation:	24 February 2000
Registered Postal Address:	P.O. Box 582
	Pretoria
	0001
Address of Facility:	Pipe Store Facility on Thabana, Pelindaba East Site

Necsa is wholly owned by the state. The Thabana Pipe Store Facility is managed by the Waste Management Department (WM) of Necsa, which puts it under full state ownership and control. No foreign involvement or control.

Necsa has two subsidiaries namely NTP (Nuclear Technology Products Radioisotopes SOC Ltd) and Pelchem SOC Ltd.

3.0 FACILITY DESCRIPTION [6]

3.1 GENERAL DESCRIPTION OF THE FACILITY

The TPS facility including the intended TPS extension is located on the Thabana radioactive waste storage complex as is shown in Figure 4 below.

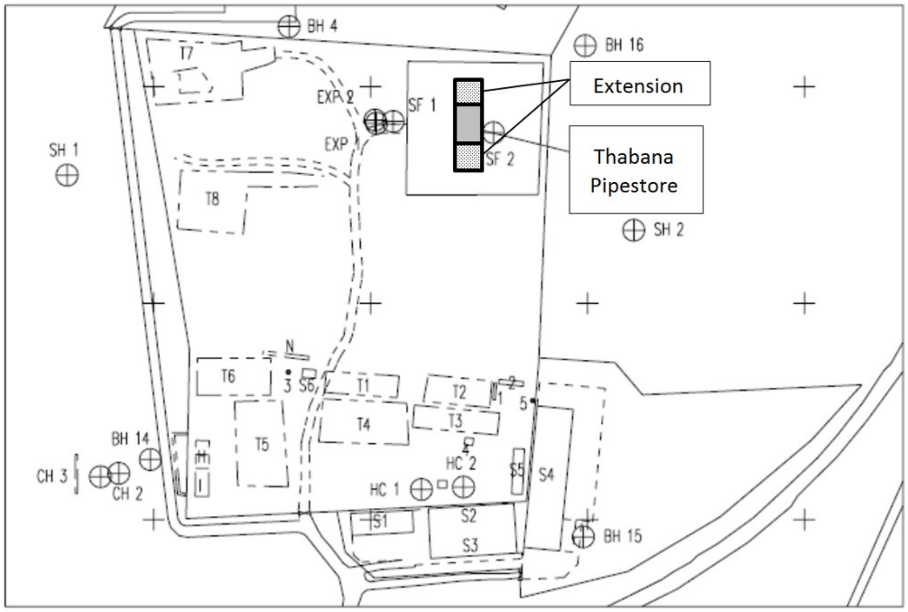

Figure 4: Location of the TPS on Thabana also showing the extension areas and other storage facilities

The current facility layout and extended layout is shown in Figure 5 and Figure 6. An emergency exit door is located at the southern end of the Pipe Store for use by personnel working inside the facility. The side view of the facility is shown in Figure 7. Storage pipes extend down to approximately 17 meters below the ground and are at a 1.5-meter centre distance from each other. The TPS building is more than 7 meters high.

Various geological and hydrogeological investigations [4] concluded that the static water level is approximately 60 meters below the Thabana Pipestore site. This leaves at least 40 meters of unsaturated rock between the bottom of the SAFARI-1 storage vessels (approximately 17m deep) and the water level. The gradient of the water level is approximately 1:10 to the north of the site.

The extended facility will accommodate 48 additional storage pipes for SAFARI-1 spent fuel and 36 storage pipes for the NTP U-residue. The layout and storage pipe design for the additional spent fuel storage vessels are exactly the same as the existing storage configuration and dimensions. However, the diameter of the storage pipes for the NTP LTS containers is larger than that of the SAFARI-1 storage pipes. The layout/pitch between these storage pipes will be the same as those for the spent fuel. The new SAFARI-1 storage pipes will be installed to the Southern side and the NTP U-residue storage pipes to the northern side of the Thabana Pipestore, see Figure 6.

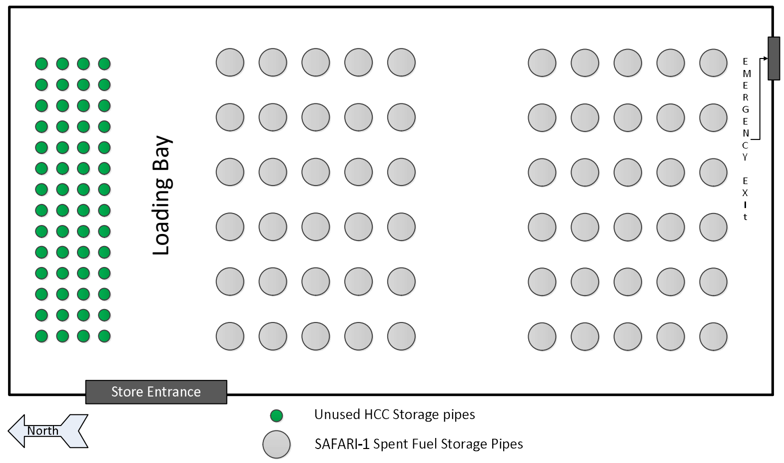

Figure 5: Existing TPS layout

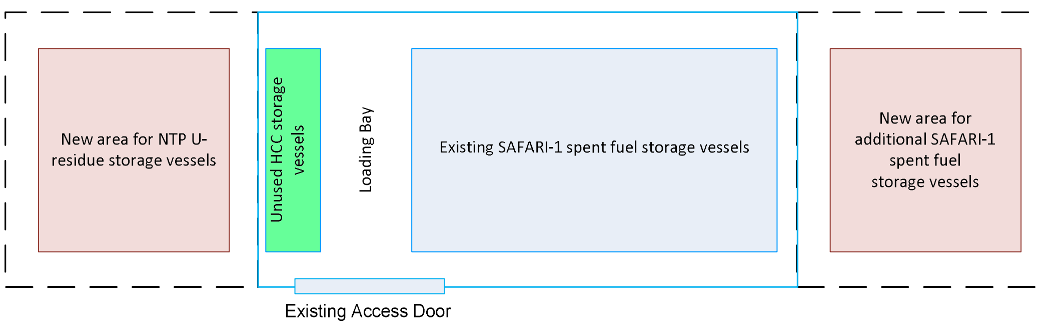

Figure 6: Layout of the TPS expansion

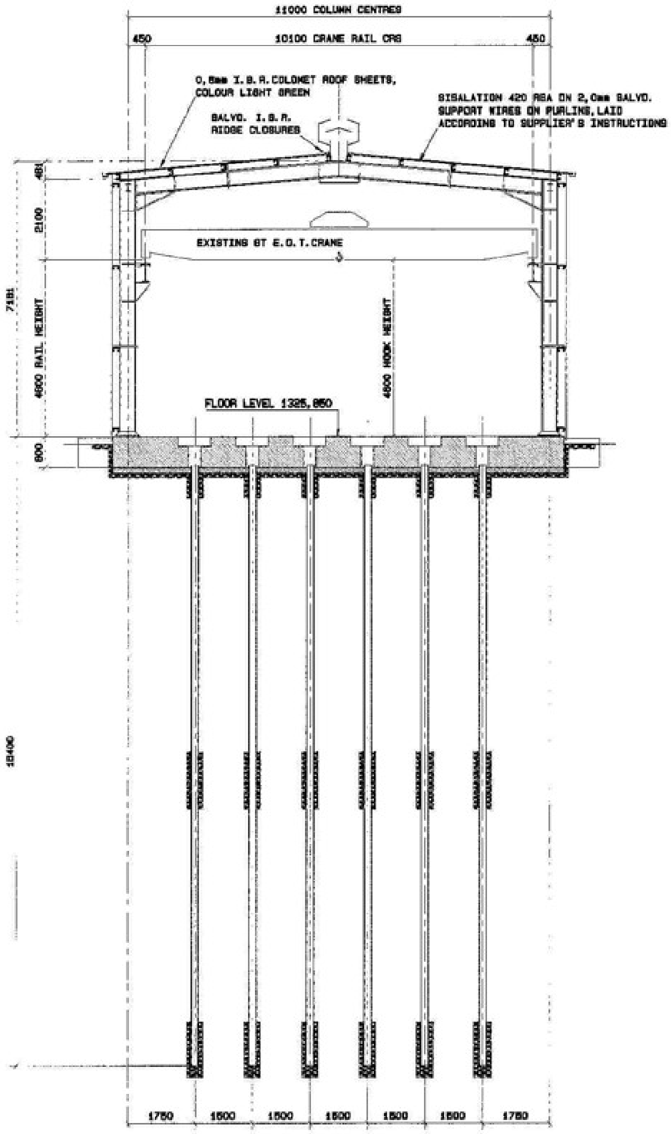

Figure 7: Sectional view of the TPS showing the portions above and below floor level

3.2 *Facility Structure*

The sides and the roof of the existing building are clad with IBR profiled sheeting to provide shelter for the storage vessels and equipment, protecting the store from natural elements (rainwater, wind and heat from sunlight). Access into the building is via the main loading/vehicle access doors located between the unused HCC storage pipes and the SAFARI-1 storage vessels. An emergency personnel exit door is located at the building end furthest from the loading bay. Both access doors are controlled by a lockout procedure to prevent unauthorized entry into the store. The same design is used for the structure required for the extended sections of the facility.

