MILESTONES IN THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR THE URANIUM PRODUCTION CYCLE

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FOREWORD

One of the IAEA’s statutory objectives is to “seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world.” One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Article III.A.6 of the IAEA Statute, the safety standards establish “standards of safety for protection of health and minimization of danger to life and property”. The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist research and development on, and application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

Energy is essential for development. Nearly every aspect of development — from reducing poverty and raising living standards to improving health care and industrial and agricultural productivity — requires access to modern energy sources. Current forecasts suggest that global electricity use will increase 65–100% by 2030, with most of the growth in developing countries. Many IAEA Member States without current uranium mining and production activity have expressed interest in introducing or reintroducing it in order to meet their or other countries’ energy needs.

To introduce or reintroduce uranium mining and production, a wide range of aspects need to be considered. This report elaborates a ‘Milestones’ approach to the uranium production cycle to assist Member States in taking a systematic and measured approach to responsible uranium mining and processing.

The guidance in this report is provided within the context of the IAEA’s other guidance and materials relevant to the development of the uranium production cycle. These include the IAEA Safety Standards Series.

The IAEA is grateful to all the experts who contributed to this report. The IAEA officers responsible for this publication were B. Moldovan and P. Woods of the Division of Nuclear Fuel Cycle and Waste Management.
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1. INTRODUCTION

1.1. BACKGROUND

A national uranium production programme is a complex undertaking requiring careful planning. A Member State that decides to support a national uranium production programme either through national or foreign investment needs to be based on the commitment that uranium will be used for peaceful purposes. Further, development of a national uranium production programme requires the establishment of sustainable national infrastructure that provides governmental, legislative, regulatory and industrial support for the lifetime of the programme. These aspects ought to be based on accepted nuclear safety standards, security guidelines, safeguards requirements and international good practice. Decision makers, relevant governmental organizations, regulatory bodies, academic institutions and industrial organizations ought to be consulted and ensure that the required national infrastructure is developed to initiate and sustain a national uranium production programme.

This publication was developed to facilitate the assessment of progress in the development of infrastructure in a Member State that is considering a national uranium production programme. To enhance its support to Member States in the development of a national uranium production programme, the IAEA seeks to better describe and communicate an associated Milestones approach [1] to these stages in the nuclear fuel cycle [2]. First, this will enable Member States to understand the stages of knowledge and infrastructure required for them to effectively and efficiently evaluate their territories for uranium deposits. To allow for uranium exploration to occur in a Member State, indicates they intend to allow for mining and processing of the uranium ore to also occur under certain conditions. If uranium deposits are found, the knowledge to further evaluate and potentially develop them for mining and processing in a socially, financially and environmentally sound manner is required before committing to these activities.

All aspects of the uranium production cycle from cradle to grave (e.g. from exploration to site remediation) need to be considered by Member States in a logical and systematic way when planning to mine and process uranium bearing ore. Completion of activities associated with these aspects can be characterized as milestones along the road to sustainable development of a national uranium production programme. At the outset, the establishment of a national uranium production programme requires a systematic approach that can be divided into two general areas:

— Uranium exploration and resource evaluation — applicable to all Member States;
— Uranium mining feasibility studies, engineering, construction, commissioning, mining, processing and closure — applicable to Member States that find one or more potentially significant uranium deposit(s), or where uranium is a potential by- or co-product of the mining of other commodities, such as copper, gold, tin, rare earth elements, heavy mineral sands or phosphate.

Four milestones are identified for the uranium production cycle, each representing the beginning or boundary point of a stage or phase that a Member State may be currently advancing to in the progression of uranium production cycle development from exploration, mine and process facility development, operation of the mine and processing facility and finally decommissioning and remediation of the site. Sixteen aspects are identified at each phase and they ought to be considered prior to advancing to the next milestone.
This publication can be used by Member States to assess their own status of uranium production development against each of the milestones. This includes the exploration, resource delineation, licensing, construction, commissioning and safe operation of a uranium mine and processing facility, and finally, the decommissioning and remediation phase. In addition, the publication aims to support Member States to regulate and oversee uranium mining and processing activities. The publication may also be used to support self-assessment by a Member State already operating or looking to restart a uranium mine and processing facility. This publication sets the foundation for IAEA integrated uranium production cycle review missions which, upon request from the Member State, will review a Member State’s developmental progress of their national uranium production programme. Other stakeholders or interested parties, such as proponents (operators), academic institutions, suppliers and contractors for uranium mining and processing, may also find this publication useful as they advance their respective programmes.

The information presented in this publication is intended to relate the experience, lessons learned, and good practices of countries with established uranium mines and processing facilities. Experience has shown that early attention to all of the aspects presented in this publication can facilitate the efficient, safe and sustainable development and operation of a uranium mine and processing facility.

1.2. OBJECTIVE

This publication defines milestones in the development of the uranium production cycle and provides information on the activities that need to be carried out in a systematic manner at each milestone. A Member State can use it to ensure that it has:

— Recognized the commitments and obligations associated with the establishment or re-establishment of a national uranium production programme;
— Prepared the local and national infrastructure adequately for the establishment or re-establishment of a national uranium production programme;
— Developed all the competences and capabilities required to regulate and potentially operate a national uranium production programme safely, securely and sustainably, and to manage the resulting wastes.

1.3. SCOPE

The scope of this publication covers the governmental, regulatory and operational requirements to effectively and safely develop, commission and operate a uranium mine or processing facility. These requirements are considered from the time a Member State decides to begin to explore for uranium through to decommissioning and remediation, thereby encompassing the life cycle (cradle to grave) requirements.

Uranium mine and processing facility operation, waste management and decommissioning and remediation are addressed to the degree necessary for planning purposes prior to advancing to operating a uranium mine or processing facility. Good practice indicates that all key issues across the life cycle of a uranium project, including licensing, environmental assessment, construction, commissioning, operation, decommissioning, remediation and waste management, ought to be considered early in the development of a uranium mine and processing facility. The related operational planning ought to be well advanced, prior to the initiation of any construction activities for the respective mine or processing facility. Having reached the point of readiness to commission a uranium mine or processing facility, the Member State ought to have developed an understanding of the commitments required for safe operation of these facilities and have programmes in place that are sustainable for the life of the respective
operation through to its decommissioning, remediation and subsequent long term management, ensuring they have “started with the end in mind”.

This publication covers the milestones of the front end of the nuclear fuel cycle up to the point of production and transportation of uranium ore concentrate (e.g. yellow cake) and management of its wastes. Refining, conversion, enrichment of uranium and nuclear fuel fabrication are outside the scope of this publication. This publication is not intended to be a comprehensive guide on feasibility studies and project management, but rather presents the national infrastructure requirements that ought to exist at significant times in the development process.

1.4. USERS

The main users of this publication will be government decision makers and decision influencers, such as advisors in relevant government departments, regulatory bodies involved in regulation of uranium mines and processing facilities, the uranium exploration and mining/processing industry and researchers, including those in academic institutions. This publication is intended to be used as guidance on how to evaluate the progress toward establishing a national uranium production programme and to aid in planning the steps necessary to develop the national infrastructure requirements for uranium production in a Member State.

1.5. STRUCTURE

This publication consists of three main sections, including the introduction. In Section 2, the four major milestones are presented, along with a brief description of each milestone. In Section 3, a total of 16 relevant aspects of these four milestones are presented, along with the desired conditions required to achieve each milestone. The appendices provide two relevant case studies. A comprehensive list of References completes the publication.

2. THE MILESTONES

2.1. KEY CONCEPTS

A milestone describes a set of conditions that would be expected to be achieved before advancing into a new phase in the development of the life cycle of a uranium project. For a Member State to prepare for the introduction of uranium exploration and potentially uranium mining and processing, several activities need to be completed. These activities can be divided into five progressive phases of development. A description of the conditions that would be expected to be achieved in each phase of the development of a uranium mining and processing programme is provided. The term ‘milestone’ refers to the conditions that are required for a Member State to show that activities have been completed before advancing to the next phase of uranium mine and processing facility development.

Five generalized phases are considered to characterize the development of a national uranium production programme. The five phases on development are:

— Phase 1: Considerations before a decision to explore for uranium;
— Phase 2: A Member State undertakes exploration for the first time, or the first time in many years, but with no significant commitment to proceeding to mining and processing;
— Phase 3: A Member State initiates or reinvigorates uranium mining development with known exploitable uranium reserves;
— Phase 4: A Member State commissions and operates a uranium mine and processing facility or increases current capacity;
— Phase 5: A Member State with uranium mines and processing facilities at the end of mine life or at a stage where mine sites are made safe but kept in a state for possible reopening in the future.

2.2. THE MILESTONES

The completion of the infrastructure requirements prior to advancing into the next phase of development is marked by a specific milestone at which progress and success of the development effort can be assessed and a decision made to advance into the next development phase. The four milestones within the uranium production cycle are:

— Milestone 1: Ready to make a commitment to explore for uranium;
— Milestone 2: Ready to commit to develop a uranium mine and processing facility;
— Milestone 3: Ready to operate a uranium mine and processing facility;
— Milestone 4: Ready to decommission and remediate a uranium mine and processing facility.

Following Milestone 4, once all legal requirements have been met and verified by the post-decommissioning and remediation monitoring period, the proponent has the right to apply to the regulatory body to be discharged of all further legal, financial and regulatory obligations of the project. If approved, the site would then be eligible to apply to enter into an institutional control framework. The institutional control framework is outside the scope of this publication and would become a separate forum for discussion with the IAEA staff. A schematic representation of the five phases and four milestones for the development, operation and decommissioning of a uranium mine and processing facility is illustrated in Fig. 1.
Essentially, like any other mineral derived raw material, uranium is where it is found, and it may or may not be technically, socially or economically viable to extract. Overall, mining in general is considered a temporary use of the land, with some operations extending from say ten to fifty years in duration, or even longer. Following a successful decommissioning and remediation phase and agreement that the remediation has achieved end state as approved by the regulatory body, the lands ought to be returned for public or private use under a long-term institutional control programme.

In the development of a national uranium mining and processing programme within a Member State there are typically three major organizational entities involved. These are the government, the owner/operator (proponent or responsible party) of the uranium mine and processing facility and the regulatory body. Each has a specific and independent role to play with responsibilities changing as the programme advances. It is assumed that the government will be the entity that initially supports exploration for uranium and development of national infrastructure for uranium mining and processing through a well established national policy and strategy and also funding for these activities. This includes the development and funding of an independent regulatory body. The owner/operator (proponent) may be State owned or be another commercial entity or be a combination of the two. The regulatory body needs to be effectively independent from the owner/operator and other government agencies responsible for development of the uranium production programme but may exist within the government. Each of these entities is also accountable to the public, stakeholders, and other interested parties and these entities ought to be informed and consulted throughout the uranium production cycle.

For each milestone, 16 aspects that need to be considered are included in the discussion for each of the milestones. These aspects are summarized in Table 1. The order of the aspects is not based on hierarchy or importance as each aspect is important and requires careful consideration. The three main entities noted above (government, owner/operator, regulatory body) need to be aware of all these aspects and to manage them according to their respective roles and responsibilities.
TABLE 1. URANIUM PROGRAMME DEVELOPMENT ASPECTS AND MILESTONES

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2.2.1. **Milestone 1: Ready to make a commitment to explore for uranium**

This section describes the background and key considerations when planning for a uranium exploration programme (Phase 1) and the conditions that ought to be met prior to initiating an exploration programme for uranium (Phase 2).

Each Member State interested in uranium exploration ought to have or acquire adequate knowledge of the uranium potential of its own geological situation. For the assessment of undiscovered uranium resources both spatial/qualitative and quantitative approaches can be considered. Early exploration qualitative methods (e.g. literature studies, geology, geological surveys) are mainly focused on exploration targeting and project generation, while late exploration quantitative methods (e.g. drilling, geochemical assaying, processing tests) are used for the assessment of potential recoverable mineral resources. The application of qualitative methods allows for the efficient location of the exploratory targets with greater chances of locating uranium deposits of a certain typology. Quantitative methods are applied depending on the geological knowledge and the degree of similarity of the deposits that could be found in a given domain to determine the potential uranium ore grade and order of magnitude of uranium ore tonnage at the level of undiscovered resources. Grade–tonnage models and deposit density models of uranium deposits are required at this stage to complete this type of uranium potential modelling.
The estimation of undiscovered uranium resources constitutes a valuable tool to sustain the national policy on planning exploration and potential mine projects, in accordance with the adopted nuclear supply strategy, independent of immediate uranium requirements. The aforementioned supply strategy may take into account both the domestic supply for the manufacture of fuel to be used in nuclear reactors within the country or the delivery of uranium ore concentrate abroad. However, the magnitude and economics of the eventual emerging production projects needs to predict the real possibilities of competing in the international market.

Exploration projects can lead to the discovery of uranium deposits and the subsequent evaluation of identified resources. This process can take several years, beginning with consultation and engagement of all interested parties with an ultimate goal of obtaining and maintaining informed consent of the exploration activity. Due to social, political, economic and technological factors only a small fraction of the uranium resources identified have advanced to production. Thus, expectations need to be understood and managed carefully at every stage, especially with stakeholders, and communities in project areas through well-disseminated informational materials, opportunities for consultation, and managed public education campaigns.

The exploration process to confirm a new uranium deposit takes on average 10–15 years, from the moment that the very first indications are discovered to the confirmation of a potentially recoverable resource. Further, exploration may continue throughout the life of the mining project to identify additional potential recoverable supplementary resources in close proximity to the initial deposit. With site infrastructures already in place (processing plant, mine shops, waste management areas, access roads, etc.) the economics of finding another orebody nearby the existing mine become very attractive. In open pit operations, deep exploration drilling can be executed while production is ongoing from the open pit, and additional uranium resources can be added to the existing resources if results are favourable.

Different phases of exploration can be considered, as outlined in the subsections that follow.

2.2.1.1. Selection of favorable areas for exploration

There are many factors to consider when planning an exploration programme within a Member State. These include geological factors, logistics and accessibility, environmental and social impact, land use, and economic and political issues. At the outset, political and geological factors are the most important of these. However, the others, which will grow in significance if the project progresses, also need to be considered from the outset to ensure that an exploration programme results in the achievement of its objective, namely the development and exploitation of a mineral deposit. Identification of additional elements of economic interest may also occur, and this may increase the viability of the project if other resource streams are identified. Geological factors include knowledge of the local geology, including previous geophysical surveys (in particular radiometric), geochemistry, geomorphology, drilling and analytical logging data and past production activities.

Historical information regarding the geology within a Member State can be obtained from government records, mining companies, universities, private exploration companies and IAEA and NEA publications. Relevant publications include Quantitative and Spatial Evaluations of Undiscovered Resources [3], Geological Classification of Uranium Deposits and Description of Selected Examples [4], Uranium Resources Production and Demand [2], Forty Years of Uranium Resources, Production and Demand in Perspective: The Red Book Retrospective [5], World Distribution of Uranium Deposits (UDEPO) [6] and World Uranium Geology, Exploration, Resources and Production [7]. Information obtained from exploration for minerals other than uranium may be used. For example, coal and oil exploration companies typically
have radiometric information recorded in their drilling results. In Australia, the Olympic Dam project is essentially a copper mine, but their resource streams include additional mineral reserves of uranium, gold and silver.

