

# National Nuclear Regulator



# Strategy Document

No	Title	Rev.
NNR-SD-0002	REGULATORY STRATEGY FOR THE REMEDIATION OF THE WONDERFONTEIN CATCHMENT AREA	0

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## APPROVAL RECORD

	Name	Designation	Signature	Date
Prepared By	C O Phillips	Senior Manager: NTNS	<i>C Phillips</i>	5/10/2009
Recommended for Approval By	C O Phillips	Senior Manager: NTNS	<i>C Phillips</i>	5/10/2009
Reviewed By	A Joubert	Principal Specialist: RRD	<i>A Joubert</i>	5/10/2009
Approved By	T F Hill	Acting Chief Technical Officer	<i>T Hill</i>	6/10/2009

## REVISION

## HISTORY

Rev No.	Date Approved	Nature of Revision	Prepared by
		No preceding document	C O Phillips

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## 1.0 INTRODUCTION

The National Nuclear Regulator (NNR) commissioned a study in November 2006 to assess the radiological impacts of mining activities in the Wonderfonteinspruit Catchment Area (WCA). The study set out to determine the radiological impacts of the current mine water discharges, the diffuse emissions of seepage and runoff from slimes dams and legacies of past radioactive contamination, now present as radionuclides that have accumulated in sediments and soils.

The Wonderfonteinspruit catchment area is a complex terrain situated in the south-west of Johannesburg, with the upper section of the catchment in the Gauteng Province and the lower part in the North West Province. The WCA comprises the eastern catchment of the Mooi River. The main course of the drainage channel is known at various points as Mooi River and Wonderfonteinspruit. For the purposes of this study Wonderfonteinspruit refers to the water body in the whole catchment area between Krugersdorp in the northeast and the inflow into the Mooi River north of Potchefstroom in the southwest.

Dispersed low level contamination poses a particular challenge to those charged with its remediation. Below certain concentration thresholds identified technological options for remediation may not be efficient. This could result in more severe impacts on certain environmental compartments than the contamination itself. In such cases there must be a need for justification of remediation.

Since a complex pattern of dispersed contamination is present in the WCA, the remediation solutions could be presented in a permutation of technological options as the contamination differs from specific sites to the next, within the WCA.

## 2.0 SCOPE

I: REGULATORY ROLE

This document outlines the planning and managerial interventions that will be needed from the regulators perspective and mandate. The NNR is obligated in terms of Section 6, of the NNRA to give effect to the principles of co-operative governance. The essential elements for sound

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management is to give effect to the mandate of the NNR and ensure that all actions are carried out in compliance with the respective legislative imperatives for each organ of state that is affected by the planned remediation project.

II: AUTHORISATION HOLDERS ROLE

The mines that operate in the WCA are directly implicated in a broad sense for the success of the national initiatives that are proposed by the national governmental Steering Committee. The holders will be required to comply with the corrective measures that are put forward by the regulators. The forum of mining operators however needs to constructively engage in terms of problem solving and radiation safety governance matters that arise.

III: PUBLIC PARTICIPATION

The affected communities and interested parties that are connected to the WCA must also be engaged so that there is transparency of processes and decision-making in regard to ensuring that members of the public are involved in the forward planning for the corrective measures that will be put in place regarding the WCA. The role of the authorization holders and that of the NNR must be clarified as the project is rolled out. The NNR will need to ensure that members of the public are apprised of issues that pertain to the future planning in regard to the situation in WCA.

**3.0 RESTRICTIONS AT SOURCE**

Prior to the remediation of the affected area in the WCA, it is imperative that restrictions are imposed so that exposure or re-contamination of the area is averted. In respect of this factor, the mines operating in the WCA must be directed to restrict the discharge of effluent and contain migration of radioactive material in order that the dispersion of radioactive material is controlled at source. The need also to ensure that tailings retention is implemented will be important before remediation operations commence. It is therefore essential that all sources and potential sources be removed so that the spread and migration of radioactive materials is stopped prior to any remediation operation that is executed.