Vertical columns of the building frame support an 8 ton double girder electric bridge overhead crane. This crane will be extended to both the northern and southern extension sections.

Air circulation inside the Thabana Pipestore building is by natural convection. Air inlet is through fixed inlet louvers at the front and back of the store (close to the floor). Air exits the store at the top through a static ventilator that runs over the length of the building. The ventilator is equipped with bird guards.

3.3 Storage Pipe Structure

The structure of the current storage pipes consists of various components discussed below and shown in Figure 8 and Figure 9.The same design will be used for all the new storage pipes:

- Borehole: a vertical hole drilled to a depth of just deeper than 17m (about 18m).
- Borehole casing: this is a casing that is installed to keep the borehole sides from collapsing and is installed just after the borehole is drilled.
- Fibre cement pipe: This is installed between the borehole casing and the storage vessel to neutralize possible formation of nitric acid (HNO_3) that might form by radiolysis.
- Storage vessel: this is where the LTS containers or SAFARI-1 spent fuel assemblies are stored in and forms the primary containment of stored spent fuel or NTP U-residue. The storage vessel will be filled with inert gas under positive pressure and thus is air tight.
- Spring: a spring is installed at the bottom of the storage vessel to absorb the impact of an accidental falling SAFARI-1 spent fuel assembly or LTS container.
- Pipe plug: a cylindrical pipe plug is placed inside the top section of the storage vessel to provide radiation shielding. A spiral tube runs through the lead-filled plug to allow gas flow during evacuation and pressurizing of storage vessel.
- Lead seal: the lead seal provides shielding in the space between the concrete slab and the storage vessel.
- Pedestal: the pedestal is installed to support the storage vessel and provide a flat surface for the lead seal to rest on.
- Flange and gasket: this provides a vacuum tight seal of the storage vessel. The flange has a threaded hole for equipment fittings which enables the pressurization of the storage vessel with a helium/argon mixture.
- Valve and fitting assembly (installed on the flange): this enables the pressurizing and routine pressure checking of the storage vessel with inert gas. The fittings include a manual valve, a pressure gauge and a vacuum flange. All connections between these components are helium tight connections and prevent leaking of any gas from the storage vessels.
- Blinding: a cement layer on the in-situ soil to allow the installation of the concrete.
- Concrete slab: this provides additional shielding from radiation.

- Anti-tamper cover: A steel protection/anti-tamper plate on which an IAEA seal can be installed. This is a safeguards requirement and will detect if any tampering took place into the storage vessel without IAEA knowledge.
- Floor plate: The floor plate is a cover over the borehole to provide a level floor cover of the hole in the concrete floor.
- The top of the storage vessel, including the concrete floor around it, are compatible with the applicable transfer cask and or adaptor. This is used during the placement and retrieval of SAFARI-1 spent fuel or LTS containers.
- Interface: (not indicated in Figure 9) Provide shielding during the loading / retrieval operations of LTS containers.

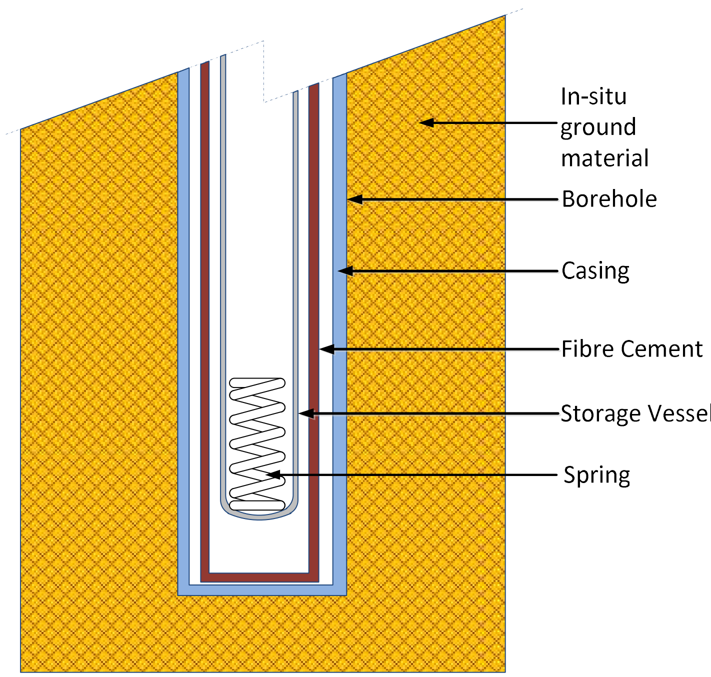

Figure 8: Schematic diagram of the borehole bottom components

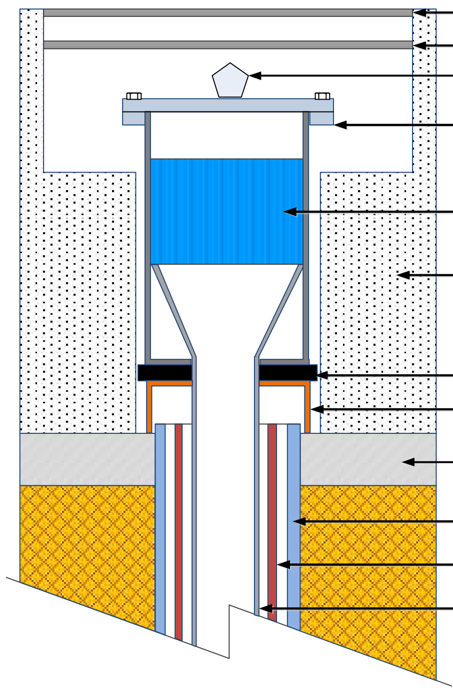

Figure 9: Schematic diagram of the top part of the borehole components

3.4 SAFARI-1 SPENT FUEL AND LTS CONTAINER

This section provides an overview of the design of the SAFARI-1 Spent Fuel basket and the LTS container for NTP waste. These are the final items stored inside the Thabana Pipestore.

3.4.1 SAFARI-1 SPENT FUEL AND BASKET

<u>Spent Fuel Transfer Basket</u>

The transfer basket is manufactured from aluminium and allows for easy handling of the cropped SAFARI-1 spent fuel assemblies (refer to Figure 10 for illustration of the basket).

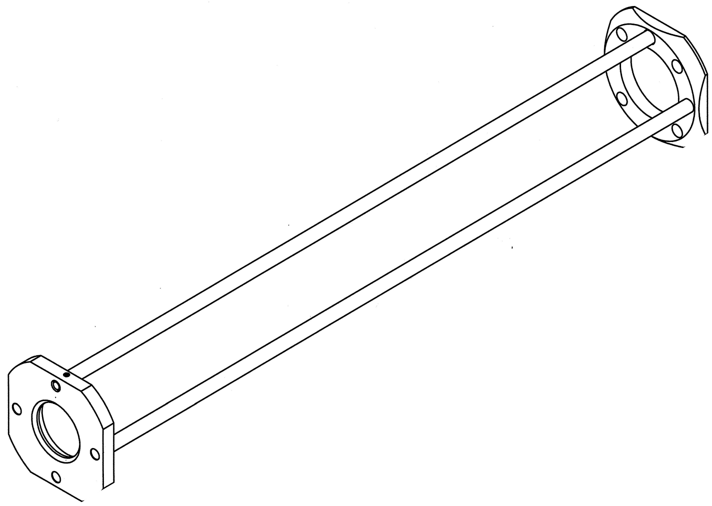

Figure 10: Schematic diagram of the basket containing SAFARI-1 spent fuel

The basket has three important functions:

- It protects and centres the SAFARI-1 spent fuel assembly during transfer and storage inside the transfer cask and storage vessel;
- It provides a coupling interface for the pneumatic grab mechanism by which the assembly is loaded and secured in the cask, and positioned inside the TPS storage vessel. (details of this coupling interface is not shown in Figure 10);
- It provides structural support inside the storage vessel at the Thabana Pipestore where up to 20 assemblies may be stacked on top of one another.

Spent Fuel

SAFARI-1 fuel elements and their control rods have the same dimensions once they are placed inside the basket. Once the spent fuel is removed from the reactor core, it is allowed to cool in the SAFARI-1 pool, before being cropped and packed into open baskets ready for transfer to the TPS.

A cropped fuel element is about 680 mm long and weighs about 6.5 kg. The overall basket and fuel assembly combination of about 700 mm long and 110 mm diameter.