2.2.1.2. Exploration licence or permit

An exploration licence or permit (in essence both are the same at this stage in the uranium production cycle) provides the holder with the exclusive right to explore for a specified mineral group within the exploration licence area, during the term of the licence. Prior to physically exploring for minerals, interested parties, including organizations, first need to obtain an exploration licence (or permit). The definitions and rules may differ between countries and licences (or permits) are issued according to the mining laws of the host country. An exploration licence (or permit) does not allow mining, nor does it guarantee that a mining lease will be granted. Only a very small percentage of land that is subject to exploration licences/permits is developed into a mine. However, rules for the repartition of the stakes in a future project (between the investor and the country) can be included in the exploration licence/permit.

2.2.1.3. Regional prospecting

The objective of regional prospecting is to define the geological context of a selected area and potential zones for additional work. Regional prospecting includes geological mapping, remote sensing studies, airborne surveys, geochemical analysis and reconnaissance drilling to better define local geology. Regional exploration ought to focus on geological areas that have the potential to host uranium deposits. Selection of geological areas for more detailed exploration ought to be based on positive results from detailed and comprehensive analysis of all available geological, geophysical, geochemical and remote sensing data. The main activities at this phase of exploration will be the identification of potential uranium hosted areas, staking of claims and application for relevant exploration licences (permits).

2.2.1.4. Detailed exploration

Once areas favourable for uranium mineralization, including ore grade or near ore grade mineralization have been identified, the next stage of exploration may begin. In general, the specific activities in detailed exploration include geological surveys, radiometric mapping, geochemical analysis, geophysical studies and drilling. Clear guidance to the managers of the exploration programme needs to be provided to protect workers and the environment. In most cases, ground geophysical surveys and drilling are essential to advance exploration at this stage. Detailed exploration involves a stage gate decision process. As such, during the detailed exploration stage, the potential of the zone for uranium mineralization will be evaluated and a decision will be made whether to proceed to definition and resource estimation or to remediate and vacate the exploration area.

In addition, during the first stage of detailed exploration an environmental baseline study needs to be considered if there is potential the project may proceed. The assessment ought to evaluate the baseline conditions of the site to support the determination of the anticipated impacts on the flora, fauna, wildlife and economy and assess relevant historical and social factors. This is particularly important should the project advance to the mining stage. The preliminary baseline information that ought to be collected includes site location, meteorology, surface hydrology, hydrogeology (water quality, aquifer properties), flora and fauna, wildlife, soil/subsoil, background radiological characteristics, background non-radiological characteristics (heavy metals, pollutants), previous and current industrial and agricultural activities, local population, employment opportunities and other environmental features. This
assessment ought to be conducted in consultation with local organizations and communities [8–10].

2.2.1.5. Delineation drilling

The delineation drilling stage of an exploration programme begins when the potential for significant resources has been recognized (during the detailed exploration stage) and a decision has been made to fully evaluate the prospect and perform an accurate determination of the resources. At this stage, it is essential to drill holes on a well-defined grid pattern, so an accurate estimation of resources can be made. The spacing of that grid pattern will depend on the nature of the mineralization and in particular its spatial continuity. The spacing of delineation drill holes is also dependent on the degree of confidence that is required before a decision to begin mining can be made. If the deposit is only marginally economic, then the resources will need to be determined quite accurately and the drill hole spacing may need to be quite small. Activities at this stage may include detailed geophysical, geological and geochemical analysis, topographical analysis, detailed drilling and logging, chemical analysis of drill core samples or drill cuttings, resource estimation modelling, mining tests and hydrometallurgical process evaluation tests (laboratory scale and pilot plant). Increased regulatory oversight and controls are also common during this phase, and once again clear guidance to the managers of the exploration programme needs to be provided at this stage to protect workers and the environment. The outcome of the delineation drilling stage is a well-defined uranium deposit with mineral resources and/or ore reserves if results are favourable. Expansion of the environmental baseline studies EIS may also be required, as localized impacts from the expanded delineation drilling can occur.

2.2.1.6. Resource estimation

Resource estimation is an ongoing activity through the life of a mine, starting at exploration and continuing through development and production. The decision whether to develop a mine to extract uranium from the defined deposit is made at this stage. Mineral resource and reserve classification are assigned to mineral deposits based on their geological certainty and economic value. Classification, because it is an economic function, is governed by statutes, regulations and industry best practice norms. There are several classification schemes globally which are aligned with the international (CRIRSCO) code [11] and the NEA/IAEA classification scheme for uranium resources [2]:

— The Canadian CIM classification (NI 43–101) [12];
— The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the JORC Code) [13];
— The South African Code for the Reporting of Mineral Resources and Mineral Reserves (SAMREC) [14].

2.2.1.7. Reporting

Reporting requires accuracy, reliability and transparency in the information from exploration results, resources and reserves. Many developing countries do not utilize national codes for reporting mining project data and results and further action is required to establish adequate legislation and a regulatory framework for reporting, as well as capacity building in the areas of administration and infrastructure (e.g. qualification committee, professional registry of competent persons). In contrast, publicly traded uranium exploration and mining companies usually report project deliverables using a codified set of rules and guidelines for
reporting and displaying information related to mineral properties. Examples from Australia (e.g. the Australasian Joint Ore Reserves Committee (JORC) Code [13]), Canada (e.g. the Canadian National Instrument 43–101 [12]) and South Africa (e.g. the South African Code for the Reporting of Mineral Resources and Mineral Reserves (SAMREC)) align with the International Committee for Mineral Reserves International Reporting Standards (CIRSCO) Code [11]. A reporting scheme specifically for uranium resources was developed by the Nuclear Energy Agency (NEA) and IAEA [2] and is used by many Member States to report uranium resources.

2.2.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

In preparing the infrastructure to be ready to initiate or reinvigorate uranium mining and processing (e.g. Phase 3) following identification of a uranium resource, there are several sequential activities that need to be completed. These include: (i) understanding the orebody and surrounding host material; (ii) understanding the environmental conditions; (iii) mine plan and processing facility development; (iv) infrastructure and services plan development; (v) application for a licence to construct and a licence to operate; (vi) mine and processing facility construction; (vii) commissioning; and (viii) understanding decommissioning and remediation requirements.

2.2.2.1. Understanding the ore body and surrounding host material

The first stage of mine development involves gaining an understanding of the orebody and its surrounding host material. This is accomplished via additional delineation drilling, which will provide information on the depth, spatial geometric layout and hydrogeological conditions of the deposit. From these data a decision can be made as to whether to advance with underground mining, open pit (strip) mining or in situ recovery [15–17]. This drilling programme will also provide information regarding ground stability and dewatering requirements. Finally, this level of delineation drilling will provide information on the amount of mine rock that will be generated during the development and mining phases. Adequate segregation and management, including storage and treatment where appropriate, of mine rock material (including radiological free clean rock and mineralized radioactive (contaminated) waste rock) from a safety and environmental perspective also need to be considered. Clean mine rock is a valuable construction material, and this asset ought to be identified early in the process.

From a processing perspective, the delineation drilling programme will provide spatial information on the uranium grade of the ore deposit and its mineralogical and geochemical nature. The uranium grade and geochemistry of the ore are required to determine the processing and tailings management method that will be employed to extract and produce a marketable uranium concentrate.

This knowledge base may already exist for a pre-existing developed mine and processing facility during the previous mining campaign(s). From a due diligence perspective, however, such as is likely to be required by an investor or lender, a comprehensive review of the updated information is necessary to assess any changes in ground and hydrogeological conditions. In addition, a detailed review of any existing mine plan is required, and additional drilling may be necessary to confirm the reserves and resources and verify that the current mine plan is still accurate and meets current or modern safety and regulatory requirements.

2.2.2.2. Understanding the environmental conditions

The second activity in developing a mine is to develop a comprehensive understanding of the local environment and the potential impacts that mining activity could have on the local
biota. This may be summarized in an environmental (or environmental and social) impact study (or statement (EIS or ESIS), or assessment (EIA, ESIA), or similar) [8–10]. During this phase the activities are moving into a more comprehensive EIS as the extent and possible duration of the project are further defined.

According to the IAEA General Safety Guide GSG–10 [18] “In the framework of international legal instruments or national laws and regulations, States may also require that for some facilities and activities, a governmental decision making process, including a comprehensive initial assessment of possible significant effects on the environment, be carried out at an early stage in the development of the facility or activity. In this case, the radiological environmental impact assessment is generally part of a broader impact assessment, which is generally referred to as an ‘environmental impact assessment’ or by its common abbreviation EIA. An environmental impact assessment prospectively evaluates biophysical impacts (including radiological impacts) and also covers social, economic and other relevant impacts of a proposed activity or facility prior to major decisions being taken. In the context of this Safety Guide, the term ‘governmental decision making process’ refers to the procedures carried out at all planning, pre-operational, operational and decommissioning stages by the government or governmental agencies, including the regulatory body, in deciding whether a project for a facility or an activity may be undertaken, continued, changed or stopped.”

As such, an improved understanding of pre-existing conditions forms part of the environmental baseline study. This will identify the condition of, for example, the water courses, groundwater, transported dust, wildlife, biota, flora and fauna. Project stakeholders, including the authorities and those in close proximity to, or dependent on the water, biota, wildlife, flora and fauna in the region, ought to be consulted on the possible implementation of the uranium production project. Timely engagement of all stakeholders early in the project, starting with the exploration phase, is recommended: Obtaining social acceptance of the project may be the most prolonged step in the study phase of any mining project.

Both water and waste management ought to be included in an EIA. In keeping with all mining projects, water ought to be considered to be a critical resource in terms of usage and overall management including treatment and, where possible and as approved by the regulatory body, disposal. Consideration ought to be given to maximizing efficiencies for water use in mining and processing and that clean waters are not unnecessarily contaminated by mining or processing activities. Wastes such as those derived from stripping any overburden from the ore need to be characterized so that their location, either temporary or final, can be identified and decommissioning and mine closure activities and costs need to be considered at the initial stages of mine development as part of a full life cycle analysis (LCA).

It is important to note that the operator ought to develop end of mine life plans at this stage and before operations commence. Aspects to consider in the end of mine life plan include decommissioning and remediation objectives and costs, desired end states and future land use options, including long term institutional control if appropriate.

2.2.2.3. Mine plan and processing facility development

Once the resources and reserves have been delineated and an understanding of the structural geology and ore deposit has been gained, the next step is to develop a detailed mine plan. Also, environmental baseline conditions and preliminary environmental impacts ought to be assessed at this point. The mine plan ought to detail the type of mining proposed, the development and infrastructure requirements, and the dewatering and hydrometallurgical processes. Depending on the type of mining proposed, specific safety and training programmes ought to be developed to ensure the safety of the workers and the general public. Some considerations include ground stability, ventilation, dust control, radiation safety (monitoring and management of gamma, alpha, long lived radioactive dusts (LLRD)), electrical safety,
conventional construction and operational safety, and safe operation of mining, transport and processing equipment. The mine plan also needs to include an understanding of the skilled workers required to manage and operate the mine. This can have an impact on the schedule of the project should extensive training be required prior to developing, commissioning and ultimately operating the mine.

Based on the type of mine (ISL, underground, open pit) and processing facility proposed, a detailed engineering and construction plan needs to be developed. This includes the mine workings and associated infrastructure. For the hydrometallurgical processing facility, the ore mineralogy and geochemistry, and pilot plant test work will determine the processing options. The mine and processing facility construction plans ought to be developed by a multi-disciplinary team that will include geologists and mining, processing, civil, mechanical, environmental, and electrical engineers, as well as a project management team to develop project, scope, budget, schedule, procurement, commissioning and start up plans [19–22].

2.2.2.4. Infrastructure and services plan development

Infrastructure and service requirements including procurement also need to be considered during the planning stage of the mine. These include, but are not limited to, the adequacy of the local electrical grid to support mining activities, access to water, roads, emergency response, administration offices, maintenance, warehousing and worker residence (camp facility), if required. The ability to readily procure equipment, spare parts, bulk reagents and fuels also ought to be taken into consideration.

2.2.2.5. Application for a license to construct

Applicable regulatory approvals ought to be requested at this point, prior to advancing the mining project to the construction phase or restarting an existing mine. This may include formal public meetings to provide the public, non-government organizations and regulators, and others interested stakeholders an opportunity to participate, provide feedback and ask questions on the safety, environmental and socioeconomic aspects (EIA, EIS) prior to approval of a mine project. The entire process, from resource delineation through to regulatory hearings, may take 5–10 years to complete due to the complex nature of each of the phases of mine and processing facility development.

At this stage, the Member State ought to have a regulatory framework developed including all necessary policies, standard operating procedures and related regulatory oversight and reporting frameworks for construction and eventual operation of the facility. This includes aspects such as radiation protection, conventional safety, and waste management. In addition, the Member State ought to have environmental regulations that require the operator to meet regulatory requirements for environmental performance that are in keeping with the best available and practical technology. There also ought to be guidelines and regulations in place for management systems such as human resource development (e.g. recruitment and training), information knowledge management and contractor management to ensure safe, reliable production. This infrastructure would be expected to be in compliance with international standards and would cover all current activities, practices and facilities in that Member State [8, 21].

2.2.2.6. Mine and processing facility construction

Once regulatory approval has been granted to construct the uranium mine and processing facility, construction may begin. Construction is a structured, regimented process. The proponent may contract a specialized company, or numerous companies to complete the
construction of the facility. Each stage of construction needs to be carefully scrutinized and completed without deficiencies and be approved by senior management prior to advancing to the commissioning phase.

At this stage, operators need to have an approved preliminary decommissioning plan in place and an appropriate funding mechanism identified, to ensure that decommissioning and remediation activities can be completed by the operator at any stage going forward. This removes any burden on government or the public in the event the operator was to abandon the project on short notice.

2.2.2.7. Mine and processing facility commissioning

Commissioning can be defined as a series of systematic steps to ensure that all constructed systems and components of the mine and process facility are designed and installed as per design and that all systems and components will operate to ensure safe and reliable operation. Ideally, initial commissioning (e.g. functional testing) of all systems and components ought to be a specific and staged part of the construction cycle, as the contractor hands off the facility to the operator. Final commissioning with uranium ore ought to be delayed until all systems and components are determined to be compliant to design. Commissioning or start up of a mine and process facility with mine equipment and uranium ore fed into the processing facility increases the risk of a serious safety incident (including fatality) or a significant environmental release that can impact on public safety, unless it is well planned and the proper regulatory approval is given. A formal, structured commissioning plan needs to be developed and executed such that commissioning is completed in a systematic and safe way as the mine and processing facility advance toward full production. Mine and processing facility construction, commissioning and ramp-up may take three to five years, depending on the complexity of the project.

At this point the conditions outlined in Milestone 2 for mine and processing facility development ought to be met and the proponent is ready to advance to Milestone 3 where they are ready to operate a uranium mine and processing facility.

2.2.2.8. Understanding decommissioning and remediation requirements

Good environmental site planning in Phase 3 includes the full lifecycle plans, through to the post-decommissioning period, so that the project "starts with an end in mind" and ensures sustainability from cradle to grave. The operator ought to propose acceptable decommissioning and remediation plans for the orderly closure of the site, even before the initial construction license is issued. This planning provides an opportunity for the stakeholders who are engaged in the EIS phase for the first license, are also aware and can support the final site configuration or close-out options.