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The applicable requirements of the Safety Standards and Regulatory Practices (SSRP) shall be enforced for the actions and interventions that are introduced in the WCA. Section 6 states that the provisions of the section is applicable to emergency exposure situations requiring protective action to reduce or avert temporary exposures. Although this situation would not be considered as an emergency, as the case may be, the concern and pressure from environmental groups indicate that immediate action is required by both the regulators and the mines operating in the area. The view of NNR is that in a sense the criteria of a nuclear incident would be applicable to the problem in the WCA. It is also probable that the spread of contamination, being historical, was unforeseen at the time of authorization of the mines operating in the area.

The applicable risk limit that must be applied from the SSRP is as follows:

**Table 1: PUBLIC- probabilistic risk limits**

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Average annual population risk	$10^{-8}$ fatalities per year per site (One fatality per one hundred million per year per site)
Maximum individual risk	$5 \times 10^{-6}$ fatalities per year (One fatality per two hundred thousand per year)

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For the purposes of the strategy the three principles from ICRP Publication 26 will apply, namely that the remediation actions that are carried should be undertaken as follows:

- Justification of actions

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- Optimization of protective measures
- Compliance with the limits set by the NNR

Impacts of the actions will necessitate the calculation of the effective dose equivalent and the committed effective dose equivalent for individuals and populations.

#### 4.0 REMEDIATION STRATEGIES

In order to develop technical solutions for the remediation of dispersed environmental contamination, input from various scientific and engineering disciplines, including health sciences, chemistry, physics, geology, microbiology and environmental engineering is necessary. It is also necessary to include information on the political, social and economic context. The issues of the proactive actions of regulators and public perception will also come into play. While attempting to reduce residual contamination over large areas, factors such as dose, cost, public perception and anxiety, and minimal disturbance to the environment should be taken into account. The overarching objective of the operation must be to remove or reduce the source term, or prevent the likelihood of exposure to a harmful dose.

A generic **process map for decision making** and technology assessment is given in figure 1.0 below.