3.4.2 NTP LTS Container

LTS container

The LTS container has a volume of 17 litres, an outer diameter of 242 mm and is 410 mm in height. The container is manufactured from stainless steel and the lid is seal-welded to the container body. Inside this LTS container is another stainless steel container, referred to as a 174DPTE container. The lid of this container is locked by rotation into position. A seal provides for a leak tight seal between the container and lid, to aid in minimising uranium contamination on the outside of the 174DPTE container. The 174DPTE container accommodates two smaller NTP U-residue stainless steel containers, each with a volume of 2 litres. U-residue from production processes at NTP is stored within these 2 litre containers. Figure 11 provides a schematic diagram of the LTS container and its content.

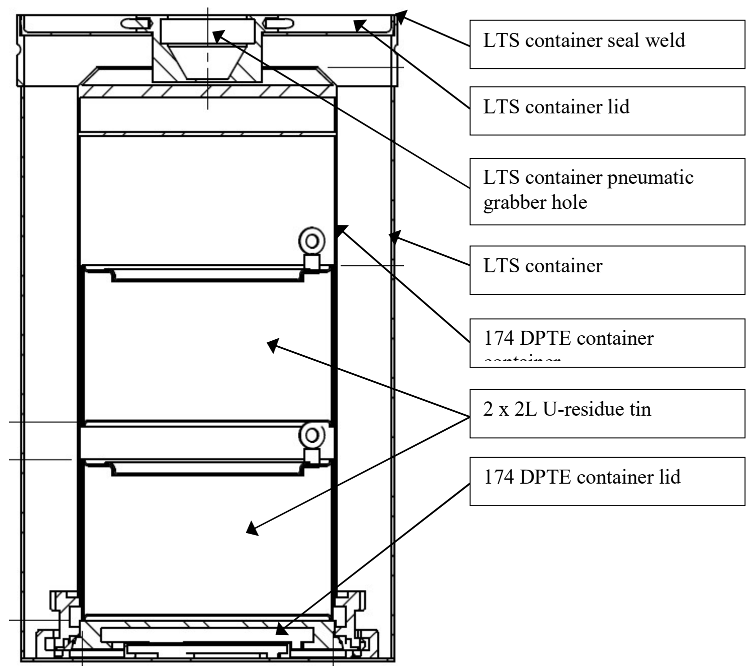

Figure 11: LTS container

When at least 2 years have lapsed since the 2 litre containers were filled with U-residue and placed in the 174DPTE container at NTP, these containers are then transferred into an LTS container.

3.5 Facility Equipment

3.5.1 Overhead Crane and Transfer Casks

An overhead crane is used to move the transfer casks from the vehicle to the applicable storage vessel. It is also used to lower and retrieve the fuel basket and LTS container. The crane in the facility is a double girder electric bridge crane and its travel rails are mounted on the Thabana Pipestore building vertical columns. The travel rails will be extended to allow crane operation and use in both new extended Thabana Pipestore areas.

3.5.2 Transfer Casks

Two different transfer casks are used for the safe transfer of SAFARI-1 spent fuel and the LTS container.

The SAFARI-1 spent fuel transfer cask is used between SAFARI-1 and the Thabana Pipestore (Figure 12). A newly developed transfer cask will be used for the transfer of NTP U-residue inside a LTS container between NTP and the Thabana Pipestore.

3.5.3 CASK – STORAGE VESSEL ADAPTOR

In order to safely transfer an item between the transfer cask and the storage vessel, a shielding adaptor is used. This adaptor provides shielding to ensure safe radiation levels at all times.

4.0 FACILITY AND TRANSFER PROCESS DESCRIPTION

The process description provided in this section is equally applicable to the storage of spent fuel from SAFARI-1 and LTS containers containing U-residue from NTP. Throughout the transport and waste emplacement processes a RPO will take radiation measurements and smear samples as is prescribed by the approved radiological safety requirements.

4.1 TRANSFER TO AND PLACEMENT OF ITEMS AT THE TPS

Transfers to the TPS are performed on a campaign basis. Typically once a year about 60 elements are moved over a duration of a few weeks to the TPS. During a campaign, the cask is transferred from the respective originating facility (SAFARI-1 or NTP) to the Thabana Pipestore using a licensed cask in accordance with the respective on-site transfer procedures.

The loading of the SAFARI-1 spent fuel elements from the reactor storage pool into the transfer baskets takes place in a hot cell using remote controls. The basket with the fuel element is hoisted into the transport cask using a specialized tool. The transport cask is then loaded and secured onto the transfer vehicle (trailer/trolley) and attached to a towing vehicle (Figure 12 and Figure 13). The trailer is then slowly towed to the TPS about 1, 5 km east of the reactor. A similar loading and transport procedure will be applied and used when transporting the LTS container from the nearby NTP to the TPS.

When the transfer vehicle with the cask arrives at the Thabana Pipestore, the vehicle is parked at the allocated loading bay inside the facility where the cask is to be off-loaded using the overhead crane.

The cask is hooked onto the crane and placed on the floor at the storage vessel to be used. After the top cover from the applicable storage vessel is removed, the cask is located in position over the storage vessel with the applicable shield placed in position. The bottom door of the cask is then opened, which ensures that the item can be lowered into the storage vessel.

Figure 12: The transport cask being placed over SAFARI-1 storage pipe

Figure 13: Cask being transported between SAFARI-1 and the TPS.

Thereafter coupling rods, connected to the overhead crane, are systematically one by one attached to the grabber, holding the item inside the cask, by which the item is slowly lowered through the bottom of the cask into the storage vessel. This is repeated until the item is positioned either on top of the previous placed item, or at the bottom of the storage vessel. This is confirmed by a load cell, connected to the crane, showing a zero mass.

Compressed air or gas is then connected to the top coupling rod. Through the coupling rods the grabber is released from the item, after which the coupling rods are lifted out of the storage vessel through the cask.

The cask is then removed from the storage vessel with the crane after which the storage vessel plug and flanges are returned into position to seal the vessel.

For unloading or retrieval of SAFARI-1 spent fuel assemblies or LTA containers from the storage vessels the reverse of the above process is followed. The item is grabbed, after which the load cell will show that the item was grabbed. The item is then lifted into the transfer cask, after which the cask is closed.

After the vessel is closed, a vacuum is drawn on the vessel and then backfilled with an inert gas. The pressure readings is inspected and recorded.

4.2 Thabana Pipestore Facility Inspection

To ensure that the stored items are kept under an inert atmosphere, the pressure readings on each storage pipe is monthly recorded and checked. Should, based on certain detail rules the pressure drop, detail follow-up steps as prescribed are followed to identify the possible cause of pressure drop. This typically is the seal between the storage vessel and the flange that started leaking. The seal is then replaced and the pipe resealed, vacuum drawn and again back filled with an inert gas.

Further routine radiological survey inspections are performed.

4.3 Facility and Environmental Monitoring

Environmental monitoring is a continuous process designed to give early warning if there has been a breach of SAFARI-1 spent fuel or NTP U-residue containment at the TPS. It should be noted that a breach of radioactive material can only happen when the storage vessel has failed (corroded through) and the items itself has been damaged or the integrity damaged. To prevent corrosion of the storage vessel, the fibre cement pipe protects the outer surface, and the inert atmosphere the internal surface. The stored item is also protected from corrosion by the inert atmosphere.

A Radiation Protection Surveillance and Control Programme are in place to monitor the TPS Facility. The TPS has a specific radiological classification according to its radiation and contamination risk which resulted in the facility being classified as a blue radiation area and white contamination area.

Both routine and ad-hoc surveillance (when items are transported and emplaced) is undertaken and include smears, radiation surveillance, iodine air sampling, and direct contamination measurements.

Should any storage pipes be opened for the removal of SAFARI-1 spent fuel elements or NTP waste tests will be done to check for e.g. presence of fission products or other contamination indicators according to specified procedures.

Environmental monitoring on a site and wider scale include monitoring and analyses of a variety of samples such as plant material, milk, effluent water, air filter samples, and water and fish from the adjacent Crocodile River and nearby Hartbeespoort Dam. Necsa applies the international ISO 14001 [13] standard to its environmental management systems.

4.4 *Environmental Impact Assessment*

An official Environmental Impact Assessment (EIA) process was registered with the Department of Forestry, Fisheries and Environment (DFFE) for the TPS extension. The public participation process has commenced in October 2019 with invitations to the public and existing Necsa stakeholders to register as Interested and Affected Parties (I&AP's) for the EIA process. This process has been completed and DFFE issued Necsa with an Environmental Authorisation for the extension of the Necsa Pipe Storage Facility for SAFARI-1 Spent Fuel and NTP Uraniferous Waste [14].

4.5 *Proposed Development Stages and Estimated Time Scales*

Table 1 summarizes the main development stages for the TPS extension up to operation in 2025. NNR guidance and requirements for the licensing of nuclear facilities is followed throughout.