The decommissioning and remediation plans ought to address key factors such as:

- Any infrastructure or access roads that will remain;
- Site topography, revegetation and general regrading to local standards;
- Mine rock piles resloped and covered as necessary;
- Mine areas returned to a natural configuration; waste management sites closed and wastes isolated;
- Environmental monitoring and surveillance after decommissioning to ensure that the mine closure activities are adequate, and they are functioning as planned;
- The options for long term institutional control. Financial guarantees to cover all costs associated with the decommissioning and remediation ought to be considered at the first construction license and updated with every subsequent license thereafter.
2.2.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage, the operator is ready to begin to mine and process uranium ore, including its shipment offsite for processing. The Member State ought to have a regulatory framework fully functional with standard operating procedures and related regulatory oversight and reporting frameworks to oversee the operation of the facility, including transportation safety. The Regulatory Body ought to ensure that the operator has an effective management system and related staff capabilities to ensure that the operation meets current regulatory requirements.

The regulatory requirements need to be the foundation for operations either looking to increase capacity or to come on-line for the first time. Revitalized or new operations need to, at minimum, meet current regulatory requirements for safety, environmental performance and compliance with required management systems. As technology advances, new operations or revitalized operations are expected to adopt the best available technology to optimize production efficiency while ensuring protection of the workers, the public and the environment. In addition, prior to commissioning a new operation or revitalizing an existing operation with the intent to increase production capacity, a detailed risk assessment on critical aspects of the uranium mine and processing facility needs to be completed, followed by the development of a risk mitigation strategy [8, 23] to ensure sustained safe and reliable production.

2.2.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Prior to decommissioning and remediating a uranium mine and processing facility, a Member State needs to have regulatory infrastructure developed based on international guidance such as the IAEA Safety Standard for decommissioning of facilities [24]. A Member State that has uranium mines and processing facilities that are either reaching end of life or are already closed needs to ensure that the operator (or in some cases the State) meets the conditions outlined in national regulations for decommissioning and remediating closed uranium mines [25, 26]. A comprehensive closure plan including decommissioning and remediation complete with monitoring activities ought to be developed by the operator in accordance with the regulatory requirements, noting that different stages of closure may require separate approvals from the regulatory body (or bodies). Closure of a mine and processing facility is complex from both an operational and regulatory perspective. To prepare a mine and processing facility for closure the first step would be to complete all mining and processing activities. The operator would then complete decontamination and demolition of all required mine and processing facility infrastructure and have a well defined plan for management of mine wastes and effluents. The final step would be for the operator to remediate all affected areas to a pre-determined condition suitable for final lands use. All of the aforementioned activities require review and approval from the relevant regulatory bodies before commencement of decommissioning and remediation. Remediation may be a long-term process, in some cases lasting several decades, and both the regulatory body and the operator need to be aware that remediation may require long-term monitoring until a find state is confirmed. Upon completion of all decommissioning and remediation activities the operator may then apply to transfer ownership of the lease to a representative government body through a prescribed institutional programme.

The closure plan needs to be assessed and approved by the regulatory body and may include consultation periods with interested parties. The operator needs to show due diligence during decommissioning activities that is verified through on-going monitoring. In addition, operators need to have funding and qualified personnel in place to ensure that decommissioning and remediation activities are completed, and the impacted site or area is returned to an end state agreed with relevant interested parties and approved by the regulatory body. The end state
is defined as “A predetermined criterion defining the point at which a specific task or process is to be considered completed. Used in relation to decommissioning activities as the final state of decommissioning of a facility; and used in relation to remediation as the final status of a site at the end of activities for decommissioning and/or remediation, including approval of the radiological and physical conditions of the site and remaining structures.” [27]. The operator and Member State ought to be aware that decommissioning activities may take a decade or longer to complete.

Mines or processing facilities that are put into a care and maintenance state need to do so in accordance with the relevant guidance and licenses issued by the regulatory body. The operator needs to present a comprehensive care and maintenance plan to the regulatory body for review and approval that demonstrates that the facility is in a safe state and workers, the public and the environment remain protected. An overview of the general safety requirements for protection and safety for workers and the public is described in IAEA Safety Standards [28] and [29].

In developing the care and maintenance plan, consideration ought to be given to decommissioning and remediating areas of the lease that will no longer be used, should the mine or processing facility resume operation in the future. This may include structures such as mine rock dumps or waste management facilities or any other disturbed areas that will no longer be required should operations resume. In addition, all activities that support environmental compliance (e.g. treating tailings pore water/supernatant or runoff from contaminated waste rock dumps) are to be sustained while an operation is in care and maintenance, in accordance with the appropriate license issued by the regulatory body.

2.3. PRIVATE–PUBLIC DECISIONS

The government ought to consider the roles that public (government) and private enterprise can undertake in its jurisdiction for the development of a uranium production programme. This may depend on national legislation that might define uranium as a strategic mineral under exclusive ownership and development by the government and its agencies, through to the consideration of uranium as one of many types of privately owned metal mines, with the addition of radiation protection and international safeguards and security arrangements.

A government agency such as a geological survey will typically be involved in gathering and publishing general geological, geochemical and geophysical information, including maps and geological publications. This could be on a national scale, or in some larger countries, on a State or provincial government scale. In addition to general geological information, a general geological survey or the geological branch of a national atomic energy agency, authority or commission may undertake targeted geological studies regarding uranium occurrence and prospecting in a country. This can be known as pre-competitive geological information.

Further and detailed exploration for uranium could then be taken up by private companies (such as what is currently done in Australia, Canada, Namibia, South Africa, the United States of America), by a government agency or government owned company (e.g. Brazil, Jordan) or by a combination of private and government or government owned organizations (e.g. joint ventures in Kazakhstan).

Similarly, if a potentially minable deposit is discovered, the next stage of resource delineation and staged feasibility studies could be undertaken by the government agency or government owned company (e.g. Brazil, Jordan, Viet Nam) or by private companies (e.g. Mauritania, Namibia, Turkey).

Many forms of private–public partnerships are known. It can involve passive government equity in private companies, joint ventures between government owned and private companies
(e.g. Kazakhstan), partial financing from parastatal or state-owned organizations, or other arrangements.

Normally, a form of monetary, infrastructural or social return is negotiated between an operator and State/provincial and/or national governments. This may include direct and indirect taxes, royalties, tax breaks or incentives, provision and sharing (with possible handing over) of infrastructure (e.g. water supply, roads, electricity supply), training and scholarships, or provision of or assistance with education and health services, and can take many other forms.

This publication notes the importance of these aspects but does not attempt to analyse or provide guidance on the most appropriate forms of private–public arrangements or societal returns.

3. ASPECTS OF MILESTONES

The following section provides additional detail on the sixteen aspects (Table 1) associated with the development of a uranium production programme, with each of these aspects requiring specific actions during each phase. Completion of the identified actions represents attainment of the conditions for achieving the associated milestone. As discussed previously, the order of these aspects does not imply importance or hierarchy. All aspects are important in the development of a uranium production programme and require appropriate attention.

3.1. NATIONAL POSITION

The government ought to adopt a clear policy stating long-term support for uranium exploration, mining, processing, transportation and sales or uranium ore concentrate, and communicate that intent locally and nationally. The government policy ought to identify that these facilities will have measures put in place so they are operated to achieve the highest standards of safety that can reasonably be achieved [30]. The national policy may define uranium as a strategic mineral under exclusive ownership (meaning development by the government and its agencies), or uranium may be considered as one of many types of privately owned mineral commodities. The national policy may also describe the economic benefits of uranium mining on both local and national economies. Consideration may include employment opportunities (both direct and indirect) and economic value added through taxes and royalties. Examples of these economic benefits are illustrated in the Namibia Case Study (Appendix I).

In line with the national policy, the rationale for pursuing a uranium production programme within a Member State may then be either strategic (to ensure a reliable source of uranium to support domestic needs) or economic (to market uranium on a global basis), or both. Strong government support, both provincially and nationally, is vital for the successful implementation of a uranium production programme as part of the front end of the nuclear fuel cycle (e.g. uranium exploration, mining and processing). The intent to support and develop such a programme ought to be announced at the most senior level of government. Further, a stable national government is required to ensure sustainability of the uranium mining industry [21]. Careful consideration and effort for ongoing dialogue may be needed to maintain the long-term political, economic and social stability required throughout the life of a uranium project.

If attraction of foreign investment is required to fund development of uranium mining, then a stable government is important to attract such investors as investors will not develop in a country where they cannot be assured of continued beneficial ownership and operation of the uranium mine. Overall, the national policy developed for uranium exploration, mining, processing, decommissioning and remediation and needs to be stable, transparent and aligned with other relevant and related national policies.
The government ought to include in their national policy a strategy for safety, as described in the IAEA’s GSR Part 1 [31]:

“The implementation of which shall be subject to a graded approach in accordance with national circumstances and with the radiation risks associated with facilities and activities, to achieve the fundamental safety objective and to apply the fundamental safety principles established in the (IAEA) Safety Fundamentals.”

The national policy also identifies the basis of national legislation and the regulatory framework for uranium mining. As part of the development of a national policy, the government ought to introduce how regulations and an independent regulatory body to regulate uranium mines and processing facilities will be implemented or expanded to protect the health and safety of the workers and public as well as to regulate nuclear safety and security and protect the environment [32]. The term ‘safety’ is used here similar to the IAEA safety standards, as safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of radioactive materials. A number of measures can also be described in the National Policy in order to ensure that the regulatory body is independent in its regulatory decision making. This is described in paragraph 12 of INSAG 17 [33]:

“The establishment of the legal framework governing regulatory activities and their associated objectives, principles and values, including the legal basis for adequate and stable financing of regulatory activities.”

3.1.1. Milestone 1: Ready to make a commitment to explore for uranium

The national policy needs to support uranium exploration, as part of allowing the development of a uranium production programme. This includes funding for a national geological survey and development of the legal and regulatory framework (aspect 2) including specific guidelines for land claims as well as environmental regulations that relate to uranium exploration activities. The Member State needs to define potential locations where uranium exploration activity may be acceptable and areas where it is not. For example, a Member State may not allow uranium exploration to be conducted in areas that are environmentally or culturally sensitive, or densely populated. An economic uranium deposit may ultimately lead to active mining and processing. Therefore, the long-term socioeconomic advantages and disadvantages for exploration areas, including public support, ought to be considered prior to granting regulatory approval (e.g. licence or permit to explore for uranium). The international reporting codes (such as the JORC Code) can be also adhered to by governmental exploration organizations in Member States that anticipate a need to attract foreign investors who see significant strength in adherence to known reporting standards in order to make reasoned and well-informed investments decisions regarding the nature of a project and the risks associated with it.

3.1.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Integral to the development of a uranium production programme, the national policy needs to support uranium mining and processing, otherwise uranium exploration should not be allowed. In addition, it needs to consider the life of the uranium mine and provide consideration such that the national policy supports uranium mining, at a minimum, for the life of the mine. Finally, the national policy ought to define the regulatory framework for regulation of uranium mines through the uranium production cycle and beyond (i.e. decommissioning, remediation
and long term institutional control) [34]. The National Policy ought to include a requirement for financial security to be paid to the Government in case the operator is unable to decommission and remediate the site.

Correspondingly, at this stage, the Member State needs to have an effective, independent and competent regulatory body adequately financed or budgeted to develop a regulatory process to ensure that every step of mine development, operation and waste management is completed in a safe and environmentally compliant manner. Furthermore, the Member State ought to develop a national security policy and strategy for uranium mines and processing facilities [35].

Within the regulatory and licensing framework, a public consultation process ought to be developed as part of the national policy for uranium mines and processing facilities, as it is important to gain and maintain the confidence and support of the general public and interested stakeholders. This is accomplished by maintaining open, transparent and timely communication, and providing ample opportunities for interaction throughout the uranium production cycle. Consideration for other planned uses of the land post-mining ought to be considered at this stage.

If the mine is to be developed domestically with the government as the operator, then the Member State’s national policy ought to identify support mechanisms to ensure that it has the required expertise to advance the mine development through to production. This may include enhancing mining and mineral processing related university programmes and providing support mechanisms to foster research and innovation. In addition, trained mining staff are required to ensure that the uranium is extracted safely and in compliance with all applicable regulations. The Member State needs to either develop the required expertise for mine development and operation domestically or rely on outside resources to provide that expertise.

3.1.3. **Milestone 3: Ready to operate a uranium mine and processing facility**

To be at a point of readiness to perform final commissioning and to operate a uranium mine and processing facility, the government ought to have established the basic regulatory infrastructure to licence, regulate and safely operate the mine and processing facility according to the established laws and international best practice. At this stage the regulatory body ought to be fully funded, staffed and trained to meet the competencies to regulate the developed uranium mine and processing facility. Further, the regulatory process needs to be fully transparent with the roles and responsibilities of the regulator clearly defined. Finally, the regulatory body ought to be empowered to regulate and enforce based on the developed regulations with full authority. Additional detail on the responsibilities and functions of the government and the regulatory body may be found in the IAEA Safety Standard “Governmental, Legal and Regulatory Framework for Safety” [31].

Member States that have active uranium mines and processing facilities and are looking to increase capacity through either augmenting production capacity at existing (brownfield) sites or developing and commissioning new mines and/or processing facilities will have to evaluate each project on an individual basis. It is assumed that if a Member State has mature uranium mining and processing activities it may already have a developed set of guidelines and regulatory licensing requirements for uranium mining and processing. However, the government needs to review these requirements and regulatory licensing requirements and update to international best practices if necessary, whenever an operator of a uranium mine or processing facility looks either to increase production capacity or to develop a new uranium mine and/or processing facility. Whether the objective is increased production at a brownfield operation or launching a greenfield development, there needs to be a comprehensive review of the licensee. This review will be based on the project proposal provided by the operator and may include an environmental and social impact study. The scope of review ought to encompass at a minimum safety, radiation protection, environmental monitoring, training,
decommissioning and regulatory reporting. It will define what activities the operator needs to take to meet current regulatory requirements as it invests in capacity expansion for existing facilities or the development of a new mine or processing facility.

3.1.4. **Milestone 4: Ready to decommission and remediate a uranium mine and processing facility**

Member States need to recognize that mining is a temporary use of the land. Eventually the mineral resources become depleted and the productive life of a mine comes to a conclusion. The mine sites then enter a period of formal decommissioning and remediation to remediate areas disturbed by the mining or processing activities, including the waste management and mine rock areas, to leave them in a state as defined by national regulations and associated licence conditions. Criteria for any type of mine closure are developed beforehand and updated periodically according to the intended post-closure land use to protect human and environmental health. In other words, “start with an end in mind” approach.

Future work includes continuation of monitoring and assessments of data trends and projected long-term performance of remediated areas and infrastructure until such time that the site is in the required condition to be released from formal licensing. If the site performs in accordance with the decommissioning and remediation plan and achieves the predicted stability during the transition phase (post-decommissioning) monitoring period, the operator may make an application to the regulator(s) to obtain a release from further monitoring and maintenance responsibilities. The post-closure period then becomes the post-licensing phase, under a national approach to long term institutional control.

The National Position ought to include language that shows national support through the entire life cycle of uranium mining and processing. This includes the decommissioning and remediation phase which may take 25-30 years to complete depending on the complexity. It is therefore important that the National Position specifies that the regulatory body remains active and funded for the life cycle of the uranium mine and processing facility to ensure that all Phases in the uranium production cycle have regulatory oversight.