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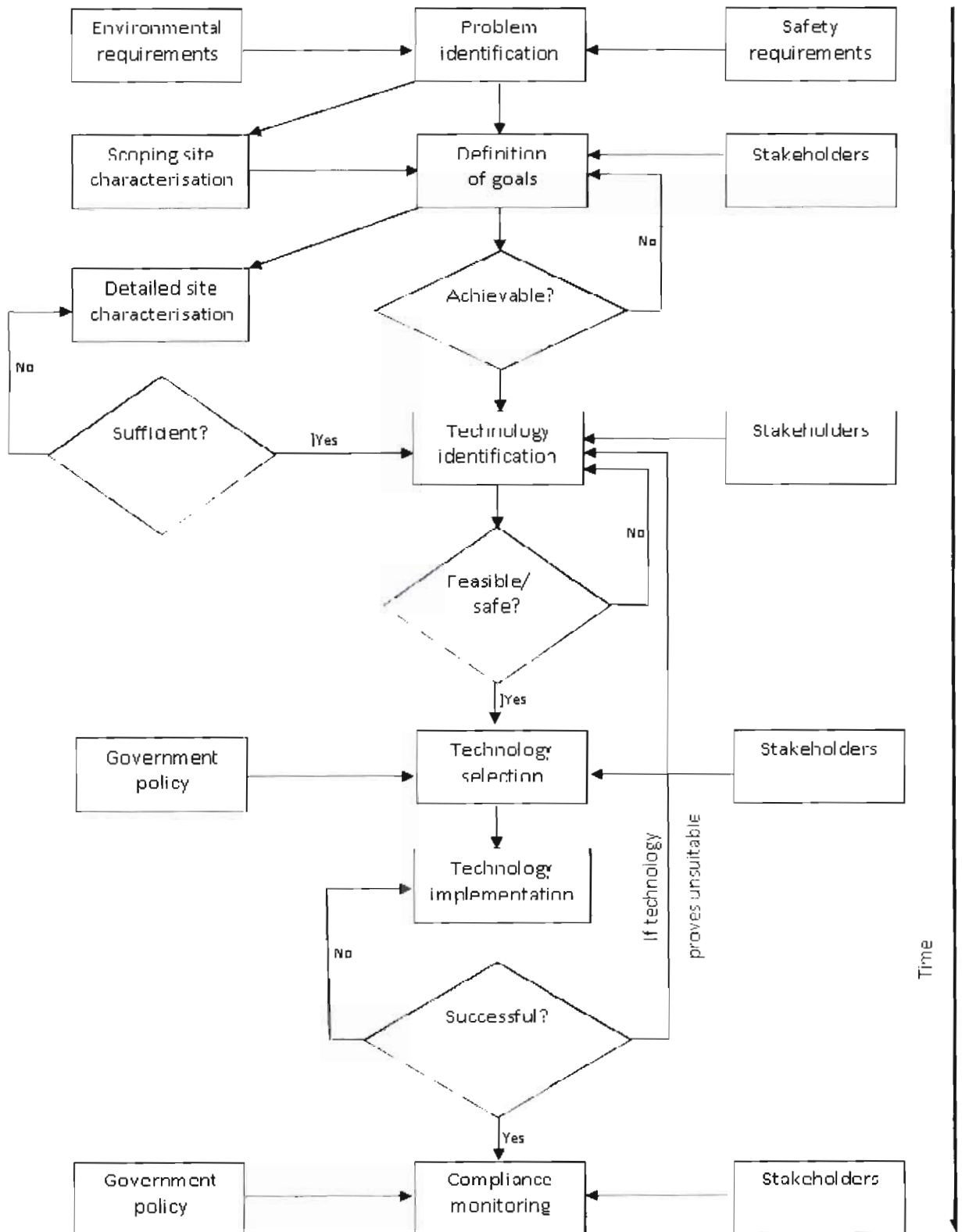


Figure 1: Process map for decision making



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## 5.0 ROLE OF THE NATIONAL STEERING COMMITTEE

The Committee was established to:

- Coordinate the facilitation and implementation of the integrated approach to the processes, solutions and decision-making related to the management of the radioactive contamination in the WCA and other similar catchment areas in South Africa.
- Facilitate the coordination of the respective legislative requirements for the pollution / contamination footprints related thereto.
- Ensure the proper and collective coordination of assessment, research, information and media matters related to cross-cutting issues that arise during the course of the work of the Steering Committee.

The Committee's work will be based on the following legislation and related provisions:

- Minerals and Petroleum Resources Development Act (MPRDA), 2002.
- Mine Health and Safety Act (MHSA), 1996.
- National Water Act (NWA), 1998.
- Water Services Act (WSA), 1997.
- National Nuclear Regulator Act (NNRA), 1999.
- National Environmental Management Act (NEMA) 1998; and
- Any other relevant Acts and operational Memorandum of agreements.

Members of SCRMRC are:

- The Department of Minerals and Energy (DME)
- The Department of Water Affairs (DWA)
- The Department of Environmental Affairs and Tourism (DEAT) and Provincial Environmental Departments;
- The National Nuclear Regulator (NNR)

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- The Department of Agriculture (DA)

### Work Done

The SCRMRRRC has met thrice thus far and work done include the following:

- The terms of reference for its existence have been adopted.
- Resolutions to focus primarily on the management and remediation of radioactive contamination from mining activities within identified areas, and to prioritize the remediation of the WCA, have been adopted.
- A WCA Technical Project Working Group (WCATPWG) has been established.
- A Project Manager has been appointed to commence with planning and coordination that will be required for the remediation of the WCA.

## 6.0 ROLE OF THE MINES OPERATING IN THE WCA

The overall responsibility for the planning and implementation of the clean-up will remain that of the responsible parties.