Table 1: Main development stages for the TPS extension project

Task Name	Finish
TPS EXTENSION PROJECT	**2025/02/19**
Project Kick off	Completed
Initiation Phase	**Completed**
Design Phase	**2023/07/07**
Concept Design	Completed
Basic Design	Completed
Safety Assessment Report	2023/05/31
Detailed Design	2023/05/31
EIA Studies	**Completed**
NNR Public Participation	**2023/08/07**
Public Participation (Publish and Public Comments)	2023/08/04
NNR Board Decision	2023/08/07
Construction/Installation phase	**2025/01/23**
Commissioning Phase (Spent Fuel Only)	**2025/02/06**
Project Closure	**2025/02/19**

5.0 SITE DESCRIPTION

5.1 FACILITY LOCATION JUSTIFICATION

A techno-economic management study [3] was undertaken to establish the best option for the further storage of the SAFARI -1 spent fuel and for the uraniferous waste from NTP.

The main options that were considered included reprocessing of the spent fuel, locally or abroad, return to supplier (abroad), wet and dry storage options including importing of dry storage canisters, storage at the Vaalputs Facility in the Northern Cape and extending the current facility. The study compared the advantages and disadvantages of each option from a practical, safety and safeguards, time constraints and risk, and economic point of view and the option to extend the current TPS clearly stood out as the best option.

The extension of the current facility on Thabana with its existing NNR licence (NIL-04, Variation 0) was therefore selected for the storage of Necsa's SAFARI-1 spent fuel and the NTP uranium based waste.

An extension option study [8] was also conducted to determine the optimum extension configuration of the current TPS in terms of practicality, economics and other criteria.

Four extension options were considered:

Option 1: Install both the SAFARI-1 and NTP pipes northward from the current facility

Option 2: Install both SAFARI-1 and NTP pipes southward from the current facility

Option 3: Build a parallel conjoined facility east from the current to house both waste types

Option 4: Install the NTP waste pipes northward and the SAFARI-1 pipes southward from the current facility

The following main criteria were used, however also taking in account the safety, security, environmental, geological and Safeguards issues:

1. Minimize the need for the extension of the current electrified security fence while also respecting the space requirements on either side of the security fence.
2. Topography: minimize the volume of soil to be excavated down to floor level in order to extend the facility.
3. Avoid having to duplicate expensive equipment such as the overhead crane.
4. Maximise the distance between the extended pipe store facility and other facilities elsewhere on Thabana to avoid any cross interference during :
    a. Construction
    b. Operation and monitoring
5. Make maximum use of the current infrastructure like existing pipe store space, roads, gates, and auxiliary equipment and access doors to the facility in order to avoid unnecessary upgrades.

6. Geological formation: avoid the very hard magnetite quartzite horizon outcropping just north of the facility. It will be difficult and costly to excavate to current floor level and also difficult to drill into for the storage pipes.

By carefully applying the selection criteria to the four options (assigning weights and points) Option 4 was identified as the best option and selected for the extension (see Figure 4 and Figure 14 for illustration of extension option).

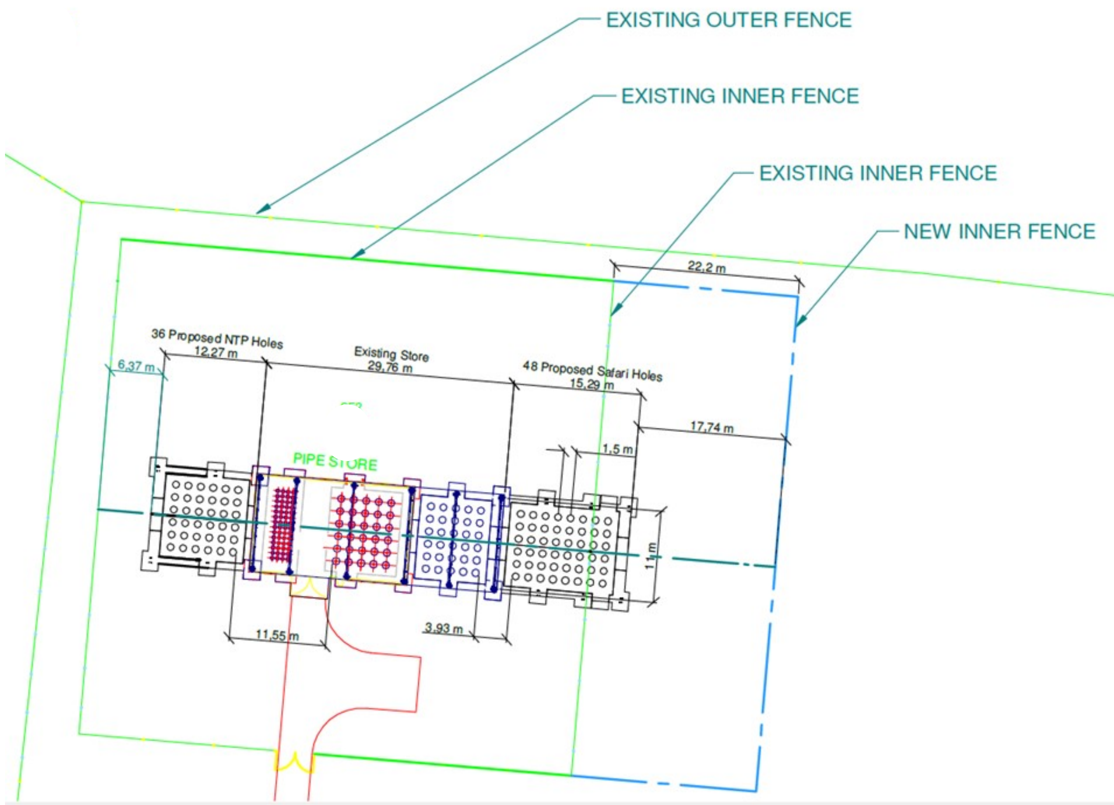

Figure 14: Area layout, showing the extended TPS facility, and the existing and new security perimeter

5.2 *Site Geography*

Infrastructure and Geography

Figure 15 demonstrates the regional location of the Necsa site and infrastructure of the surrounding area. The location of the TPS is right on top of Thabana which is a local hill on the Necsa site and one of the highest points in the area. This makes the probability of flooding insignificant.

Rainwater from the TPS will drain in a north north-easterly direction and eventually into the Moganwe Spruit, a perennial drainage with its source on the western outskirts of Pretoria, and itself a tributary of the Crocodile River. Since it is only rainwater that will drain from the TPS into the Moganwe Spruit the probability of contaminating this water is highly unlikely.

The monitoring of surface water forms part of the existing environmental monitoring surveillance programme of Necsa. Monitoring points for surface water sampling exist in the drainage below the proposed TPS site. These points are sampled on a regular basis depending on flow in the drainage.

A number of monitoring boreholes exist on the Pelindaba East site, to address potential pollution originating from activities such as the TPS or other facilities. A groundwater-monitoring programme is in place to sample all the monitoring boreholes at regular intervals. The monitoring results for all environmental monitoring are reported to the NNR on a quarterly basis.

The public roads utilized by large cargo carriers are the R512 (from Johannesburg via Lanseria to Rustenburg and Brits) and the R511 (from Johannesburg via Hennops River to Brits). These roads bypass the proposed TPS site at distances of 4 and 2 km respectively. Large cargo carriers that use the R104 (at about 1 km in a northerly direction) are mainly carriers destined for Necsa.

The Wonderboom Airport that is utilized by light aircraft and small passenger and freight aircraft, as well as two military airports (Waterkloof and Swartkops) in Pretoria are all in excess of 30 km from the TPS site. None of these airports have, on account of the layout of their runways any established air traffic landing or take-off corridors over Necsa.

The Oliver Tambo International Airport (OTIA, in excess of 60 km from the TPS site) and the Lanseria Airport (LA, approximately 20 km from the TPS site) do have an air traffic corridor that passes over Pelindaba. Pelindaba is approximately 4 km from the centreline of this corridor.

However, the width of the corridor has been increased dramatically since the introduction of satellite navigation systems. Passengers using the Lanseria Airport have almost tripled from 2012 to 2019. This implies that although the number of flights from OTIA using this corridor is approximately 19,000 per annum (data from a few years back) the actual number of planes currently passing in the proximity of Pelindaba is estimated to be about 4000 to 5000 p.a.