3.2. **SAFEGUARDS**

Non-nuclear weapons States that are party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) [36] are required to conclude a comprehensive safeguards agreement (CSA) with the IAEA in accordance with INFCIRC/153 [37]. This requires the State to accept safeguards on all source or special fissionable material within its territory, under its jurisdiction, or under its control. In order to strengthen the effectiveness of the international safeguards system, many countries have a protocol in addition to its CSA, which is known as the Additional Protocol or INFCIRC/540 [38]. The CSA and the Additional Protocol contain the rights and obligations of the State and the IAEA.

The country ought to be aware of the obligations in both documents regarding mining and processing operations. To implement the provisions of these documents and facilitate cooperation with the IAEA the State needs to maintain a State system of accounting for and control of nuclear material (SSAC). The SSAC needs to maintain the accounting and control of nuclear material within the State and facilitate cooperation between the country, the facility operator and the IAEA in safeguard implementation [39].

All States with a CSA are required to provide timely information to the IAEA regarding the import and export of any material containing uranium or thorium for nuclear purposes. States with an Additional Protocol in force also need to declare imports and exports of any material containing uranium or thorium for non-nuclear purposes meeting certain requirements. Under the Additional Protocol a State needs to inform the IAEA of its uranium exploration
projects under and also needs to declare the location, operational status and estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants. Additional guidance for implementing IAEA Safeguards Agreements is available [40].

3.2.1. Milestone 1: Ready to make a commitment to explore for uranium

Prior to achieving Milestone 1 the country ought to ensure its legal and regulatory framework is adequate to meet its safeguards obligations. This includes establishing laws, regulations, and a SSAC to ensure its safeguards requirements are fully met, thereby providing timely, correct, and complete declarations to the IAEA. This includes responding to requests from the IAEA including providing support and timely access to the IAEA to locations and information necessary to perform safeguards activities. This is also important during the exploration phase as there may be many exploration projects taking place in a Member State.

The safeguards requirements for a Member State will depend on the specific safeguards agreements the country has with the IAEA. For states with an Additional Protocol, Article 2.a.(x) notes that the Member State is to inform the IAEA about its nuclear development plans for the succeeding ten-year period [38]. This includes the exploration of uranium deposits, the country’s plans and schedule for developing new uranium or thorium mines and plans to extract uranium or thorium as by-products from other kinds of mines. See §8.2 of IAEA Service Series 22 for additional details [41].

3.2.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

At this phase, relevant Member States need to have processes well developed for Safeguards reporting of uranium mining and processing activities. This includes clearly defined roles and responsibilities for the required safeguards reporting. During this stage the Member State ought to continue to develop its regulatory framework to ensure timely reporting of relevant mining and processing activities to the IAEA. The Member State Regulatory Authority ought to develop and communicate reporting requirements with the operators involved in uranium mining and processing to obtain the information it needs for reporting to the IAEA. Setting up a coordination mechanism also facilitates an understanding of the safeguards reporting requirements, which benefits the Member State, the IAEA, mine operators, and other stakeholders. At this stage a Member State may wish to enhance the capabilities of its State Regulatory Authority. If requested, the IAEA can provide assistance to states through training, workshops, and additional activities. See §5.5 of IAEA Service Series 22 for additional details and how to request assistance [41].

3.2.3. Milestone 3: Ready to operate a uranium mine and processing facility

The point in a nuclear fuel cycle from which full safeguards requirements specified in comprehensive safeguards agreements start to apply to nuclear material is defined in INFCIRC/153 paragraph 34(c) as the point when any nuclear material has reached a composition and purity suitable for fuel fabrication or being isotopically enriched [37]. This does not apply to material in mining or ore processing activities. However, some safeguard provisions are relevant to mining activities and the SSAC needs to keep records about this material. Under INFCIRC/153 paragraph 34 these can be summarized as follows:

— The State is to notify the IAEA regarding the quantity, composition and destination of any material containing uranium or thorium that has been directly or indirectly exported to a non-nuclear weapons State unless exported for specifically non-nuclear purposes;
The State is to notify the IAEA regarding the quantity and composition of any material containing uranium or thorium that has been imported, unless the material is specifically for non-nuclear purposes;

If uranium ore concentrates (UOCs) produced in the State are of the purity and composition suitable for enrichment or fuel fabrication, then they will be subject to full safeguards reporting.

Under articles 2.a.(v) and 2.a.(vi) of the Additional Protocol, the obligations regarding material in mining or ore processing activities in a Member State are expanded. Article 2.a.(v) requires the SSAC to specify the location, operational status, and estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants and the current annual production of those mines and concentration plants as a whole [38]. This includes mining activities that produce uranium or thorium as a by-product [40]. The IAEA can also request the current annual production of any individual mine or concentration plant.

Article 2.a.(vi) addresses the State’s requirement to declare information on source material that does not meet the purity and composition described in INFCIRC/153 paragraph 34(c) (e.g. pre-34(c) material); specifically, information on the quantity, chemical composition, the use or intended use of material exceeding certain quantities at a single location, whether it is intended for nuclear or non-nuclear use. This information also needs to be provided for material in smaller quantities at different locations if the aggregate amount of material in the State exceeds the thresholds specified in the article.

Article 2.a.(vi) requires the State to supply the IAEA with information on the quantities, chemical composition and destination or current location of pre-34(c) material over a certain amount exported or imported by the State for non-nuclear purposes. This includes information on exports or imports of smaller amounts of material if the total amount of material still exceeds those thresholds.

Under the Additional Protocol, the State is also required to submit a declaration of its general plans for the next 10 years relevant to the development of the nuclear fuel cycle, including research and development activities. The IAEA’s Safeguards Department has guidance [40] for States on how to provide additional information to implement a CSA and an Additional Protocol.

At this stage applicable Member States need to have IAEA Safeguards reporting protocol well developed including the organization (or agency) responsible for completing the Safeguards report and the organization (or agency) responsible for reviewing, authorizing and submitting the Safeguards report(s) to the IAEA.

3.2.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

The points defined for Milestone 3 above are also applicable to this, with the exception that uranium will no longer be mined or processed. However, during reclamation, uranium can still be produced from water treatment, so that would have to be noted. Under the Additional Protocol as part of the initial declaration to the IAEA, information needs to be provided regarding both operating and closed uranium and thorium mines and concentration plants [40].

3.3. LEGAL AND REGULATORY FRAMEWORK

A suitable legal and regulatory framework needs to be in place to support a uranium production programme. An established regulatory framework will demonstrate to potential suitably qualified domestic and foreign investors that the government is ready to support its development.
GSR Part 1 [31] defines this expectation:

“The government, through the legal system, shall establish and maintain a regulatory body, and shall confer on it the legal authority and provide it with the competence and the resources necessary to fulfil its statutory obligation for the regulatory control of facilities and activities.”

“The government shall ensure that the regulatory body is effectively independent in its safety related decision making and that it has functional separation from entities having responsibilities or interests that could unduly influence its decision making.”

The regulatory body needs to develop the following with respect to uranium production:

— Regulatory policies on matters relating to health, safety, security and the environment;
— Legally binding regulations;
— A mechanism for making licencing decisions based on developed laws and regulations;
— A compliance and enforcement program that will ensure licensing actions and requirements are fulfilled.

Several measures can be established in order to ensure that the regulatory body is independent in its regulatory decision making. As described in paragraph 12 of INSAG 17 [33]:

— “The establishment of the legal framework governing regulatory activities and their associated objectives, principles and values, including the legal basis for adequate and stable financing of regulatory activities”;
— “The establishment and implementation of clearly defined processes for regulatory decision making”;
— “The establishment and implementation of a clearly defined competence management programme for the regulatory body which includes an internal management programme for human resources and provides the necessary means to secure independent scientific and technical support for the regulatory activities, with international co-operation as an important component.”

The legal and regulatory framework for uranium production ought to cover all aspects of applicable mining laws, as well as those aspects specific to the uranium production cycle from exploration to decommissioning and remediation1 [42]. National legislation also has to be developed to ensure effective legal control over the export and import of uranium ore concentrate or other nuclear devices required for operation. Existing legislation in areas including industrial and radiation safety, human resource management (labour law), financial law, contractual law, reporting requirements for publicly traded companies (if applicable), surface lease agreements (land claims) and transport needs to be followed or modified to meet the requirements of the uranium production cycle [31]. Finally, all relevant laws need to provide for clear, enabling regulations. The legal and regulatory framework for mining, including uranium mining and processing, ought to provide for fair and transparent licencing processes, royalty mechanisms and tax structure that lead to predictable outcomes [21].

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1 A uranium mine and processing facility is separated from those for other commodities due to the mineral being a naturally occurring radiological material (NORM) that when developed through a mine and processing facility has the added requirements for radiation safety, international safeguards and security arrangements.
The hierarchy of the regulatory framework is generically illustrated in Fig. 2 below and is intended to address a broad range of Member States. Starting with national laws, the enabling legislation or Act is developed (First Tier) based on the Constitutional powers of the Member State. The Second Tier illustrates the supporting Regulations, which are based on the developed legislation. Any authorizations, approvals or licenses will be issued in accordance with these Regulations. Further specific requirements can be provided as license conditions.

**FIG. 2. Hierarchy of the legal and regulatory framework.**

Regulations or decrees according to the legal system of the country are issued by a government ministry or other ‘competent authority’ such as the regulatory body as specified under the law. Whereas the law is giving the general framework within which a certain activity or type of activity may take place (for instance a law on environmental protection or a labour law), the regulations give specific explanations on how the law is to be applied in practice [43]. The requirements that apply to a specific installation or to a specific activity are given in the authorization or licence that is to be granted to that installation or activity before it starts and are known as licence conditions. The authorization is more detailed or specific and is issued in accordance with the Regulations and any regulatory documents, requirements or standards so specified (Tier 3). Thus, the detailed authorization is written so that it applies to one particular facility or activity.

The principal purpose for establishing regulations is to codify requirements of general applicability. By providing well-founded and clear statements of administrative and technical requirements, regulations serve to provide consistency and stability in the regulatory process.

Regulations are commonly more technical than the corresponding law but are part of the national legal system. Their purpose is to achieve safety through the establishment of detailed requirements regarding the application of the law and to provide a framework for more detailed conditions and requirements to be incorporated into individual licenses. In order to avoid misinterpretation, regulations ought to be clear, easy to understand, unambiguous and precise [43]. However, any significant changes to legislative framework, standards and limits should not be made without prior consultation with the operator and other impacted stakeholders.

Also important is the very last tier (e.g. Tier Four). The regulatory body ought to provide further supporting information or guidance, explanations of regulatory requirements, how to use the standards, and finally, the broad use of supporting regulatory guides or information. These documents are not regulatory requirements per say, but rather clear direction and
examples that may better inform the operators, the public and other stakeholders how the regulations are best applied.

In practice, national regulations will often combine performance-oriented requirements with prescriptive requirements. The relative importance of these two approaches depends upon national policies and strategies, because some Member States have a strongly prescriptive approach to all their regulations and others do not. The knowledge and experience of the operators, and the level of experience of a regulatory body are also impacted by these approaches.

A regulatory body overseeing uranium production and waste management needs to be separate and independent from promoters of any nuclear technologies, resource development, or uranium mining and processing and from operators of uranium processing facilities. The reason for this independence is to ensure that regulatory judgments can be made, and regulatory enforcement actions taken, without pressure or influence from any other interests (direct or perceived) that may conflict with overall safety. The views of the general public, and of any elected official, will depend in large part upon whether the regulatory body is considered to be independent of the organizations that it regulates. Section 2 of the IAEA International Nuclear Safety Advisory Group report “Independence in Regulatory Making” summarizes the key features and challenges regarding independence in regulatory decision making [33].

The main areas of Regulatory review for a uranium mine or processing facility include:

— Site characterization;
— Act and regulations requirements;
— Stakeholder engagement;
— Design principles and hazards;
— Construction methods, controls adequate, as-built plans;
— Management systems and human performance programmes;
— Radiation and environmental protection;
— Conventional safety;
— Water management;
— Waste management — mine rock, tailings, etc.;
— Transportation;
— Emergency planning;
— Site security;
— Safeguards;
— Decommissioning;
— Remediation, and associated financial guarantees;
— Social and cultural aspects.

As described in INSAG-17 [33]:

“Regulatory bodies have three basic functions: (1) to develop and enact a set of appropriate, comprehensive and sound regulations; (2) to verify compliance with such regulations; and (3) in the event of a departure from licensing conditions, malpractice or wrongdoing by those persons/organizations under regulatory oversight, to enforce the established regulations by imposing the appropriate corrective measures.”

The regulatory body is responsible for reviewing applications for licences based on developed regulatory requirements, provide recommendations to senior government officials and enforce regulatory requirements and licence conditions set forth by regulatory policy and developed regulations. Finally, the Member State may choose to issue separate licences that
align with each stage or milestone within the uranium production cycle. An example list of licences that may be issued includes:

— Licence or permit to explore for uranium;
— Licence to construct* a uranium mine and processing facility;
— Licence to operate* a uranium mine and processing facility;
— License or permit to allow sale and transport of uranium product nationally or internationally;
— Licence to decommission and remediate a uranium mine and processing facility;
— A release from licensing of the decommissioned and remediated uranium mine and processing facility, for institutional control.

*Note: Some forms of commissioning are associated with the end of construction. This may include rotational checks, process control checks, etc. to ensure that the equipment functions as per design and are constructed properly. Commissioning will then continue during the operations stage once there is a formal sign off from construction to operations. Commissioning at the operations stage includes first commissioning the process using only water in the feed to ensure integrity of the process prior to ramping up production using ore feed material and process reagents. The licence to construct and operate may include these two main stages of commissioning, as alluded to earlier in Section 2.2.2.6.

In many countries, regulatory authorities responsible for health and safety, radiation safety (e.g., nuclear substances), environmental protection, import and export, mining etc. existed prior to the regulatory body responsible for uranium mining and processing, and the management of its radioactive waste. The legislator needs to therefore pay close attention to the clear allocation of responsibilities between the various authorities. In particular, the powers and responsibilities of the regulatory body regulating uranium mining and processing ought to be clearly defined in the legislation establishing it.

Mechanisms to resolve jurisdictional conflicts between national authorities, or national-provincial type authorities, need to be put in place. In such instances, a memorandum of understanding or an administrative agreement between authorities ought to be formulated to clearly define the conditions under which either authority will take lead regulatory responsibility and coordination. They will define how they will operate in a co-ordinated manner to limit regulatory gaps and contradicting overlaps, and provide a defence-in-depth approach. Together, they should harmonize where practical, and avoid regulatory delays, confusion, or contradictions [43].

GSR Part 1 [31] goes on to explain the need to coordinate efforts when more than one regulatory authority may be involved:

“Where several authorities have responsibilities for safety within the regulatory framework for safety, the government shall make provision for the effective coordination of their regulatory functions, to avoid any omissions or undue duplication and to avoid conflicting requirements being placed on authorized parties.”