The responsible parties will be required to develop a public information document. This document shall be published in a local newspaper, and comment requested by members of the public, and interest and affected parties regarding the remediation efforts that will be implemented in the WCA.

The mines operating in the WCA are also required to comply with the directives issued by the NNR. The process shall also be tracked for compliance by the RENS department.

The mining operators in the WCA have been directed to undertake the following corrective actions:

- (i) To immediately conduct a comprehensive investigation in order to determine the full extent of the radioactive contamination arising from their operations over the WCA and provide a report to the NNR with respect to the findings of such an investigation.

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- (ii) Furthermore, the operators are required to provide a plan of action for the immediate control of the area to prevent exposure to members of the public.
- (iii) Review and update their environmental monitoring programme in light of the indications of radioactive contamination in the WCA.
- (iv) Provide the NNR with a schedule to review and update the Public Hazard Assessment of the mine, taking into account the additional exposure pathways.

## 7.0 NNR RESOURCING

### Responsibilities

The NNR is responsible for the following:

- Identification of all associated responsible parties and stakeholders
- The prioritization of contaminated areas
- Establishing remediation criteria and ensuring the enforcement thereof
- Be involved in the timeframes specified for the remediation activities
- Monitoring the remediation activities during implementation
- Verification that all final conditions related to the site have been met prior to termination of regulatory control over the area
- Taking administrative action to formally terminate regulatory control over the area
- Ensuring that public participation take place in regard to the remediation process
- Liaising with other regulatory bodies that have responsibility for non-radiological hazards in the same demarcated site
- Ensuring that holders comply with the directives of the NNR.
- Planning for monitoring and environmental protection during the clean-up operations
- Inspections and compliance assurance
- Authorization of actions carried out in the WCA.
- Consolidation of documents that are submitted for review and assessment by external participants

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## 8.0 RESOURCING BY CONSULTANTS

External resourcing at this stage comprised the need to engage and contract in external consultants that can ensure the proper safety assessments, remediation plans, radiation protection procedures, and radioactive waste management is carried in accordance with the requirements of the NNR.

A Specialist Task Team (STT) has been appointed as an external independent consultant.

External resourcing and project planning by the authorization holder shall include but shall not be limited to the following actions:

- Provide the necessary resources and implementation expertise for the remediation
- Ensure that appropriate administrative controls are applied for the remediation operation
- Ensure the safety of workers and the public and protection of the environment during the implementation of the remediation operation.
- Provide routine reporting to the NNR on a scheduled basis during the remediation operation
- Report to the NNR any unusual incidents that may occur during the remediation process
- Ensure the retention of records and maintenance of the procedural aspects of the remediation activities.
- The consultant to work closely with an NNR employee for skills transfer.

## 9.0 PUBLIC PARTICIPATION

Development and compilation of a Public Information Document on Remediation of the WCA.

The issues that need to be elevated for public participation are as follows:

- Consult with the key affected and concerned stakeholders.
- Identify and address their concerns and issues.
- Develop and implement an engagement plan.
- Track and analyze stakeholder WCA issues, and develop response

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### Stakeholder management

- The NNR needs to engage affected and concerned stakeholders – affected communities, farmers, mining operators, regulating bodies, local government authorities, government departments, parliamentary portfolio committees, and other interested parties such as environmental bodies and activists - in relation to the issues raised and the implementation of the corrective and remediation programme.
- The NNR needs to work closely with the affected and concerned stakeholders towards finding a lasting solution to the WCA contamination challenges.
- Key stakeholders must be identified and an engagement programme developed and implemented.

### 10.0 AUTHORISATION OF CONTAMINATED SITES

The site that shall be remediated shall be appropriately demarcated sufficiently to be called up in a formal authorization. The site coordinates shall be specified on a map of the area in order that the NNR may authorize this site. This site map shall be called up in a Certificate of Registration and shall be the site on which all clean-up operations take place. The site coordinates shall be provided to the NNR by the responsible mines operating in the area.