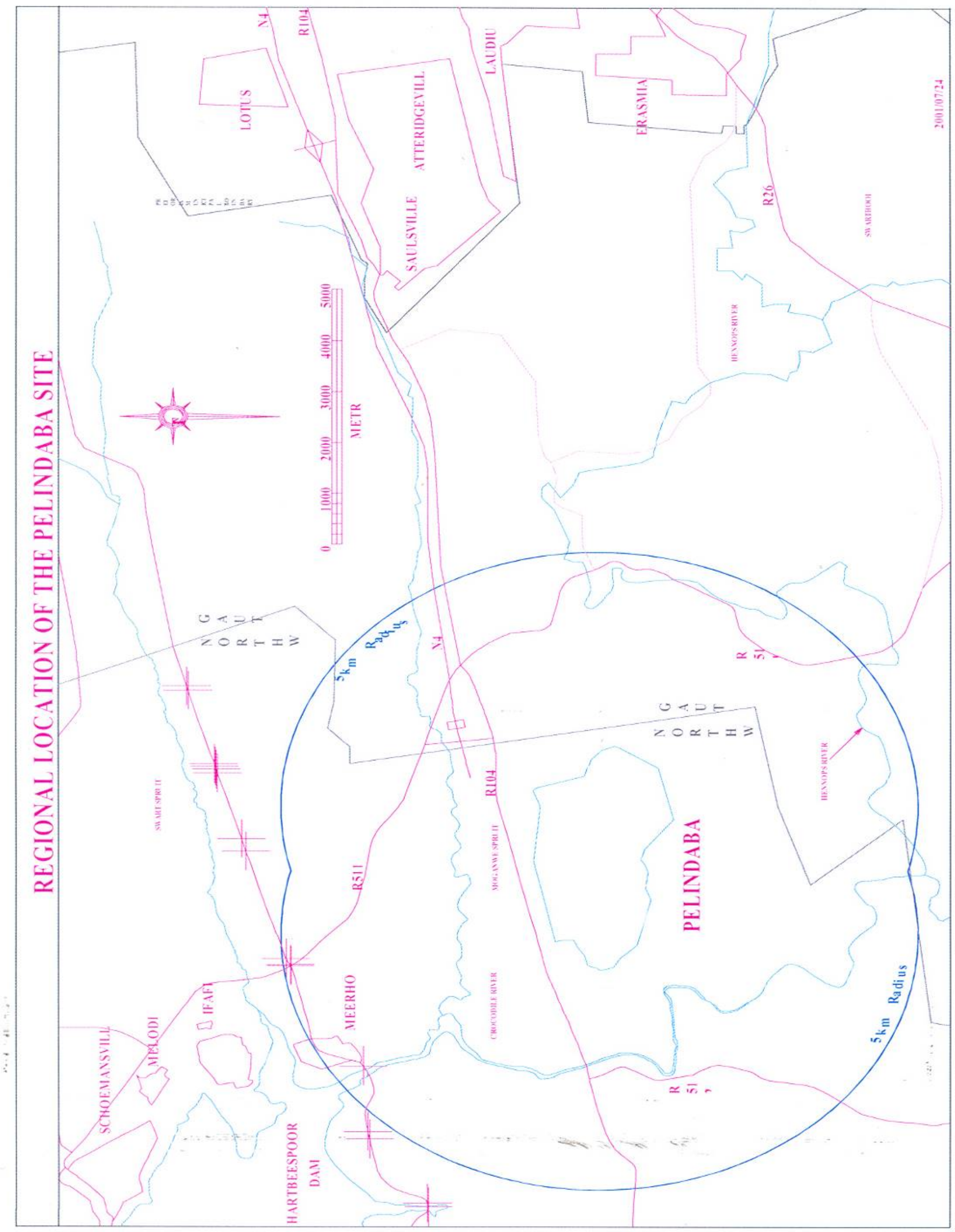

Figure 15: Regional Location and infrastructure of the Pelindaba Site

Demographics

The current Necsa Emergency Plan, as required by the nuclear license for Pelindaba, specifies an EPZ (Emergency Planning Zone) with a 5 km radius from the SAFARI-1 reactor. A land use census undertaken by Necsa in 2018/19 showed that the population living next to Necsa within the EPZ is 2231. Statistics South Africa (2018) indicates the general population density for the North West Province in the vicinity of Pelindaba as being about 38 persons per square kilometre.

The area within the EPZ does not have great potential for further agricultural development because of the lack of perennial streams and suitable arable ground. Currently only a few farms and smallholdings in the EPZ are producing agricultural products.

There is a large potential, however, for the development of recreational and tourist resorts next to the Hartbeespoort Dam. The Cradle of Humankind World Heritage site (COHWHS) is another node of tourism development centred approximately 15 km to the southwest. The dam lies outside the EPZ. None of these potential developments will be negatively impacted by the TPS extension.

The Pelindaba site is also classified as a major hazard installation (with respect to hazardous chemicals). As such it complies with the relevant regulations, which include requirements for a risk assessment of all the facilities and a site Emergency Plan (see Section 6.0).

Off-site there are no other major hazardous installations within the EPZ.

5.3 *METEOROLOGY*

No severe weather phenomena like hurricanes, tornadoes, freezing rain, snow, ice or sandstorms normally occur in the area. Thunder, lightning and hail however occur during the summer. It is not envisaged that the latter phenomena will have a significant impact on the TPS building, a sturdy steel structure designed to withstand these severe conditions, and no damage was recorded on the current facility since construction in 1997. Any potential impact will be limited to the TPS building but not the storage pipes which occur underground.

5.4 *GEOLOGICAL SITE SUITABILITY AND SAFETY*

A geological suitability report [4] provided the structural geological, hydrogeological, seismic hazard and geotechnical information relevant to Thabana and the Pipestore Facility and demonstrates the suitability of the site for the extension of the Pipestore.

The purpose of the report was firstly to provide a basic geological and hydrological model of the TPS site and environment. Secondly, the various geologically related site characteristics and features of the site were compared with national and international criteria for spent fuel storage in order to confirm the safety and suitability of the site for the extension of the facility. A brief summary of the above subjects follows below:

<u>Geology, Geohydrology and Seismicity</u>

The proposed extension for the TPS is located on interbedded slates and quartzites of the Rooihoogte and the Timeball Hill formation of the Pretoria Group.

The surface geology is largely dominated by a veneer of Cenozoic (geological time period) overburden consisting of likely Cenozoic gravel at the top of Thabana hill (maximum thickness ±2 m to 3 m), and by a widespread Quaternary colluvium on its flanks. Due to these deposits, the exposure of bedrock slates is sparse and largely concentrated on the steeper slopes west of Thabana. The geological profile (from top to bottom) at the TPS can be subdivided into 5 zones, namely:

- Topsoil or Cenozoic overburden;
- Upper weathered light brown and pink slate;
- Dark brown weathered slate;
- Grey weathered slate; and
- Dark grey, unweathered slate; and purple quartzite.

The storage boreholes at the TPS intersect only the 2 top geological zones described above and the dark brown, grey and dark grey zones occur only from about 25 m and deeper.

Generally, the geomorphology of Thabana is controlled by NNW trending faults responsible for the riverine incisions, whereas the quartzite, especially those rich in magnetite, have protected the more easy to weather slate from further erosion. The geology of Thabana is shown in Figure 16.

Due to various tectonic deformational events in the geological past the rocks tend to show various fractures. Given this structural context, it is not surprising that several of these fractures yield water during drilling, while fault zones also tend to disturb the homogeneous nature of the stratigraphy. There is some degree of correlation between the fractures in the unconsolidated soils and in the neighbouring slate formations. These fracture zones serve as preferential pathways for groundwater flow which will cause slow seepage into boreholes where it is intersected by drilling.

The contact between the weathered and unweathered zones roughly follows the unsaturated-saturated interface. To the north of Thabana, intrusive dolerite or diabase outcrops as boulders among the soil cover or as a sill in slate/quartzite. Two large-scale fault zones, with a NNW and NNE trends respectively are present east and west of Thabana. These two fault zones form the traces for the streams and are the reason for the existence of the incised valleys.

The TPS is situated on a topographical high with groundwater levels that varies in depth from 52 m to 60 m. The groundwater level is therefore much deeper than the bottom of the TPS and new NTP storage pipes.