At a working level, the various regulatory staff and compliance officers can form a working group relationship where information and exchanges of findings or issues are discussed. This Joint Regulatory Group (JRG) can be highly effective in cooperative approaches and regulatory defence-in-depth.
3.3.1. Milestone 1: Ready to make a commitment to explore for uranium

A Member State that is making a commitment to explore for uranium for the first time ought to initially review existing national legislation for conventional exploration to determine if modifications of the existing legislation are necessary to allow uranium exploration, as noted in Section 3.2. Member States could consider input from experts in the development of legislation for the uranium production cycle and also look to other Member States that have a well-developed legislative framework for uranium exploration for guidance.

The legal and regulatory framework for this milestone ought to address topics including the requirements for staking land claims, fees, taxation, mineral rights, areas identified within the country where exploration is banned (if applicable), legal aspects associated with stakeholder engagement, interaction with indigenous land claims (if applicable), exploration licence application, review and approval process, environmental protection, health and safety including radiation safety and transport of radioactive ore samples in public areas.

The legal and regulatory framework may provide for the establishment of regulatory oversight of exploration activities by the regulatory body. Activities of the regulatory body at this stage may include authorization, inspection and enforcement for exploration activities [44]. Regulatory oversight for uranium exploration may fall under the control of another established regulatory body that can also address the additive radiation safety issues. The regulatory oversight at this stage is not as comprehensive or resource intensive as it is for uranium mining and processing, but still requires some controls for radiation safety of the workers, public and the environment.

At this stage the proponent (e.g. exploration company) will be interested in the continuity (duration) of exploration rights, exclusivity of the area staked (claimed) for exploration activities and the legislation for mineral rights that may be discovered [42].

3.3.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Member States initiating uranium mining for the first time ought to have in place the legal framework required for the uranium production cycle. All relevant international legal instruments specific to the uranium production cycle ought to be reviewed at this stage by a competent authority and all relevant legal aspects ought to be incorporated into the national legal framework. In addition, a comprehensive expert review of any existing relevant legislation within the Member State needs to have been conducted to ensure that all legal elements are current, are not in conflict, and meet provincial, national and international requirements for uranium production. This may include any legislation relating to the national policy for uranium mining and processing including economic and commercial considerations. Legislation ought to be developed for specific regulation of uranium mines and processing facilities based on gaps identified in existing legislation. Consideration includes a legal system for licencing (including a mining lease), inspection and enforcement for all aspects related to the uranium mining industry (e.g. radiation protection, radioactive sources, safety, security, safeguards, transportation, export and import controls, environmental law, waste management). Section 3 of the IAEA Safety Standard “Functions and Processes of the Regulatory Body for Safety” summarizes the core regulatory functions and processes that can be applied to uranium mines and processing facilities [44].

Legislation ought to outline the legal requirements for the operator of the uranium mine and processing facility to provide closure plans for decommissioning and remediation before construction begins. The specific laws for closure plans ought to include legislation for financial assurances to be paid to the government so that if the mining company goes bankrupt or abandons the site, the government has access to the funds required for effective decommissioning and remediation. The legislation ought to prescribe the frequency at which
these closure plans are reviewed during the operational phase of the mine and processing facility to ensure they are current based on the status of the mine and processing facility. The closure plans will employ industry good practice and that sufficient financial assurances are available to complete decommissioning and remediation.

The legislation developed at this stage also needs to clearly define the responsibilities of all authorities involved in the uranium production cycle and cover all legal aspects associated with the uranium production cycle, which include but are not limited to radiation protection, safety, water and waste management, environmental law, bond, liability coverage, labour laws, safeguards, security, transport of uranium ore concentrate, decommissioning and remediation.

Applicable regulatory approvals ought to be requested at this point, prior to advancing the mining project to the construction phase or restarting an existing mine. Once regulatory approval has been granted to construct the uranium mine and processing facility, construction may begin. As part of the construction phase, the regulator needs to be aware that commissioning activities are initially done with benign material (e.g., water, clean rock) and the operator ought to demonstrate that the mine and process facility were constructed in accordance with the approved design and that all systems, structures and components operate safely and as per design intent. This is also the time when a construction firm demonstrates they have completed their contract obligations and can turn the as-constructed part of the facility over to the operator.

For Member States that are looking to reinvigorate uranium mining, the existing legislation may or may not align with the technology or business climate within the current uranium production cycle. Legislation may therefore have to be updated to reflect current technological, financial, legal or regulatory elements within the uranium production cycle before Phase 3 is initiated.

3.3.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage all required legislation and associated regulatory framework for uranium mining and processing ought to have been developed. Funding needs to be guaranteed and allocated for human resource and infrastructure requirements to ensure sustainability of the relevant legislative processes and the independent regulatory body [31, 33, 45]. At this stage the proponent needs to have the legal right to mine, process and potentially sell the uranium ore concentrate.

Any Member State with a long-standing history of uranium mining and processing and considering restarting production may already have a well-developed legal and regulatory framework that supports safe, reliable production of uranium. However, the existing framework ought to be reviewed to ensure that it aligns with the proposed increase in capacity and capability. This recommendation applies to the re-start of an existing uranium mine, increased production rates at existing mine and processing facilities as well as the development of new mines and processing facilities within the Member State. For existing mines that are looking to increase production capacity, a Member State needs to review the means by which the increase in production capacity will be achieved and if the existing framework provides adequate legal and regulatory oversight. If not, the legislation needs to be revised to reflect current conditions.

At this stage the owner/operator ought to have applied for a licence to operate the constructed uranium mine and processing facility. It is the responsibility of the owner/operator to demonstrate to the regulatory body that it has established safety management systems and plans and programmes that are appropriate to ensure safe and secure operation. In addition, completion of construction needs to be exhibited and any deviations from the original engineering design ought to be identified and described. Final commissioning and operational plans for the mine and process facility need to be submitted as part of the application for a
licence to operate. In relation to environment and waste management, an application for a licence ought to also contain the effluent and environmental monitoring programmes.

The regulatory body ought to conduct a thorough regulatory review of all construction, operational, conventional safety, radiation safety and environmental aspects associated with the uranium mine and processing facility. The regulatory body ought to consider completing a detailed site visit with the owner/operator as part of the detailed regulatory review. If all these aspects are determined to be complete and effective for initial commissioning and operation then the regulatory body may consider approving that activity under either an interim licence, or as part of a hold point for the final phase of a construction license. This allows the owner/operator the ability to commission the mine and processing facility, but not advance to full-scale operation. All required and relevant commissioning tests and as-built reports need to be completed and demonstrated to the regulatory body prior to the regulatory body issuing the operating licence.

3.3.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Mining and processing are a temporary use of the lands. As such, the mine life, processing facility operating life, and / or capacity of the waste management area will eventually come to an end. As the end of a uranium project approaches, the closure plan, incorporating decommissioning and remediation, now will need to be updated and reassessed. The regulatory framework may require the owner/operator to conduct an environmental assessment and stakeholder engagement specific for decommissioning and remediation, and eventually for long term institutional control. The IAEA Safety Guide “Release of Sites from Regulatory Control on Termination of Practices” provides a comprehensive summary of the legal and regulatory framework as well as activities that are required to be completed prior to a site being released from regulatory control [46]. This may serve as an effective mechanism to assess the current environmental status of the facility and verify the plans for decommissioning and remediation to ensure the agreed and approved end state for the lands and environment will be met. The plans also need to include a detailed monitoring programme to evaluate progress on remediation and towards achieving the approved end state for the lands and environment will be met. The decommissioning and remediation environmental assessment, which includes the current decommissioning and remediation plans ought to be reviewed and approved by the regulatory body in consultation with the stakeholders and in accordance with the established legal and regulatory framework. However, in order for the operator or responsible party to understand the operational and financial requirements to decommission and remediate the site to prepare it for long term institutional control, a clear understanding of requirements that have to be met ought to be established.

Once the plans are reviewed and approved, the regulatory body ought to provide frequent oversight at the operation to ensure that the decommissioning and remediation plans are being followed and the monitoring programme, including any applicable bonds or similar financial instruments in place for funding decommissioning and remediation have been implemented. Treatment of tailings, including supernatant and pore water, as well as runoff from waste dumps, will be a critical activity during decommissioning and remediation, and will be of particular significance for local stakeholders such as municipal authorities or local residents. Therefore, the regulatory body has to ensure that the infrastructure and expertise are in place to regulate this critical activity. Decommissioning, remediation and post-decommissioning monitoring activities may last up to 25 years, or longer, depending on the complexity of the mine and processing site. The Member State needs to ensure that funding is in place through the aforementioned bond or similar financial instrument to support these important activities, ideally as an element of the original operational licence.
Uranium mines that are in a care and maintenance state in anticipation of reopening require a detailed care and maintenance plan that needs to be prepared and presented to the regulatory body, as it has the potential to differ from the licence to operate. For conventional mines, water treatment of tailings pore water and supernatant water, as well as drainage from contaminated rock dumps, dewatering wells, and accumulating mine waters will once again be a critical activity. A monitoring programme needs to be developed to monitor activities on-site (e.g. effluent discharge) as well as near and far field downstream receptors. A uranium mining operation may remain under these conditions for several years, so the legal and regulatory framework needs to ensure that the operator retains sufficient funds and expertise to support care and maintenance over the required duration. Finally, should an operator of a uranium mine and processing facility that has been in care and maintenance wish to restart mining and processing of uranium, then a comprehensive assessment of the mine and processing facility infrastructure needs to be completed to ensure that the site is in a good physical and mechanical state and is safe to operate. The operational staff may also require retraining to ensure they are competent. These reviews may be subject to assessment and approval by the regulatory body.

The government needs to ensure that mechanisms are in place to enforce existing legislation to ensure that national, provincial and, where relevant and appropriate, international guidelines for decommissioning and remediating the former uranium mine are followed. This includes a review of financial guarantees or secured funds legislation as well as the legal requirement for the transfer of institutional control back to the state [46]. Once all legal requirements have been met for decommissioning and remediation the proponent has the right to apply to the regulatory body to be discharged of all further legal, financial and regulatory obligations of the project, and the site may enter into an institutional control framework. The owner/operator may also wish to apply to recover any remaining balance of the financial guarantee that was set for the project [42].

3.4. OVERVIEW OF THE ROLES AND RESPONSIBILITIES OF THE GOVERNMENT, REGULATORY BODY AND OPERATOR

The roles and responsibilities of the government, the regulatory body and the operator will change as a project advances from exploration, resource delineation, mine and processing facility engineering design, construction, commissioning, operation and ultimately decommissioning and remediation. Due to the complexities of the uranium industry, a highly competent regulatory body and operations management team are essential to success at all stages of development. General management and financial management will be required at each stage of the project; however, technical/operational management will vary based on the stage of the project. Additional detail is provided below for each milestone.

An open question for new entrants is how far the competence base reaches within government, and how to work in a constructive but arm’s length relationship with operators and investors and their respective roles. Done well, this can ensure a smooth and well-accepted project delivery, with objectives and decision-making being mediated in a transparent manner when the government is both the regulator and (platform) investor and when government and private companies are both involved.

Government

The legal and regulatory framework for the uranium production cycle needs to establish a clear understanding of the roles and responsibilities for all organizations required to advance uranium production. The primary parties involved in uranium processing activities are the operator (proponent) and the regulatory bodies. Both parties have responsibilities to minimize and control impacts from the uranium production activities. The government has the
responsibility to develop a legal framework (laws) that the operator needs to meet, and to establish a regulatory framework, including regulations and a regulatory body with the resources to enforce applicable laws, regulations and licenses. The operator has the responsibility to design, construct, operate and decommission uranium recovery operations in accordance with laws and regulations that protect the health and safety of workers, members of the public, and the environment.

Regulatory Body

The authority and responsibilities of the regulatory body are based on the Legislation and Regulations adopted or enacted by each government. To ensure that the regulations are applied adequately it is essential to have a clear structure of roles and responsibilities, and operating procedures, for an adequate handling of all regulatory processes. Roles and responsibilities in the oversight of say, a new tailings management facility and the review of its siting or design plan ought to be clearly identified between National, Provincial and other local regulatory bodies. Conflicting overlap of these roles and responsibilities needs to be avoided such that it is clear to the operator which body is the decision-maker. It is important to lay down the hierarchal structure of legal roles and responsibilities and ensure that oversight is aligned.

One of the key roles of the regulator is to confirm (or establish if not done so already) the safety criteria and other regulations and guidance for the entire lifecycle of the facility. The regulator is responsible for review of new license applications, renewals, and amendment requests, and for issuance of licenses. In addition, the regulatory body is responsible for inspection and enforcement to ensure activities are being done in accordance with the license and regulations. The regulatory body will have its own responsibilities for engagement and consultation with stakeholders or interested parties.

The operator

The responsibilities of the operator of a site will be defined in the laws and regulations. The Operator generally will have responsibility for:

— Providing documentation necessary to obtain a license or permit from the regulator, including environmental impact assessment;
— Constructing and operating the facility in accordance with the license and the regulations;
— Protecting the health and safety of people and the environment;
— Providing financial surety to ensure funds are guaranteed to be available to appropriately close the facility;
— Decommissioning the facility in accordance with the license and regulations;
— Providing opportunities of stakeholder engagement.

The responsibilities of the operator and proponent are explained further in GSR Part I [31], and are summarized up in the following statement of Requirement 5:

“The government shall expressly assign the prime responsibility for safety to the person or organization responsible for a facility or an activity, and shall confer on the regulatory body the authority to require such persons or organizations to comply with stipulated regulatory requirements, as well as to demonstrate such compliance.”
3.4.1. **Milestone 1: Ready to make a commitment to explore for uranium**

At this stage there needs to be support from national and local governments and local communities to explore for uranium and to develop physical and regulatory infrastructure to support uranium exploration. An exploration company needs to have strong management personnel who understand the legal, regulatory, cultural, safety, environmental and social aspects associated with uranium exploration. Effective management at this stage is essential to obtain long term support for uranium mining. Exploration companies need to ethically follow the legal, cultural and social rules within the area for which they are exploring for uranium and act accordingly.

3.4.2. **Milestone 2: Ready to commit to develop a uranium mine and processing facility**

At this stage of uranium mine development, the government needs to ensure that national laws are in place regarding uranium mining and processing. In addition, the regulatory body needs to be adequately funded and staffed. The owner/operator needs to be financially and technically responsible for the development and implementation of the uranium mine and processing facility. Further, the owner/operator ought to function independently of the political and regulatory bodies within the country.

At this stage the government is responsible for:

- Collaborating with the legislative body to have developed and enacted the required laws to facilitate the development of uranium mining and processing;
- Developing an independent regulatory body for uranium mining and processing;
- Establishing policies for the development of a required financial guarantee (i.e., trust fund/bond) to be provided by the owner/operator to ensure financial responsibility for decommissioning and remediation;
- Establishing a public education campaign and stakeholder consultation programme to show support for and oversight of safe uranium mining and processing.

At this stage the regulatory body is responsible for:

- Recruiting and training staff as required to have in place an effective regulatory structure and associated licencing and regulatory processes, including an effective compliance and enforcement programme;
- Establishing a structured and formal management system and associated regulations in conjunction with staff training to create a safety and quality culture to ensure effective licensing, regulation and oversight of uranium mines and processing facilities;
- Communicating the independent role of the regulatory body to internal and external stakeholders.