In terms of the tactical planning of the National Steering Committee, the areas that are prioritized for remediation shall be called up in the authorization thereafter; an authorization request can be submitted in order to include the clean-up of the other remaining areas. Since the remediation prioritization is firstly aimed at the water bodies in the WCA, the secondary priority will then focus on the land areas.

### 11.0 PRIORITIZATION OF CONTAMINATED AREAS

Contaminated areas that have been identified will need to be prioritized. The locations, types and properties of the contaminants, the environmental characteristics of the area shall be determined.

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The basis for the prioritization shall be determined in accordance with the level of risk to human health and the environment.

Other factors that need to be taken into account are:

- Socioeconomic considerations
- Deployment of available remediation techniques
- Availability of scientific data required for the site characterization
- Potential effects of adjoining properties and protection of the environment
- Availability of funds
- Inputs from the interested and affected communities

Involvement of other organs of state in influencing the decision-making regarding prioritization of the remediation will be taken into account.

It is recommended that the severity of the impacts of the contaminants on human health be also taken into account during the exercise.

## 12.0 INITIAL DECISION MAKING-REMEDATION CRITERIA

The fundamental basis for specifying remediation criteria is extracted from the International Basic Safety Standards for Protection against Ionizing Radiation (BSS). Reference levels have been defined for use with in this system of protection.

A generic reference level for aiding decisions on remediation is an existing annual effective dose of 10 mSv from all sources, including the natural background radiation. This reference level shall be used for decision making in regard to remediation option selection.

Additionally, the application of the dose limits and activity concentrations of radioactive material present in the area shall be determined in compliance with the Safety Standards and Regulatory Practices.

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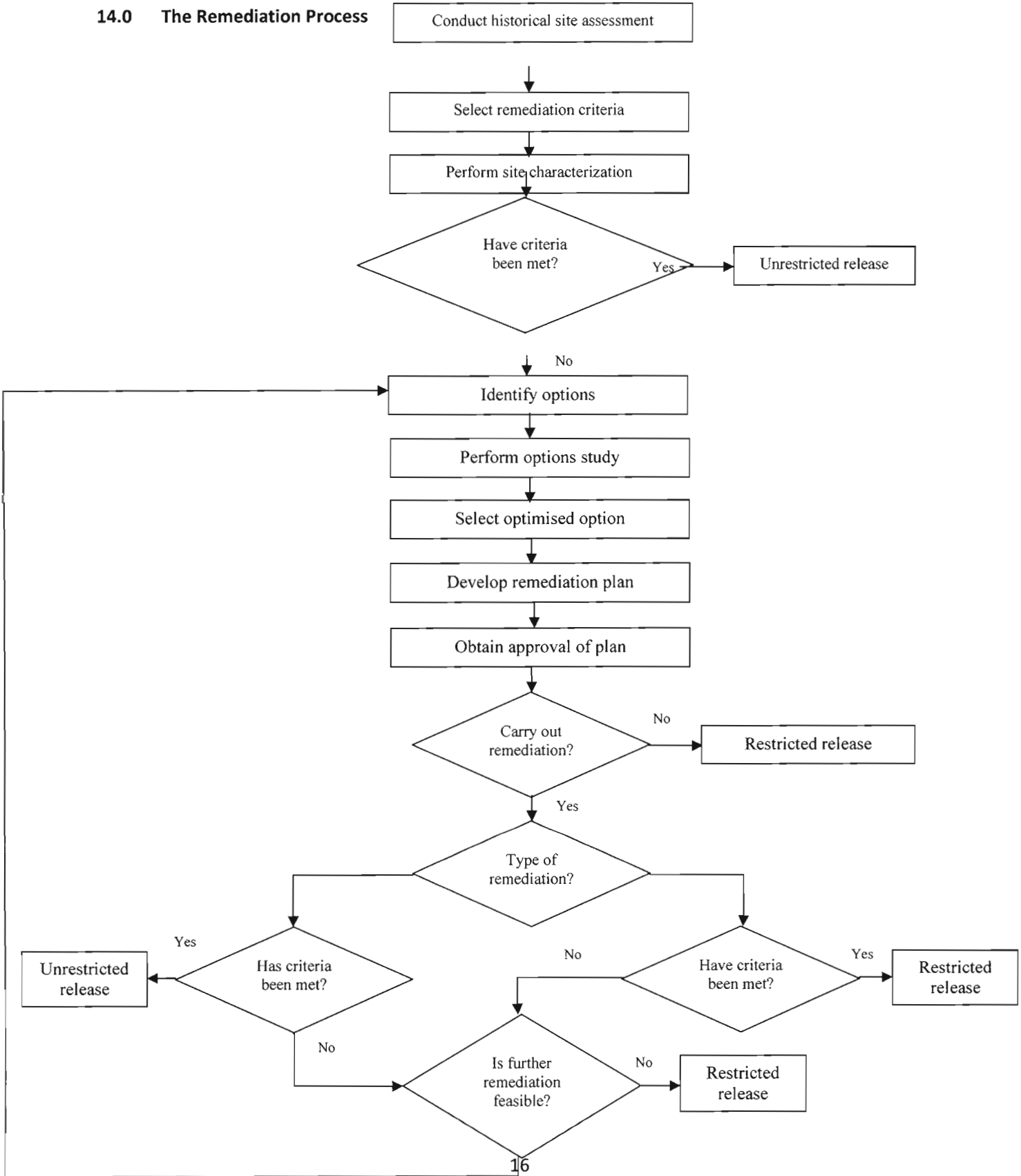
### **13.0 OVER VIEW OF THE REMEDIATION PROCESS**