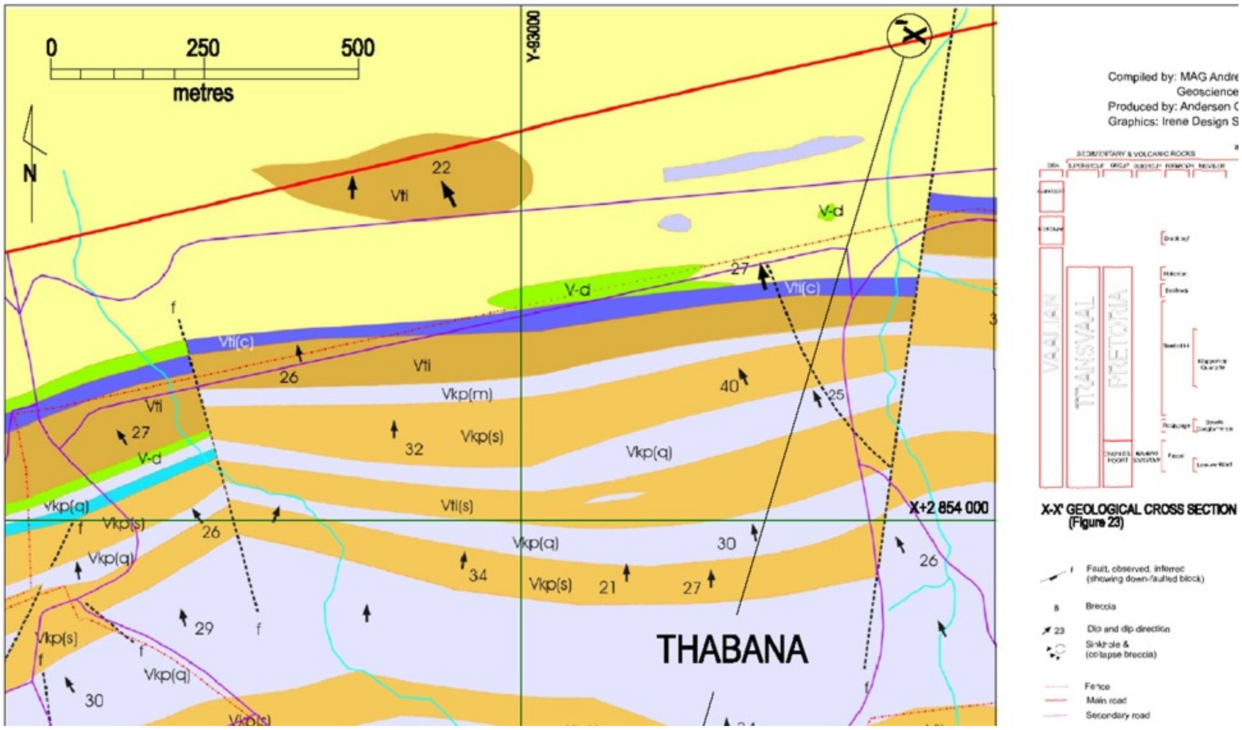

Figure 16: Geological map of Thabana and the TPS

Geotechnical investigations [9] have confirmed that the allowable load capacity of the site foundations can exceed 200 kPa, if necessary, and that the compressibility (settling) potential is minor. This means that the engineering characteristics and capabilities of the foundations easily exceed the minimum requirements for the current and extended facility.

The Council of Geoscience has conducted a seismic hazard study for a proposed pebble bed fuel plant to be sited at the BEVA area, on the western side of the Pelindaba industrial park. In view of the geological similarities between these two nearby sites, the conclusions reached by the Council for Geoscience will also apply to the TPS site. This study is based on the assumption that the seismic hazard in the BEVA site is dependent on its relative location to five mine induced seismic active areas: Welkom, Klerksdorp, Carletonville, East Rand and Rustenburg, and the Zoetfontein fault, as well as on background seismicity. The major contribution to the seismic hazard at the site comes from the magnitude of the largest earthquake in the vicinity of the site, Richter Scale (RS) = 5,05 ± 0,50, which is capable of producing a maximum possible Peak Ground Acceleration (PGA) at the site with median value of 0,178 g, with the one standard deviation confidence interval being [0,12 g; 0,36 g]. It should be noted that the value of the PGA equal to 0,37 g corresponds to a non-exceedance probability of 84 %.

This PGA value is based on the worst-case scenario, where the maximum credible earthquake increased by its standard deviation (RS = 5,55) took place at an epicentral distance of 0,25 km from the site at a depth of 10 km. A simple probabilistic assessment of the PGA indicated that such an event has a frequency of 1.8E-5 per year to occur. Deterministic assessments of the ground motion of mining induced seismic events from the mining areas surrounding Pelindaba, or any major faults indicates that these events are too far from Pelindaba in order to pose any significant threat to the TPS or any other nuclear facility on the site.

Confirmation of Site Safety Criteria

According to various IAEA guidelines [5] concerned with geological and foundation requirements for nuclear facilities the following features are being advantageous for the storage of spent fuel:

1. Stable regional geology
2. No faulting at the site
3. Negligible probability for the development of sinkholes
4. Deep groundwater level many meters below the facility
5. Insignificant seismic risk
6. Stable and simple geosphere (geology surrounding the facility) with adequate geotechnical conditions (e.g. high load capacity and minor settling potential) to support the facility engineering
7. Low erosion rates
8. Availability of detailed site characterization information for site selection purposes

The geology and structural geology of Pelindaba and Thabana described above confirm that the Pipestore is situated on interbedded shale/slate and quartzite from the Timeball Hill Formation of the Pretoria Group sediments. The Pretoria Group is well researched and the rocks of the Timeball Hill Formation are widely accepted as providing stable geology for engineering purposes. It is the same formation that the SAFARI-1 Reactor is constructed on.

Although certain areas on Pelindaba and the wider environment has a more complex geological make-up due to faulting and folding the geology of the TPS site and immediate vicinity are simple and undisturbed by faulting, as is confirmed by the drilling results and geological investigations stretching over many decades.

The TPS site is far removed from the dolomites which occur further to the south on Pelindaba and are situated on rocks which are not conducive to the forming of sinkholes. The groundwater level (or saturated zone level) on Thabana varies between 52 m and 60 m below the surface. The groundwater level is therefore well below the bottom of the spent fuel storage pipes which will not exceed a depth of 20 m below surface.

More recent drilling results and original TPS investigations indicates no sandy layers, faulting or weak zones in the geosphere of the facility which could negatively affect the facility during a seismic event (collapse, liquefaction or sliding).

The seismic hazard investigations concluded that the design basis earthquake for facilities on the Timeball Hill Formation will have maximum possible Peak Ground Acceleration (PGA) at the site with median value 0,178 g, with the one standard deviation confidence interval being [0,12 g; 0,36 g]. It can therefore be concluded that the seismic risk hazard to the Pipestore facility and its proposed extension is insignificant.

Drilling results also confirm a uniform and undisturbed geosphere for the TPS facility.

The associated drilling penetration rates show a consistency between the boreholes and confirm the absence of cavities or soft and weak layers in the geosphere. The geosphere can therefore be considered as stable from a civil engineering point of view.

The geotechnical foundation conditions at the site have been found to be favourable and suitable for the proposed development.

The presence of the hard quartzite layers provides stability and erosion resistance for Thabana Hill and its facilities. Manual observations around Thabana and the Pipestore confirmed the absence of any developing erosional features that could affect the longevity of the facility. It therefore confirms the low erosion rate at or near the Pipestore facility.

The detailed site characterization information coupled with extensive data from previous investigations allowed for the extension option to be accurately sited on the desired position.

Summary of Site Suitability and Safety

Thabana and the TPS site have been well characterized in terms of geological features relevant to the suitability of the TPS Facility. This information has been documented in various reports obtained over many decades and complimented with recent site specific investigations. The site characteristics have been demonstrated to comply with international guidelines and criteria which enhance the site suitability and safety for the intended extension of the facility.

A sound scientific base therefore exists to support the suitability of the site for spent fuel storage as well as for the further extension of the facility.

6.0 SAFETY ASSESSMENT AND HAZARDS

6.1 RADIOLOGICAL SAFETY ASSESSMENT

A safety assessment [10] was performed for the following activities in the TPS:

- Constructing and installing the SAFARI-1's and NTP sections of the existing TPS by additional 48 pipes and 36 pipes respectively.
- The operation of the Pipestore extension with its 144 pipes totally filled with spent fuel elements from SAFARI-1 and NTP (LTS) containers.

Source Term

The planned Pipestore extension will store a maximum of 960 SAFARI-1 elements and 969 NTP LTS containers. One SAFARI-1 pipe can store up to 20 elements, and that of NTP can store up to 32 LTS containers. The planned extended Pipestore will be able to store all the spent fuel and uranium residue which will be conservatively generated when the SAFARI-1 is operated until at least 2035.

Operator Dose Calculations for Normal Operations

Using conservative shielding calculations for the SAFARI-1 spent fuel elements and the NTP LTS containers dose rates were calculated for filled storage pipes for both types of stored waste.

The dose calculations were then further divided into two scenarios, namely the:

1. The emptying (retrieval of all SAFARI-1 spent fuel elements or LTS containers) from filled storage pipes and:
2. Emplacement of waste into an empty storage pipe and filling it.

For SAFARI-1, if the packages are stored at 60 per annum i.e. filling 3 pipes, and the contents of one pipe is retrieved in a year, the annual dose to an operator (who performs all these tasks) would be 4 times the dose from emptying one pipe, so that the operator receives 3.2 mSv/a .

For NTP, if the LTS containers are stored at 96 per annum i.e. filling 3 pipes, and the contents of one pipe is retrieved in a year, the annual dose to an operator (who performs all these tasks) would be 4 times the dose from emptying one pipe, so that the operator receives 0.4 mSv/a.