At this stage, the operator is responsible for:

- Working with an engineering, procurement and construction management firm to design, engineer and construct the uranium mine and processing facility;
- Recruiting and training staff required for commissioning and operation;
- Establishing a formal management system to ensure a quality and safety culture where each employee feels responsible for their own safety;
— Establishing required conventional safety and radiation protection programmes (including processes for reporting safety statistics and radiation exposure data to the required regulatory agencies);
— Establishing an asset management strategy including a predictive and preventative maintenance programme to ensure safe sustained operation of the uranium mine and processing facility;
— Establishing an environmental protection and monitoring and reporting programme that meets regulatory requirements;
— Establishing and delivering public information and consultation sessions for stakeholders;
— Developing business relationships with suppliers required for operation;
— Developing a financial strategy, including an annual operating budget;
— Developing a working relationship with regulators and international and professional organizations.

3.4.3. Milestone 3: Ready to operate a uranium mine and processing facility

Much of the discussion for Milestone 2 (Section 3.3.2) also applies here to bring a uranium mine and processing facility into full production. For operators in a Member State looking to reinvigorate uranium mining and processing operations the operator ought to have a comprehensive understanding of the scope of work required to enhance existing capacity and capability for mining and processing uranium. Further, the operator ought to complete a thorough analysis of the project to determine the potential environmental, safety, social and cultural impacts associated with the increase in capacity. They ought to present these findings to the local and/or national regulatory bodies (as applicable in the area of interest) in a framework that meets regulatory standards for this type of application. In addition, the operator ought to develop and implement a comprehensive communication and consultation strategy to consult with stakeholders and endeavour to obtain stakeholder support. This level of communication also ought to include a discussion of training and employment opportunities for local communities as well as business opportunities for local and national businesses. The regulatory body needs to have an in-depth knowledge of the project and be able to thoroughly review and understand the impacts that this project may have on the environment, worker health and safety, local communities and, if the application to produce is approved then ultimately issue an amended or new operating licence.

3.4.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Closure of a mine and processing facility would begin with completion of all mining and processing activities. Then based on a regulatory approved decommissioning and remediation plan the operator would complete decontamination and demolition of all required mine and processing facility infrastructure. The operator ought to have a well defined plan for management of mine wastes and effluents. The operator would then remediate all affected areas to a pre-determined condition suitable for final lands use. This may require long-term monitoring until a find state is confirmed. Once all decommissioning and remediation activities are complete the operator may then transfer ownership of the lease to a representative government body through a prescribed institutional programme.

A significant concern of local, national and international communities regarding uranium mining and processing is the long-term impact on the environment, economy and cultural way of life in the local area (e.g. agriculture, hunting, fishing, recreation, community development adjacent to an abandoned or reclaimed mine or process area). Operations management ought to
have the capacity to develop a strategic plan in order to conduct communication and education sessions within the community and look to involve local stakeholders in the planning and decision making for decommissioning and remediation of the site, and its long-term stability. Operational management then need to develop a robust decommissioning and remediation plan and show commitment to fully remediate the site to the agreed and approved end state to ensure minimal long-term environmental impact. Regulatory bodies ought to have the capacity to review the decommissioning and remediation plans (with external consultants, if required) to ensure that the operator’s decommissioning and remediation plans meet regulatory requirements and will achieve the agreed and approved end state, regardless of the need (or not) for an institutional control programme after remediation.

3.5. STAKEHOLDER ENGAGEMENT

Engaging with a variety of different stakeholders is essential throughout all phases of a uranium production programme. A lack of an effective stakeholder engagement programme has been consistently ranked in the top 10 business risks for mining and processing projects and as of December 2018 it was ranked as the single most important risk [47]. The uranium mining and hydrometallurgical processing industry often face unique challenges with respect to stakeholder’s understanding and perceived risk of a number of factors. Some examples include potential radiological health impacts to local communities and biota during production or the impact and long-term management of wastes generated from such activities. Thus, effective communication and consultation are necessary to allow stakeholders an opportunity to voice their concerns, opinions and perceived risks. This two way dialogue allows experts an opportunity to answer questions, educate and provide accurate, easy to understand information for stakeholders. Effective stakeholder engagement occurs early and often in successful projects and consultation with stakeholders is integral during of all phases of the uranium production programme. Furthermore, an independent and trusted regulator plays an important part in the stakeholder engagement process. Aspect 1.2 of the IAEA Safety Standards Series No. GSG-6 [48] states:

“Communication and consultation are strategic instruments that support the regulatory body in performing its regulatory functions. They enable the regulatory body to make informed decisions and to develop awareness of safety among interested parties, thereby promoting safety culture. The establishment of regular communication and consultation with interested parties will contribute to more effective communication by the regulatory body in a possible nuclear or radiological emergency.”

To support effective stakeholder engagement strong, sustained local and national government support for uranium mining and processing throughout the lifecycle of a uranium mine and processing facility is necessary. The success and sustainability of any uranium mining and processing project is dependent on both government support and acceptance by a wide range of stakeholders. Each organization with a responsibility in a uranium production programme — the government, the owner/operator, the regulatory body, — has a role in carrying out effective stakeholder engagement activities throughout the life cycle of facilities. These organizations coordinate outreach activities while concentrating on their distinct role to address stakeholder concerns [49]. The main objectives of stakeholder engagement are:

1) To facilitate open and transparent communication;
2) To build trust and engage with stakeholders;
3) To provide opportunities for stakeholder consultations;
4) To inform and educate stakeholders of potential benefits and risks;
5) To demonstrate accountability to stakeholders.

Stakeholder is a broad term and for the purposes of this document it is defined as individuals or groups who have a specific interest in a given issue or decision, or in the performance of an organization. This includes the general public (particularly communities surrounding the area of the uranium mine and processing facility), local indigenous or native groups recognized by the government, employees of the mining company, groups that may undertake business with the mining company, the owners or shareholders of the company, operators, suppliers, partners, trade unions, the regulated industry or professionals, scientific bodies, governmental agencies, regulators, the media, and neighbouring countries. When developing a uranium project there are two general types of stakeholders: internal and external [8, 50]. Internal stakeholders can be defined as those involved in the decision-making process, while external stakeholders may be affected by the potential outcome of the project. Early involvement of both stakeholder groups is essential to achieve project goals and gain stakeholder support for uranium mining and processing [21].

General public involvement in all phases of a uranium mining and processing project is best achieved through open and transparent dialogue between the proponents of the project (e.g. government and the owner/operator) and other stakeholders [49]. Uranium mine and processing facility regulations may dictate when structured and formalized stakeholder engagement is required, for example, during the EIA process. All concerned citizens ought to be provided with access to relevant information and have the opportunity to participate in public consultation. Consultation with key stakeholders is an important step in gaining the support required to advance uranium mining in a Member State. Of equal importance is the fact that public acceptance for developing and sustaining uranium mining in a Member State will depend on the competence and credibility of the organizations and individuals responsible for the mining programme. It is essential that the regulatory body and owner/operator be competent and open to sustain public confidence. Requirement 36 of IAEA Safety Standard (GSR Part 1) [31] states “The regulatory body shall promote the establishment of appropriate means of informing and consulting interested parties and the public about the possible radiation risks associated with facilities and activities, and about the processes and decisions of the regulatory body.”

An important question that needs to be addressed during all phases of the uranium production life cycle is who are the stakeholders and how will effective engagement be achieved? The government, the regulatory body and the operator/proponent need to be aware of their respective key stakeholder groups and the overall communication approach. Developing a stakeholder engagement strategy ensures aligned communication, especially critical with multiple parties involved. This “living document” serves as an internal playbook for the project team to continually review and refine, as the project evolves, and stakeholder challenges arise. Within the strategy, a stakeholder map identifies and defines key groups of stakeholders:

- Who they are and where are they located;
- How do they receive information;
- How they relate to each other and the project itself;
- What viewpoints or concerns do they have of the project;
- What interest(s) or roles and responsibilities may they represent in relation to the project; how/if they are funded;
- How and when communication may flow to and from them to government, regulatory bodies and operators and through what mechanism; and how this information may be managed in the best interests of effective project management and delivery;
- Which stakeholders need to be represented on any task force dedicated to managing the project and its wider engagement with all stakeholders.
Within government, a stakeholder engagement strategy which includes a stakeholder map may help to resolve issues such as which part of government is responsible for each part of the permitting, regulatory and oversight process. An example of this kind of stakeholder map is in Sec. II.2.2, Appendix II, United Republic of Tanzania Case Study.

Creating a stakeholder engagement strategy and then deriving from it how best to form government internal oversight committees and task forces is a technique that has been applied successfully to the effective coordination and management of internal resources, and hence to interfacing and negotiating with investors and operators. Ideally, such relationships, at least during the negotiation of initial contracts and agreements, are best managed through a single point of contact in government.

Engaging with stakeholders requires transparency and good governance, but also good leadership from government. This starts with raising awareness and informing stakeholders as to why a given modern uranium project is in the national interest to pursue, and how it will be done safely prior to mine and processing facility construction. During this time, open discussions on safety and risk perception need to be conducted, as there is a commonly held fear of uranium mining due to its history of non-peaceful uses of exploitation and additionally, many historical uranium projects had little or no controls on health, safety (e.g. radiation protection) or environmental protection of current or future generations [34].

Stakeholder engagement is a continuous discipline that evolves throughout the uranium production cycle, as priorities and stakeholder need change. Though there are principles that can be universally applied, the application and implementation of those principles will vary depending on the organization or national context. Additional detail on the development of a stakeholder engagement strategy, stakeholder mapping, and communication tools for stakeholder effective, proactive engagement may be found in [49].

3.5.1. **Milestone 1: Ready to make a commitment to explore for uranium**

Stakeholder engagement begins at the exploration stage of a uranium project, and ought to be undertaken by the government, the regulators and the exploration company. Local stakeholders need to be advised of uranium exploration activity, not only at the start of the project, also during and once the exploration phase is complete. Updates ought to be provided to stakeholders to inform them whether or not the exploration activity has identified an economic uranium resource.

Setting and managing realistic expectations with regard to the 10–20 years it may take from the point exploration begins to the opening of a uranium mine and the processing of the uranium concentrate is essential. This process needs to be carefully and sensitively conducted from the moment exploration activities begin. For example, local communities may anticipate immediate employment opportunities and wider economic benefits that, if they occur at all, may take years to materialize. Stakeholder engagement updates ought to continue through the life of an exploration project as there may be the need to educate newly elected officials, new governing bodies, new neighbours, or businesses.

Exploration geologists and others engaged with local communities and other stakeholders need to be trained to anticipate and have the resources available to address the hopes and fears that their presence on the ground will inevitably raise, while their sponsoring companies need to provide them with field support with respect to local community relations. If airborne surveys are planned, stakeholders need to be informed about the presence and role of aircraft or drones in their skies. Some areas may be environmentally or culturally sensitive, or densely populated, or areas may have extensive agricultural development and industrial activities with local population, and therefore uranium exploration in these areas might be incompatible with these activities. Prior to commencement of any field work, the exploration
company ought to first communicate with the local administrative entities and regulatory bodies to determine what can be done in these sensitive areas.

3.5.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

The first requisite for stakeholder engagement during the development of uranium mining is for the key stakeholders to have a comprehensive understanding of the uranium project to be developed and its potential impacts and benefits through its whole life span. The stakeholder engagement strategy will guide this communication and outreach and will be informed by both the project team and stakeholders. From a practical perspective, this means assembling a team that is representative of the key aspects of the project, including mining/processing personnel, government officials, regulatory bodies and local community leaders. The objective at this stage would be for the team to tour the proposed mining and processing operations sites and then develop a plan that identifies project milestones and goals as well as roles and responsibilities. Member States planning to mine uranium for the first time or that have not mined uranium for a significant period of time may wish to bring in external expert advisors to help facilitate the process.

Stakeholder engagement activities and communication strategies at this phase include:

— The government communicates their support for uranium mining and processing, identifies the benefits of these activities and responds to concerns raised by stakeholders;
— The government communicates the development of national legislation and regulations specific to uranium processing and processing;
— The regulatory body describes its independent role in licencing, inspection and compliance for uranium production facilities;
— The regulatory body develops and communicates the formal process for public participation during the licencing process;
— The owner/operator of the uranium mine and processing facility describes the type of mining and processing and the way in which it will manage the safety, environmental and social aspects associated with uranium production;
— The economic and social benefits to local and national stakeholders are described by both the government and the owner/operator;
— The government, regulatory body and operator ought to conduct knowledge and opinion surveys as part of their stakeholder involvement programmes;
— The government, regulatory body and operator need to ensure that senior staff who communicate with the public are trained.

In order to inform key messaging, communications and outreach as outlined in the stakeholder engagement strategy, it is important to understand how stakeholders think, what they value, and what ideas or beliefs they may have that could impact the project. This type of information can be gathered by conducting stakeholder interviews or surveys. Stakeholders such as industrial suppliers, government, regulatory and public officials, environmental groups, uranium mining experts, community leaders, health professionals and other relevant agencies and parties need to be identified and interviewed to obtain their respective insights into the following issues:

— Perceptions of the uranium mining industry;
— Existing regional industry strengths;
— Workforce development challenges/opportunities;
— Opportunities for local involvement in the supply chain;
— Infrastructure needs of the area (new roads, railway, airport, water course crossings, etc.);
— New emerging market opportunities;
— Entrepreneurial and small business support;
— Positive and negative impacts (real and perceived) on the uranium mining industry.

In addition, at this stage, resident and local business surveys need to be conducted to gather input from local community members. The two surveys ought to focus on the perceived impacts of uranium mining and processing operations on local business and residents’ quality of life. The purpose of these surveys is to distinguish the community’s real/factual issues with uranium mining from emotional and perceived issues. The outcomes of the interviews and surveys will help to shape public consultation and efforts as outlined in the stakeholder communication strategy.

The second stage in stakeholder involvement is for the government to quantitatively and qualitatively estimate and report the socioeconomic benefits of uranium mining and processing on the local and national economies. Prior to advancing to construction and ultimately operations, the government ought to clearly define potential benefits to local communities and the national economy and address any concerns that were identified in the public survey. The owner/operator would also be required to address concerns of stakeholders that were formally lodged during the public notification period of the EIS. The adequacy of the responses would be reviewed by the regulatory body as part of their overall assessment of the environmental impact assessment for the project.

Four key areas to consider in the determination of the socioeconomic impact of uranium mining and processing on the local and national economies include economic development, government services and regulation, public health and the environment, and social impacts. These four key areas can be further subdivided as follows and also contribute to the design and communication tools outlines in the stakeholder engagement strategy.

3.5.2.1. Economic development

— Direct and indirect job growth and the types of jobs that will be created;
— Local content — the number and types of jobs that can be filled by local workers and those likely to be filled by workers from outside the local area or country;
— Forecasted revenue to local businesses, including local construction companies, from spending and capital investment made directly or indirectly by the uranium mining and processing operation;
— Development of regional infrastructure, like roads, bridges, power grid, cellular communication towers;
— Impact on local and national tax revenues;
— Impact on local real estate values, including potential or perceived loss of property value for properties downstream or downwind of the mine or processing facility;
— Direct and indirect impact on employment levels and revenue generation after the cessation of active mining and processing.

3.5.2.2. Government services and regulation

— Local and national government costs for the regulation and monitoring of mining, processing, tailings and waste management, decommissioning, remediation and any associated liabilities;
— Impact on local infrastructure and service industry;
— Impact on public schools, including funding and educational opportunities;
— Local and State government costs for contingency planning and emergency preparedness;
— Review of potential impact and associated costs to upstream and downstream localities, or neighbouring regions, resulting from the mining and processing operations;
— Potential costs of remediating any environmental damage (determination of mechanisms to hold the owner/operator financially responsible including the bond strategy to ensure companies retain funds for decommissioning and remediation);
— Potential funding or invoicing back to the mining company to offset government and regulatory costs.