An overview of the remediation process involves four main activities:

- (i) Initial site characterization and selection of remediation criteria
- (ii) Identification and selection of remediation options and their optimization
- (iii) Implementation of the Remediation Plan
- (iv) Post-remediation management

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**14.0 The Remediation Process**





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#### 14.1 Remediation technology selection

CHEMICAL EXTRACTION (Ex situ)	Disposal of contaminated soil is the option that has been most widely used to date. This involves the separation or extraction of contaminants. It would rely on the required substitution of the removed material with clean top soil. It may not be viable in the case of large volumes of contaminated soil.
SURFACE AND GROUNDWATERS: PUMP AND TREAT	Large quantities of ground water are pumped and stored in a suitable nearby location. Sediment is then removed and similarly heavy metals can be separated or extracted by chemical processes.
NATURAL ATTENUATION	This method relies on the capacity of natural media (rocks, soils, sediment, and ground water) to retard contaminant migration. This however will require adequate monitoring owing to the evolution of natural systems with time and our incomplete understanding of natural processes at a site.
ALTERNATIVE LAND USES	When extensive areas have been contaminated, many of the discussed remediation methods may be too expensive to carry out or too intrusive. Alternative uses of the land may need to be considered (for example if the land was used for agricultural purposes). These may range from considering uses such as a parkland or eco-tourism.

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PHYTOSTABILIZATION	<p>Involves the development of a stable and permanent vegetation cover that reduces the risk of erosion of contaminated soil and thus reducing waterborne and dust-borne exposure pathways. This technique may also change the mobility of toxic elements by reducing concentration in the soil matrix.</p>
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PHYTOEXTRACTION	<p>The use of plants to remove contaminants from the environment and concentrate them in above ground plant tissue. It requires that the target radioelement be available to the plant root, absorbed by the root and translocated from the root to the shoot.</p> <p><b>Uranium removal:</b> Free <math>UO_2^{2+}</math> is the uranium species most readily taken up and translocated by plants. It may require soil amendments that increase the availability of the uranium complexation.</p>
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CHEMICAL PROCESSES: CO-PRECIPIATION	<p>Radionuclides present at very low mass concentrations can nevertheless form solid phases by co-precipitation in mineral lattices. A useful example for NORM materials is the high selectivity shown by radium for barite. This may however involve establishing geochemical controls for the migration of radioelements in the field.</p>
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#### 15.0 DECISION MAKING REGARDING COST APPORTIONMENT

The parties responsible for the remediation programme must be identified. It is preferable to negotiate cooperative action with the interested parties involved in the remediation actions.