The above doses to an operator are less than the deterministic ALARA target of 4 mSv/a, as is prescribed by, and are therefore acceptable. Operators are normally rotated for performing these tasks, resulting in the dose of less than 3.2 mSv/a and 0.4 mSv/a for SAFARI-1 and NTP respectively. Furthermore, these doses are based on conservative assumptions. During operation the actual doses to the operators will be closely monitored, and can be expected to be substantially less than indicated above based on the operational experience of the current operational TPS facility.

Similar dose calculations were performed for the loading and transport of fuel elements from SAFARI-1 to the TPS and found to have insignificant doses. The loading and transport of the NTP LTS waste will be similar to the SAFARI-1 spent fuel element and the cask providing similar shielding, thus the dose is also expected to be insignificant.

6.2 OTHER HAZARDS AND ACCIDENT CONDITIONS

6.2.1 OTHER HAZARDS

Extending the TPS requires that an additional 84 holes will be drilled and pipes installed. A concrete slab will be installed between the pipes. The building will also be extended. During the extension activities, the overhead crane will also be extended. The potential radiological hazards of doing these extensions and installations nearby the filled pipes have been analysed [8] which indicated that operators and members of the public would be exposed to insignificant doses.

Shielding calculations for SAFARI-1 spent fuel elements have shown that routine movements on the floor above pipes are allowed under the same conditions as in a Blue area (Radiological Control Classification of an area) , with the highest dose rates occurring only in the small area directly on top of a pipe plug (17.5 µSv/h). In-between pipes the dose rate decreases to that acceptable in an uncontrolled/unclassified area.

The need for additional shielding during loading was identified and this is provided in the form of a large portable steel ring that will shield radiation while the fuel element is passing the gap between the cask and the pipe as well as a small portable steel ring that fits around the bottom part of the cask. In addition a minimum distance of at least 0.5 m from any sources of radiation is prescribed and applied by operational personnel.

The same situation and resolution will account for NTP LTS container emplacement.

A pendant controller is fitted to the overhead crane. This enables the crane operator to work at a safe distance from the load area under the crane and hence from the casks and open pipes. Personnel will thus not be exposed to hazards from the crane operation. The risk from a cask drop is low. No other hazards are foreseen from normal handling of the packages and cask.

6.2.2 Accident Condition Hazards

The following accident conditions were investigated and analysed [10] in terms of its potential to cause harm to workers, the environment or the public:

Damage to fuel rods or LTA container:

Based on historical data and/or operational experience, a SAFARI-1 spent fuel element got damaged and led to minor fission gases leaking from the fuel elements during storage in the SAFARI-1 spent fuel pool. For NTP LTS containers, there was never a case whereby the LTS container leaked during storage/handling in the NTP facility. For the accident analysis and corrective action, the SAFARI-1 spent fuel elements are used as the bounding case. It should however be noted that a leaking fuel element is not accepted for storage at the TPS.

Opening a Pipe before testing of the gas content:

For the radiological hazard associated with the exposure to gas products (e.g. Kr-85) when a pipe would be opened before any routine sampling of the atmosphere inside has been done. Calculations for a single SAFARI-1 spent fuel element were done and total dose to an operator from one fuel element is 0.27 mSv.

But, each element is made up of nineteen individual plates. The dose due to the release of the inventory of one plate is therefore 1/19 of the total dose calculated above, giving 0.27 mSv/19 = 0.014 mSv or 14 µSv.

If we assume that this 'accident' of one plate leaking, happens once a year, it is regarded as being a normal operational dose.

The external radiation dose to a member of the public is also insignificant, since the public will not be allowed in the TPS.

Fission Gas Leaking from Storage Pipes

The dose to an operator from the inhalation of fission gas leaking from a pipe was calculated assuming a worst case scenario for a very high Kr-85 value and that all the filled SAFARI-1 spent fuel pipes would leak simultaneously.

Even in such worst case scenario the dose to an operator would be only 264 µSv/a.

Members of the Public are not allowed in the facility therefore, the dose to the member of the public is calculated at 1 km from the Pipestore assuming a release rate in one month (30 days) and equates to 8.05E-07 µSv/a.

The above doses for a worker or the public are therefore insignificant.

Accidents during Transport and Handling of Items

The following accident scenarios were investigated and analysed in terms of its probability and risk [8]: to workers and the environment:

- Traffic accident
- Dropping of cask
- Dropping of spent fuel container

All of these were found to have an acceptable low risk to an operator.

Accidents Involving the Stored Elements

The following scenarios were also analysed for its risk and hazard potential to workers and the environment [4] and [10]:

- Geological fault causing break through the pipe assembly
- Lose ground settling and slope instability
- Earthquake damage
- Aircraft crash damage to the facility
- Fire damage
- Criticality
- Strong winds

All these scenarios were found to have an acceptable low risk.

6.3 CONCLUSIONS OF SUBSECTIONS 6.1 AND 6.2

The maximum dose to an operator would be 3.2 mSv/a and 0.4 mSv/a for SAFARI-1 and NTP activities respectively, including the very low doses from the accidents which could be regarded as normal operation, and the dose to a member of the public would be insignificant.

The risk associated with the proposed facility will be acceptable and that it will provide adequate protection to personnel and members of the public from harmful exposure to radiation. It also accounts for construction workers during the drilling of the new boreholes and construction of the extended facility.

The proposed operating procedures and emergency measures provide for safe operation and control over the use of the facility while provision is also made for the control and accounting of radioactive material.

Adequate provision is made for the protection of the environment from radiation and hazardous contamination, while the physical impact on the environment is acceptable.

6.4 Quality Assurance and Control

The Waste Management Department (WM) is the owner of the TPS and is responsible for the operation of the facility and its intended extension.

All phases of the project, design, construction, commissioning and operations shall be managed according to an existing documented quality system and the applicable SHEQ-INS requirement documents.

WM recognizes that personnel are responsible for the quality of products and services and making quality a way of life through continual improvement.

6.5 Demonstration of Compliance with the Safety Standards

The operation of the extended TPS will only commence after the demonstration of the safety of the facility as assessed in the various safety assessment reports and approval has been granted by the NNR. It will also have to comply with the Necsa internal safety approval process.

The design of the TPS and the extension includes specific features to ensure that the potential for release of radiation is ALARA (As Low as Reasonably Achievable) for normal operations as well as for all foreseeable accident scenarios (see Section 5.0).

Licensing Services and Analyses (LS&A) will perform a final independent review if all the required licensing and safety requirements are complied with before permission is granted for hot commissioning. This can only take place once the NNR and the Safety Evaluation Committee of Necsa has also granted their approval.

All radioactive waste generated by the operation of the TPS will be managed in accordance with an approved waste management procedure. Waste will be characterised and stored in a dedicated store for radioactive wastes.

7.0 EMERGENCY PLANNING

7.1 Introduction

Nuclear and chemical facilities are required by various Acts, (i.e. the National Nuclear Regulator Act and the Major Hazard Installation Regulations of the Occupational Health and Safety Act) to establish effective emergency plans. The aim of this is to protect personnel, the public and the environment from the potential hazards, which may arise from an accident in such facilities or during the transport of hazardous substances produced at such facilities. To comply with these requirements Necsa implemented a comprehensive emergency plan for all operations on the site.

The TPS extension at Pelindaba shall be subject to the Necsa's site emergency plan and the existing facility (or building) emergency plan shall be updated.

As indicated in the Section 6.2.2 there are no foreseen accident scenarios with off-site consequences.

7.2 *Consequence Analyses*

A comprehensive consequence analysis was conducted before establishing the Necsa emergency plan. Consideration was given to accidents, which could potentially pose a hazard to man and the environment. The consequence analysis was conducted for all foreseeable types of accidents, ranging from those involving potential releases greater than permitted under normal operating conditions and those with potentially severe consequences but with extremely low probabilities of occurrence.

Internationally acceptable computer software packages are used for consequence modelling using the latest available source terms (i.e. inventory of hazardous substances).

All new projects, including the TPS extension, are evaluated for possible scenarios to be included in the emergency planning.

7.3 *Basic Emergency Planning Requirements*

Planning for and control of the early stage of an emergency are aimed at eliminating the immediate threat and mitigating the consequences to personnel, the public and the environment. The medium to long term planning addresses the clean-up actions and rehabilitation.

7.4 *Emergency Planning Zones*

Previous consequence modelling results such as for the SAFARI-1 facility required Necsa to provide comprehensive formal emergency planning in a 5 km radius from Necsa's site. Formal emergency planning includes aspects such as activation of off-site response and the notification and evacuation of residents.

7.5 *On-Site Emergency Response Organization*

An emergency response organization (the ECC) has been established to cope with all categories of emergencies. The Emergency Control Centre (ECC) is on 24 hour standby to address any possible emergency. Emergency functionaries undergo formal emergency preparedness training.