3.5.2.3. Public health and the environment

— Potential improvements to medical care facilities which may have a positive impact on the quality of life;
— Potential and forecasted impacts on the environment and quality of life, including potential impact on quality of life from catastrophic environmental consequences (e.g. tailings dam failure). This also includes localized impacts on natural landscapes, scenic appeal, recreation and tourism, including wildlife and hunting, fishing, boating and places of historical interest that might be affected;
— Post-closure (e.g. decommissioning and remediation) procedures to ensure public health and safety are met, and the environment is returned to an acceptable long-term state.

3.5.2.4. Social impacts

— Effects of uranium mining and processing on internal and external image and reputation of the region, for example, belief that the area will remain a safe place to live, work and invest;
— Public confidence in the company to prevent adverse effects and the ability of government to properly regulate such effects;
— Impacts on schools and private institutions;
— Direct and indirect employment opportunities;
— Benefits to local and national economies based on taxes and royalties;
— Impact on aesthetics of the area.

An external stakeholder report ought to be prepared by the government at a pre-determined frequency (e.g. annual) that covers these points needs to be drafted and presented to stakeholders, for example during a public meeting, in a manner that is clear and concise and using language that can be easily understood by all present. A translator may need to be present if multiple languages are spoken, and the materials also should be accessible to stakeholders in their native language. The public meeting ought to be conducted in a manner that allows for a facilitated question and answer session in order to engage with stakeholders and address any concerns. In addition, to maintain stakeholder engagement and presence with the stakeholders, the operator ought to hire or delegate an appropriately trained and experienced employee to work as a senior spokesperson to interact with stakeholders and provide on-going updates (at intervals appropriate to the milestone, considering other influencing factors) as part of the stakeholder engagement strategy. This level of engagement shows competence of the operator and demonstrates accountability to the community. Completing these initial actions ought to result in a comprehensive public information and education programme that helps to gain and sustain the confidence of the local and national communities.
3.5.3. **Milestone 3: Ready to operate a uranium mine and processing facility**

The activities undertaken at Milestone 2 (Section 3.4.2) in regard to stakeholder engagement can also be applied during commissioning and operation of a new uranium mine and processing facility. The operator ought to review the best practices noted in Milestone 2 of this section and conduct a gap analysis in an effort to continually update and refine the stakeholder engagement strategy.

Some considerations for stakeholder engagement at this phase include:

— The government, regulator and owner/operator continue to conduct stakeholder surveys;
— The government continues to show support for uranium mining and processing, including the expected benefits and also responds to concerns raised by stakeholders;
— The regulatory body continues to engage with stakeholders and continues to provide information to stakeholders on their role, the licensing process and inspection and enforcement programmes;
— The regulatory body arranges for public involvement during the licencing process;
— The owner/operator provides regular updates on the construction process and its preparation for commissioning and operation;
— The government, regulatory body and the owner/operator inform stakeholders of on-site and off-site emergency response plans;
— The government, regulatory body and the owner/operator inform stakeholders of the mechanism for on-going stakeholder engagement as the mine and process facility advance into full operation.

As the facility moves into the operational stage, the operator or government may wish to ask a nearby community to initiate an independent environmental monitoring programme. Community members would have to be trained on proper sampling techniques and an accredited laboratory would have to be used for sample analysis. This would allow community members to periodically conduct their own independent environmental monitoring programme, to verify the facility is operating as planned. The community data could then be compared to the company and regulatory data and shared with stakeholders in an understandable format as a further means to show the site is remaining in compliance. Monitoring sites are chosen off site to ensure there are no disruption or safety issues with the operator. The regulator body ought to also consider collecting independent environmental monitoring samples at the uranium mine and processing facility site (near field) and also downstream or downwind of the facility (far field). This will enhance public confidence in the regulatory body, serve as an opportunity to engage and build capacity with local stakeholders and finally, provide an independent evaluation of the environmental performance of the facility.

When an operator looks to increase the capacity of an existing operation (e.g. new open pit mine) they need to consider all changes that will occur and the impact this may have on the relevant stakeholders. The operator will also have to work with the regulator to determine if the increase in capacity requires a new environmental impact assessment prior to amending the licence to operate or if an amendment to the existing operating licence is sufficient. With both scenarios, the operator ought to involve their stakeholders and inform them of the capacity increase and the impacts this will have. The process described in Subsection 3.5.2 is also applicable in this situation.
3.5.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Similar to that described for the preceding milestones, stakeholder involvement continues to be important for a uranium project at the end of life. This includes while the facility is advancing into decommissioning, those that are advancing to active remediation, already in active remediation or those being prepared for being placed in care and maintenance with the intention of reopening in the future. Operators of uranium mines and processing facilities that are advancing to decommissioning and remediation ought to keep relevant stakeholders informed in regards to planning, decommissioning and remediation activities, relevant monitoring programmes and the final intended state of the site (e.g. ability for the site to be used for recreational, residential, commercial or agricultural activities under institutional control) [50]. Paragraph 2.53 of GSG-15 [51] states:

“Interested parties should have a role in contributing knowledge and information to the remediation process.”

The role of interested parties (e.g. stakeholders), such as members of the public, the responsible party, the regulatory body and/or other relevant authorities involved in the remediation is to exchange information in an on-going dialogue to help ensure that well-informed decisions are made. Representatives of interested parties ought to have the opportunity to express and discuss their positions, expectations and views regarding the remediation. This will facilitate the development of a mutual understanding and meaningful involvement in the decision-making process regarding the planning and implementation of remedial actions.

Operators of uranium mines and processing facilities that are in care and maintenance need to keep stakeholders informed of on-going site activities including progressive reclamation, environmental management and monitoring and the economic and social impacts to the relevant stakeholders. For both scenarios presented in this Milestone, the best practices identified in Subsections 3.5.2 and 3.5.3 also need to be applied.

3.6. SAFETY AND RADIATION PROTECTION (INCLUDING EMERGENCY PLANNING) — WORKERS, PUBLIC

Laws, regulations, emergency planning and monitoring programmes are necessary to ensure the safety of workers and the general public. A Member State considering uranium mining and processing would be expected to have a legal and regulatory framework for conventional safety and radiation protection in place that considers and complies, where relevant, with international standards and national guidelines. The legal and regulatory framework needs to encompass all current activities, practices and facilities in that Member State. The regulatory body ought to develop an understanding of the hazards presented (biological, chemical, physical, radiological) in uranium mines and processing facilities and use that information to develop guiding regulatory principles to ensure the safety of workers and general public. In most mines, physical safety hazards are by far the most significant. This is also true for most uranium mines, except for some with very high-grade deposits where the radioactivity levels are naturally so high that only remote mining by operator controlled or autonomous equipment is possible.

Safe production ought to be a key foundation in the uranium mining and processing industry and all facilities need to strive for zero harm to their employees. The operator needs to have a sustained focus on safety in order to develop and maintain a strong culture for safety. The IAEA safety glossary defines culture for safety as “The assembly of characteristics and
attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.” [27].

To achieve this, a focused effort by the operator needs to be taken to ensure that the core components of an effective safety programme are developed. Some of the key components of an effective safety programme include:

— Development and maintenance of an effective and practical health and safety plan;
— Employment and empowering of skilled/professional health and safety personnel;
— Sustained enforcement of health and safety standards and procedures, including audits;
— Effective training of all people on the site (knowledge of the job, hazard identification, management of risk tolerance);
— Training and continual development of supervisory staff with regard to safety;
— Development of an effective incident management system;
— Continual improvement in a non-confrontational environment.

Applicable radiation safety requirements will vary depending on what stage a Member State is in the uranium mining and processing life cycle. As uranium and its associated decay products are mined and concentrated, the associated requirements for radiation safety increase. Considerations for radiation safety for each generalized situation of the uranium mining and processing life cycle are provided below.

The lead IAEA radiation protection requirement publication, available in all official IAEA languages, is General Safety Requirements Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (2014) [28], which is generally referred to as the Basic Safety Standards (BSS). It is one of the best known and most widely used of all the IAEA Safety Standards. The BSS applies to all facilities and all activities that give rise to radiation risks and lays down a consistent and harmonized system for protection of people and the environment. Additional guidance and information on safety and radiation protection can be obtained from the following IAEA Safety Standards and reports [29, 52–56].

3.6.1. Milestone 1: Ready to make a commitment to explore for uranium

The regulatory body will need to review and implement international safety standards to oversee the development and operation of an exploration project.

From a health, safety and environmental (HSE) perspective, an exploration project ought to follow all national and local regulations and standards for protecting workers, the public and the environment from harm. In the absence of such regulations and standards, or to complement and reinforce them, the exploration company or mine operator undertaking exploration activities ought to develop an appropriate worker training programme, supported by relevant standard operating procedures (SOPs). In line with industry best practices and norms, SOPs need to address specific hazards of a task and describe measures to mitigate those risks. SOPs may be developed to address proper personal protective equipment, working in potentially remote and harsh conditions, work permits as needed, lock-in and lock-out requirements, how to conduct daily checks to ensure safe operation of equipment, a process for conducting field level risk analysis, brief safety meetings at start of each shift and an incident reporting system.

The exploration company’s radiation protection (RP) programme will need to include aspects to ensure that an employee’s radiation exposure remains as low as reasonably achievable (ALARA), economic and social factors being taken into account. Some aspects of ALARA include:

— Engineering controls;
— Administrative controls;
— Contamination/zone control;
— Use of personal protective equipment;
— Radiation monitoring and record keeping;
— Implementation of good hygiene practices;
— Employee training with regard to safe practices to minimize radiation exposure.

Engineering controls ought to take precedent before administrative controls and the use of personal protective equipment. An example of this is the installation of engineered ventilation in the uranium mine and processing facility to significantly reduce or eliminate the need for personal respiratory protection.

A training programme and related SOPs need to be developed to protect workers from potential exposure to radiation during exploration activities. Such exposure can originate from:

— External radiation exposure (beta and gamma radiation) from handling of drill core material or during trenching activity. This is directly related to the concentration of uranium in the core material and the duration of exposure. Time, distance and, if applicable, shielding are the most effective controls to reduce exposure to beta and gamma radiation;
— External radiation exposure from radioactive sources used during exploration, in particular during drill hole probing;
— Exposure to radon progeny (alpha radiation) from drill core and samples stored in an enclosed, non-ventilated area. Core shacks and geology workstations that are used to store or analyse uranium-bearing drill core need to be adequately ventilated. Drilling and related exploration activities in abandoned underground mine workings has the potential to release significant amounts of radon gas, resulting in hazardous conditions. Adequate ventilation needs to be ensured prior to drilling/exploration;
— Long lived radioactive dust particles that originate from splitting or crushing drill core material. Exploration workers need to ensure proper dust control (wet cutting or dust hoods) and personal hygiene measures including use of personal protective equipment and adequate washing facilities for skin and clothing.

3.6.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Development of a uranium mine (open pit, underground, in situ recovery, heap leach) and processing facility is a complex task and will need to consider safety and radiation protection aspects as the project advances through its various stages. During the active construction phase, and as hand over of the completed facilities to the operators takes place, there is a considerable amount of activity and a large contingent of personnel coming onto or leaving the site. This includes contractors, sub-contractors, supervisors, design engineers, inspectors, specialist trades (i.e. shaft sinking, process tanks), among others. Worker and visitor safety and radiation protection becomes a complicated but essential service during the construction phase and cannot be overstated. Construction, and underground mine development, are higher risks occupations and require appropriate oversight by the operator and the regulatory body. This includes detailed design of mine and process facility ventilation as well as other engineered controls to maintain radiation exposure ALARA and ensure the structural safety of any constructed or mine workings. As noted, engineered controls ought to be the first line of defence to protect workers from radiation exposure or safety issues. Use of administrative controls and personal protective equipment ought to be secondary.

At this stage it will be necessary to have all conventional safety, radiation monitoring and protection programmes developed and implemented for construction, and prior to the start of
mining or processing of uranium ore. The IAEA Safety Report Series “Occupational Radiation Protection in the Uranium Mining and Processing Industry” provides comprehensive and practical information on radiation protection, monitoring and dose assessments for uranium mining and processing facilities [57]. In developing the mine and processing facility and before production starts, the necessary radiation protection conditions that need to be met include:

— Adequate ventilation, complete with redundant systems in place, for underground mines as well as processing facilities to ensure workers are protected from radon gas and long lived radioactive dusts. For open pit mining, the operator needs to ensure that all heavy duty mobile equipment is equipped with effective air filtration equipment in order to protect these workers from radon gas and long lived radioactive dusts;

— A management system to set guidelines for radiation zone control (e.g. wash stations and dedicated eating/drinking areas) in order to protect the workers and minimize radioactive contamination of non-working areas. Smoking can only be allowed in designated areas both from a conventional safety and a radiation protection perspective;

— Radiation monitoring equipment installed and operational—both at the mine and processing facility and off-site to measure background values in general and monitor air quality for potential radioactive dust migration (as part of a fully implemented environmental monitoring programme);

— A functioning off-site radiation monitoring programme;

— Radiation dosimetry requirements in place for all workers;

— Programmes developed to reduce radiation exposure during mine/processing facility operation and maintenance (ALARA programmes);

— Waste management practices in place for management of low level radioactive wastes.

The radiation protection and safety programmes for the construction or operation of a uranium mine and processing facility is more comprehensive than the programme for uranium exploration. During the development of uranium mines and processing facilities it is recommended that the company employ a qualified radiation safety officer to develop and ultimately manage the site radiation protection programme. Aspects of this role include, but are not limited to: (i) developing relevant radiation protection training programmes for site visitors, contractors, employees, supervisors and management; (ii) recommending and implementing relevant radiation monitoring equipment to ensure that engineered controls are effective and that personal radiation exposure can be calculated; and (iii) developing a database to track and report employee radiation exposures to the relevant agencies at the prescribed frequency. The radiation safety officer will be invaluable during the construction phase of the uranium mine and processing facility to ensure radiation protection issues are appropriately addressed so that workers remain protected. Such examples include when sources are installed for calibration purposes or during mine development and air quality checks are required.

At this stage, programmes for the protection of workers from a conventional safety perspective during operation of the uranium mine and processing facility need to be developed. Examples of aspects of a conventional safety programme that are effective include:

— Ensure roles and responsibilities with respect to safety are developed and understood;

— Conducting effective toolbox meetings every day prior to start of a work shift (review planned jobs, identify and mitigate safety risks);

— Continual management presence at toolbox meetings and in the workplace;

— Promoting the use of all staff to complete job task observations in the field;

— Making use of safety tools such as job hazard analyses to reduce safety risk for non-routine tasks;
— Completing independent audits of health and safety practices and procedures;
— Enforcing disciplinary measures for deliberate violation of safety rules, which may extend to removing personnel from site who violate important life-saving health and safety procedures;
— A programme that is developed to define how safety performance at the uranium mine and processing facility will be tracked, reported and communicated to all relevant stakeholders.

At this stage the operator ought to complete a risk assessment of potential radiation and conventional safety incidents to both workers and the public and develop mitigative strategies. Contingency plans ought to also be developed to identify and develop a response plan for radiation and conventional safety emergencies.