The “polluter pays” principle should be upheld and appropriate funding mechanisms established for the remediation activities. A process of consultation shall be embarked upon to establish the principles for financial provision for the clean-up of the WCA. The affected parties would need to enter into an agreement that governs the sharing of cost of clean-up.

It is recognized that the situation that led to the contamination of the area is complex and that the contamination may have been caused by exposure pathways that were unforeseen at the time of the authorization of the mines operating in the WCA.

#### 16.0 MANAGEMENT DURING REMEDIATION OPERATIONS

*Operational needs to be in accordance with authorization conditions of the CoR.*

The managerial responsibilities associated with this strategy are as follows:

- Optimization of remediation measures
- Remediation planning
- Radiological surveys during clean-up operations
- Dose Assessment for all pathways
- Training of workforce
- Site security during the clean-up
- Radiation protection during remediation
- On-site and Off-site monitoring
- Emergency planning
- Administrative control

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### 17.0 MONITORING OF OPERATIONS

The primary actions that need to be carried out in this regard are compliance with radiation protection measures ensures that workers, the public, and environment are protected during remediation operations. This work shall proceed with approved procedures that must be reviewed by the NNR prior to the commencement of the said operations.

There will also be a need for the other organs of state that have regulatory responsibilities to ensure that the operations proceed in compliance to their respective legislative requirements.

### 18.0 POST-REMEDATION MANAGEMENT

The release of areas

- The release of areas is based on the residual risks in certain instances combined with the need to ensure the long-term safety of a site that has been cleaned-up.

Monitoring and surveillance plan

- After remediation has been completed the monitoring and surveillance of the area will be based on the residual risks and their degree of uncertainty, and also on the long term viability of the radiological conditions.

Records

- Records are required to be retained that show the degree to which the remediation programme was effective, the lessons learnt, and changes that were made during implementation of the contaminated areas

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## 19.0 IMPLEMENTATION PLAN

The implementation of the strategy requires a programme of work, the execution of which will remain the responsibility of the Senior Manager: NTNS. The departments that will be required to support the work outline in the programme of work are as follows:

- ❖ The Department responsible for the Regulation of Natural Sources
- ❖ The Assessment Group
- ❖ The Stakeholder management and communication functions of the NNR
- ❖ The Legal Services Department of the NNR

### Project Implementation principles

- From the inception of the implementation ensure that comprehensive and effective planning takes place.
- In the determination of objectives associated with timeframes ensure that targets are achievable and realistic.
- The utilization of resources needs to be appropriate to expertise and experience.
- Place emphasis on reaching goals rather than resource allocation.
- Consider the centrality of effective communication for successful implementation.
- Meetings should be directed at addressing goal-directed actions and be productive in outcome.

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- Ensure the progress is monitored and measured periodically.

Ensure that all team members and supervisors as well as management has the necessary skills to execute their respective responsibilities.

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## 20.0 REFERENCES

- [1] IAEA Safety Standards Series No. WS-G-3.1, "Remediation Process for Areas affected by Past Activities and Accidents," 2007.
- [2] Technical Report Series No. 424, "Remediation of Sites with dispersed radioactive contamination," 2004.
- [3] ICRP Publication 7, "Principles of Environmental Monitoring Related to the Handling of Radioactive Materials."
- [4] Kerzner, H., "Project Management," John Wiley & Sons, sixth edition, 1998.