7.6 *Public Notification*

The emergency plan requires a demonstrated ability to alert residents in the 5 km formal planning zone (up to 10000 residents), educating residents to go indoors and tune into a local radio station once they have been alerted and to instruct residents on required protective actions via announcements on local radio stations.

Initial public alert must be achieved within as short a timeframe as possible but also depending on the emergency scenario.

Necsa utilises telephones, two way radios, ground-shout, auto dial-up and sky-shout to alert the public of an emergency. Pamphlets and calendars are used to educate the public. The SABC has agreed to use its various local radio stations to assist Necsa with emergency announcements. Jacaranda FM (a private radio station) and Motsweding FM have also agreed to participate with emergency announcements.

7.7 EMERGENCY FACILITIES

Basic facilities consisting of an emergency control centre, media centres, communication systems, on-line meteorological data, medical facilities, survey vehicles, warning systems and analytical laboratories are available and equipped to deal with an emergency.

7.8 IMPLEMENTATION PROCEDURES

Comprehensive procedures and instructions are in place to address all aspects of the emergency plan. Emergency functionaries are trained according to these procedures. These procedures are used (inter alia by the NNR) during emergency exercises to audit the effectiveness of the emergency plan.

7.9 EMERGENCY EXERCISE

Necsa is required to hold regular emergency exercises. The purpose of the emergency exercises is to train emergency functionaries and to demonstrate to the NNR and local residents Necsa's ability to cope with an emergency. The exercises are conducted under simulated accident conditions using the emergency scenarios assessed in the risk analyses.

8.0 WASTE MANAGEMENT AND DECOMMISSIONING

8.1 WASTE MANAGEMENT STRATEGY FOR THE TPS INVENTORY

The Radioactive Waste Management Policy and Strategy for the Republic of South Africa [11] states that Government is responsible for investigating the long-term options for safe management of used fuel and high level radioactive wastes in South Africa. Government has to investigate the options for the safe management of used fuel and high-level radioactive wastes and there is uncertainly in terms of when such a decision will be made.

According to the Policy and Strategy the options for the further management of spent fuel and high level waste includes:

- Reprocessing, conditioning and recycling
- Deep Geological Disposal
- Transmutation

However, the policy states that in the interim used nuclear fuel is and shall continue to be stored in authorised facilities within the generators sites. It is for this reason that Necsa initiated the current TPS and its proposed extension.

Necsa also obtained the required DMRE ministerial approval [15] to store the SAFARI-1 spent fuel and NTP U-residue at the extended TPS, as required by the Nuclear Energy Act [16] Section 34. (1)(s), to store this radioactive material and the irradiated fuel (when the fuel is external to the spent fuel pool).

8.2 Other TPS Radioactive Waste and Management Options

Nuclear waste is defined as material (solid, liquid and gas) that cannot be recycled economically and which therefore requires disposal. Nuclear waste is further defined as material that contains, or is contaminated with, uranium at concentrations with activity levels greater than clearance levels approved by the NNR.

<u>Classification and Management of the TPS External Waste</u>

It is anticipated that operational TPS waste and decommissioning waste during both Phase 2 and 3 decommissioning (see Section 8.3 below) will consist of only low or very low level waste. This will consist mainly of rubber gloves, paper towels, plastic and some building rubble or concrete. The building rubble, concrete and dust may even be cleared in accordance with approved NNR clearance levels.

Water that may be generated from washing actions will be evaporated at a suitable facility and the remaining sediment will form a very small part of the generated waste. The waste generated during decommissioning will be solid compressible and non-compressible waste. It is estimated that a few hundred drums of waste may be generated during the Phase 2 decommissioning of the facility.

This waste is suitable for disposal at the Vaalputs National Radioactive Waste Disposal Facility in the Northern Cape region which has been in operation since 1986.

8.3 Decommissioning of the TPS

Decommissioning refers to the actions, including shutdown, dismantling and decontamination taken at the end of the useful life of a nuclear facility (building and process equipment) in retiring it from service with adequate regard for the health and safety of workers and members of the public and protection of the environment. The ultimate goal of decommissioning is clearance for reuse of buildings or total removal of buildings and site restoration (green fields).

Decommissioning is considered throughout the life cycle of the facility and even as part of the safety case during the licence application of the facility.

A conceptual decommissioning strategy [12] is required for all new facilities at Necsa as part of the licensing approval process. The decommissioning plans for the TPS will evolve according to these requirements, which also require a final decommissioning strategy during the operation of the plant.

During shutdown and post-shutdown of the facility various NNR authorisation requests (NAR) will have to be forwarded to the NNR concerning the 3 main phases for decommissioning, namely:

Phase 1: covers the facility shutdown and the removal of the radioactive inventory to a state of passive safety.

Phase 2: covers the removal and decontamination of process systems.

Phase 3: covers the final decommissioning activity of the building to clearance levels, after which the facility is deleted from the nuclear licence

The decommissioning strategy and relevant issues are summarized below:

Expected inventory

If the TPS is filled to the maximum, it is expected to contain 144 storage pipes (108 for SAFARI-1 spent fuel and 36 for NTP LTS waste). Only minor other waste (Discussed in Subsection 8.2) is expected.

It may therefore be possible to deregulate the TPS after removal of the inventory without going through a Phase 3 decommissioning exercise.

Phase 1 decommissioning will effectively require the removal of the spent fuel and NTP LTS containers inventory.

During Phase 2 decommissioning and the removal of the inventory, the storage vessels need to be tested for contamination, especially on the inside. It may be necessary to remove each vessel to be able to determine its state of contamination.

Cleared equipment could in principle be sold and the contaminated equipment will be stored, melted and clearable melt sold.

Phase 3 will aim to reach unconditional clearance for the facility and its contents. If the storage vessels remained intact during the period of storage of the waste, it is possible that the facility may be deregulated without going through a Phase 3 decommissioning exercise.

Alternatively if some vessels leaked, any contaminated concrete near the leaking pipes would have to be removed during the Phase 3 decommissioning exercise.

Radiological conditions to be expected during decommissioning are as follows:

It is anticipated that the retrieval of the total inventories of the storage pipes will require no special handling and transfer procedures other than the present procedures and control measures. A project will however need to be licensed to perform the secondary processing of the material, e.g. reprocessing or disposal.

For the purpose of decommissioning, a hazard assessment will be required to determine the radiological safety controls required. Some measures (additional to those employed during normal operation) aimed at reducing the exposure of personnel, the spread of contamination and preventing the intake of loose contamination by decommissioning workers may be required during Phase 2 and 3 decommissioning.

Since it is anticipated that Phase 3 decommissioning can be successfully completed, rehabilitation may comprise the removal of the concrete block and sleeves and backfill of the open boreholes that was used for the storage pipes.

Necsa is experienced in decommissioning of uranium-contaminated facilities and has the necessary decontamination, waste management and waste treatment facilities.

9.0 REFERENCES

The following documents are referenced in this document:

[1] NIL-04 Variation 0 — Nuclear Installation Licence of the Thabana Complex

[2] RD-013 — Requirements on public information document (PID) to be produced by applicants for new authorisations

[3] NLM-REP-17/048 — Used Fuel Management Strategy for SAFARI-1. (2017)

[4] NLM-REP-18/162 — The Geological Suitability of Thabana for the Extension of the Pipe Store Facility. (2018)

[5] IAEA (2013): — Management and Storage of Research Reactor Spent Nuclear Fuel. Proceedings of a Technical Meeting held in Thurso, United Kingdom, 19–22 October 2009

[6] NLM-PD-00029: — Facility and Process Description for the Extended Pipe Store. (2018)

[7] NLM-WKI-136: — Work Instructions for Depositing Spent Fuel Elements in the Pipes at Thabana Pipestore. (2018)

[8] NLM-REP-18/134: — Option Study for the Extension of the Pipe Store Facility. (2018)

[9] Roadlab Report: — Engineering Geological Report for the Necsa Pipe Storage Facility. Roadlab. March 2019.

[10] LSA-NLM2018-SAR-0002 — Safety Assessment for the Thabana Pipestore Extension.

	(2020)
[11] DME:	Radioactive Waste Management Policy and Strategy for the Republic of South Africa. Department of Minerals and Energy. (2005)
[12] NLM-STRG-033	Decommissioning Strategy for the Thabana Pipestore
[13] ISO 14001	International Standards Organisation-Environmental Management Systems
[14] 14/12/16/3/3/2/2048	DFFE Environmental Authority: “The extension of Necsa’s Pipe Storage Facility for SAFARI-1 Spent Fuel and NTP Uraniferous Waste, Madibeng Local Municipality, North West Province”
[15] E2/5/9/3 (27/10/2022)	DMRE approval: Application for approval for on-site storage of SAFARI-1 spent fuel and NTP U-residue at the extension of the Thabana Pipestore
[16] Act No 46 of 1999	Nuclear Energy Act, 1999