Finally, at this stage the regulatory body ought to review and approve the operator’s radiation protection and monitoring programmes as well as reporting frequency for radiological doses to ensure that they align with regulatory requirements. The regulator ought to have developed relevant conventional safety and radiation protection regulations and enforcement mechanisms to ensure compliance with these regulations.

### 3.6.3. Milestone 3: Ready to operate a uranium mine and processing facility

The aspects covered in Milestone 2 (Section 3.6.2) apply to a uranium mine and processing facility that is ready for final commissioning and moving into the operational phase. The lessons learned on safety and radiation protection oversight from the construction phase need to be addressed and implemented in the operational phase. In fact, these are continual learning and improvement programme areas.

Regulatory systems and operational management programmes ought to be in place at this stage to address safety in a proactive manner. Both the operator and regulatory bodies are responsible to promote a strong safety culture. The IAEA Safety Fundamentals and Safety Standards provide the reference for international good practices for both the regulator and the operator. Safety ought to be an intrinsic consideration to all activities associated with uranium mining and processing to ensure a strong safety culture and ultimately strong safety performance.

The following list summarizes important considerations to maintain strong safety performance in a uranium mine and processing facility.

— The operator needs to work to create a strong safety culture through effective safety training and promoting positive attitudes toward safety;
— The operator ought to recognize that they have the first and primary responsibility to ensure safety of the workers and the public;
— An effective management system is developed by the operator that provides practical guidance in areas of safety and to ensure that sufficient funding is in place to sustain strong safety performance. The management system for safety ought to be evaluated at a prescribed frequency to ensure relevance and look for opportunities for improvement;
— A comprehensive asset management strategy ought to be developed by the operator to ensure all mining and processing equipment and infrastructure are well maintained;
— Operations staff need to be effectively trained on all technical aspects including operation of equipment to ensure safe and efficient uranium mining and processing;
— The operator ought to look for opportunities to share experiences with similar industries to share use of experience and understand lessons learned from safety related incidents;
— The regulatory body needs to be competent, independent and be empowered to enforce compliance to all regulations including safety regulations;
— Emergency preparedness and contingency plans need to be well developed and frequently reviewed to ensure completeness and that measures are in place to effectively deal with emergencies. This ought to include both proactive and reactive measures.

A Member State that is looking to reinvigorate uranium mining and processing or to enhance its existing capacity and capability needs to review historical baseline and worker radiation exposures. This may include an audit or professional review of its radiation protection and safety programmes to ensure that they will remain effective to meet the requirements of future production, including any heightened regulatory requirements or best practices that may have been introduced since earlier operations ceased.

As part of a capacity increase study, the operator ought to consider radiation modelling of the enhanced mining and processing process, in conjunction with predicted future radiation exposures to employees. A competent radiation safety officer or health physicist may be required to develop the model, interpret the data and recommend mitigation measures to either reduce radiation exposures to workers or at a minimum maintain the radiation exposure of the workers at historic levels and below regulatory limits. In addition, the assessment ought to show that the increase in capacity will not result in increased radiation exposure to contractors and the general public working and living within the impact area of the respective uranium mine or processing facility.

3.6.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

The aspects covered under Milestone 2 and 3 above (Sections 3.5.2 and 3.5.3), including emergency planning, also apply to the decommissioning and remediation phase. In fact, similar to Milestone 2, it is likely that a number of contractors will once again return to the site for some of the specialized decommissioning, demolition, and decontamination activities. More equipment may be coming on to the site, and subject to appropriate clearance procedures and approvals, more materials or salvage will be leaving the site during this phase. Contamination and clearance controls will be a priority to protect workers, and the public off site. In terms of worker safety, dismantling and destruction or demolition of large buildings and vessels, etc., carries increased safety risks to the workers in the area. As noted in Sec. 3.5.2, the examples of aspects of a conventional safety programme need to be updated for this new phase of activities. Additional detail on decommissioning of uranium mines and processing facilities can be found in [24].

Uranium mines and processing facilities that are closed or in a state of care and maintenance (i.e. not yet decommissioned or remediated) need to have a detailed radiation monitoring programme to ensure that workers or the public are not unreasonably exposed to radiation. Potential radiological hazards may include increased gamma exposure from process vessels and piping that have not been properly cleaned (e.g. excessive scale build up) prior to being put in a state of care and maintenance or decommissioning. In addition, airborne dust (e.g. long lived radioactive dust) from mine or processing facility workings (ore pads, mine workings, tailings facilities, waste stockpiles, uncleared process equipment containing dried slurries) needs to be properly managed to ensure that workers and the general public are not exposed to dusts, airborne radioactive dusts or alpha emitters. Finally, uranium mines and processing facilities may have sealed nuclear sources (e.g. nuclear density gauges) that are no longer required. These sealed sources need to be properly handled and disposed of and the disposal process needs to be in keeping with international standards for disposal [58].
addition, Section 3 of the IAEA Safety Standards Series “Disposal of Radioactive Waste” provides a more global outlook and guidance on the safety requirements for planning for the disposal of radioactive waste [59].

### 3.7. ENVIRONMENTAL PROTECTION

#### 3.7.1. General

An appropriate national and provincial (when applicable) regulatory framework for environmental protection, based on international good practice, needs to be in place to cover all aspects of the uranium production cycle [60]. Environmental regulations for each phase of the uranium production cycle need to be well developed and comprehensive. The short-term and long-term environmental impacts need to be understood based on scientific evaluation prior to initiating mining, processing or decommissioning/remediation and effective environmental regulations need to be in place to mitigate risk and minimize the short and long-term impacts of uranium production. Mining and processing are a temporary use of the land, so it remains paramount to control the size and duration of any potential environmental impacts. Start with the end in mind.

Environmental protection ought to be a key focus area through all stages of the uranium production life cycle, from exploration through to decommissioning and remediation. Aspects to be considered include water resources (ground and surface), air quality (dust, noxious gases, radiation), noise, biota, amenity and wildlife (especially rare/protected wildlife). Three guiding principles in environmental management of responsible uranium mining include: (i) sustainable development principles, (ii) as low as reasonably achievable (ALARA) principles, and (iii) precautionary principles [8]. Sustainability of the uranium mining industry is based on a balance between environmental, social and economic requirements within a regime of strong governance. Good corporate and regulatory governance are required to ensure clear direction on the appropriate balance of these three principles. Environmental impacts need to be kept as low as reasonably achievable and controls be based on best available and practical technology. However, social and economic factors need to be taken into account when developing and implementing controls. The precautionary principle requires that effective environmental management needs to anticipate, prevent and mitigate the causes of environmental degradation.

The application of good practice ought to be implemented at all phases of the uranium production cycle (exploration, conceptual design, feasibility studies, construction, operation, decommissioning, remediation and closure). The general concepts of the best practices in environmental management are [8]:

- Baseline data collection which includes socioeconomic and environmental characterization;
- Public and stakeholder involvement;
- Impact assessment and mitigation strategies;
- Design and implementation of an environmental management system and monitoring and reporting programme;
- A waste management strategy that includes identification of waste streams, volumes and appropriate storage, treatment and disposal options (see 3.15);
- Decommissioning, remediation and closure plans that are considered prior to development of the mine and processing facility.

Environmental planning and monitoring throughout the life cycle of the mine ensure that the expected performance is achieved through to the post-decommissioning period, minimising the environmental effects to acceptable standards and avoiding impacts on local populations.
3.7.2. Milestone 1: Ready to make a commitment to explore for uranium

The regulatory framework within the country, province or territory (when applicable) ought to stipulate the responsibilities for regulating and monitoring exploration activities within its jurisdiction, and for informing the public about them. Initial uranium exploration which includes airborne and ground surveys are non-intrusive and as such pose a low risk to public health and the environment. If a suitable target is found then the next stage of exploration may involve construction of temporary access roads, drilling, trenching and test pitting. These exploration activities have the potential for some localized environmental impact, in particular on surface and ground water (e.g. cross contamination of water between aquifers), so effective regulations and regulatory oversight ought to be in place. The licence/permit to explore ought to mandate appropriate conditions for exploration drilling including management of radioactive materials and radioactive and non-radioactive wastes. In addition, the licence/permit to explore needs to contain conditions that the exploration site is remediated back to the pre-existing or background conditions if no further activity is planned. During exploration drill fluids and contaminated water need to be properly managed and any resulting radioactive or hazardous solids need to be appropriately disposed of.

Exploration companies or National Geological Surveys that have exploration areas identified that show promise for more detailed exploration and potential further mine development ought to collect initial environmental baseline data at the exploration site. This includes basic information on soil and vegetation types, an understanding of the regional biota, geological and climatic conditions. Industry good practice has shown that the environmental baseline data ought to be collected for at least three years through a variety of seasonal and climatic conditions prior to commencing construction and operations [21]. This will support the environmental assessment that will be required as part of the licence to construct a uranium mine and processing facility, should this proceed after exploration activities have defined an economic resource. Environmental baseline study guidelines need to follow developed regulatory guidelines but need to include, as a minimum, information on hydrological and hydrogeological conditions, flora and fauna, wildlife, biota, archaeological and heritage surveys, anthropological surveys, climate as well as soil, water and air analysis.

3.7.3. Milestone 2: Ready to commit to develop a uranium mine and processing facility

An environmental assessment (EA) study [8–10] needs to be completed by the operator based on agreed and approved guidelines. This ought to include an assessment for both the proposed uranium mine or processing facility to analyse the environmental background/baseline conditions at the site and also the impacts that mining or processing will have on the local and regional biota (air, land, water). An effective monitoring programme ought to be developed as part of the EIS to track environmental performance. The data collected from the monitoring programme can be used to compare the impact of the site against the baseline data collected during the EIS. The EA study ought to also identify action levels, so the operator or regulator can intervene to correct any potential or emerging environmental impacts before they become serious.

The main environmental aspects and potential for long-term liability from uranium mines are contaminated waste rock, ore stockpiles, mine water, surface water, and groundwater. Correspondingly, the main environmental aspects for uranium processing facilities are tailings and waste management operations, and process and tailings water management and their impact on environmental receptors, both surface and subsurface. As such, industry good practice needs to be applied in developing operational strategies and processes to manage tailings and water management facilities, within the context of the license or permit for operating the site [61, 62]. Emissions from processing facilities (e.g. ammonia, sulphur dioxide, solvent extraction organic,
uranium(calciner dusts) need to be considered as well. Effective regulatory processes ought to be developed that utilize industry good practice for regulatory oversight of these aspects.

The operator ought to indicate what industry good practices are being applied with regard to environmental management in order to minimize the environmental impact. Mine or processing facility proposed design, including relevant environmental controls, ought to be included in the environmental assessment and the environmental impacts of the life cycle understood. In turn, the outcome of the EA process that identifies critical or vulnerable receptors (e.g. groundwater, wildlife, airborne emissions) feeds back into the final design of the facility that is seeking regulatory approval. Some specific aspects that need to be considered in the environmental assessment, that make it an important planning tool, include:

- Pathways for effluent loading and impact on downstream (near and far-field) environmental receptors;
- Impact of air emissions and dusts from mining, contaminated waste rock piles, tailings facilities and processing of uranium;
- Identification (presence / absence) of plant and animal life, their respective abundance, their particular sensitivities and impact of mining and processing uranium on them;
- Impact of uranium mining and processing on local populations (e.g. via impact to groundwater, surface water, soils and food sources);
- Volume and origin of water used for mining and processing, or clean waters diverted before they become contaminated (e.g. open pit dewatering);
- Waste management strategies (tailings, mine rock segregation, development waste, radioactive slimes and sludge, radioactive and non-radioactive wastes, putrescible landfill management).

All of these aspects need to be well understood and documented to form a strong scientific baseline and framework to monitor future potential impacts against. The operator needs to show that its management strategy is effective at ensuring minimal impact on the environment during design, construction, commissioning, operation, decommissioning and remediation. This needs to be illustrated not only through words, but through management actions and an effective environmental monitoring programme. Overall, these foundational management strategies need to be in place before the regulatory body can issue a licence to construct and a licence to operate.

The regulatory body needs to put in place science and evidence based environmental guidelines and discharge limits for environmental contaminants. These limits will be set with consideration to natural background, part of which is understood by the studies completed by the operator as part of their EIA thereby highlighting the importance of appropriate temporal and spatial studies of the receiving environment. This also includes regulations for effluent and air emissions and related guidelines and standards for the management of tailings, mine rock and radioactive contaminated waste (e.g. pipes, rags, etc.) as well as non-radioactive waste. These regulations and standards need to be in keeping with international standards for environmental protection and be based on the best available and practical technology.

3.7.4. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage the regulatory body needs to be well developed and include regulations and guidance specific to environmental management, monitoring and reporting, including reporting and follow up requirements for upset conditions such an uncontrolled releases (spills). Good practice in regard to stakeholder engagement and sustainability is that regulatory requirements for environmental reporting from uranium mines and processing ought to be public documents. The regulatory body needs to be fully staffed with qualified personnel that can review the
environmental performance of the mine and processing facility and have the authority to enforce the established regulations.

The owner/operator ought to have a comprehensive environmental management programme developed that is compliant to the established regulations and aligns with the aspects identified in the environmental assessment and the operating licence. This includes both operational and statutory environmental monitoring and reporting. Further, the mine and processing facility ought to have a fully staffed and dedicated environmental management team. During operation the owner/operator ought to assess environmental performance of the uranium mine and processing facility and look for continual improvement opportunities based on best available technology to reduce environmental risk and impact. Action levels or triggers ought to also be identified, and a corrective action programme needs to be put in place to take remedial actions before significant harm or impacts arise.

Contaminated waters collected and generated throughout the uranium mining and processing site ought to be treated to ensure efficient removal of radionuclides and unwanted metals prior to releasing effluent from the site to the environment. Contaminated waters are primarily sourced from hydrometallurgical processes (e.g. raffinate from solvent extraction), from the reservoirs in excess of processing plant requirements, from dewatering activities (e.g. mine dewatering, seepage and runoff from surface sources, including waste rock piles and ore stockpiles), and from tailings management facilities. Prior to releasing effluent from the site to the environment, the quality of the water in the monitoring ponds ought to be confirmed through sampling and analysis. Effluent ought to be released to the environment only after the results indicate that the quality of the water meets the requirements of authorized limits for release.

The regulatory framework also needs to define at what minimal frequency the regulatory body will inspect the site and audit environmental programmes to ensure compliance with the conditions prescribed in the operating licence. The regulatory body also ought to conduct a check-monitoring programme, including collection of treated effluent and discharge samples from the mine or processing facility and have them independently analysed to ensure compliance with regulatory guidelines and limits.

All of the above mentioned aspects for environmental management including performance criteria (e.g. effluent release guidelines), monitoring and reporting ought to be included in the licence to operate that is issued to the operator of the mine and processing facility, once regulatory conditions have been satisfactorily met. All lessons learned and as-built information from the construction and commissioning activities will form part of the operational environmental management program.

Member States that are looking to reinvigorate uranium mining or increase capacity may have environmental regulations in place due to their history of mining and processing. This regulatory framework ought to be reviewed to ensure that it includes provisions and licensing guidelines for new mines and processing facilities as well as for existing operators that are looking to increase capacity and capability. If a Member State is looking to approve a new mine or processing facility and there will be a new licensee, then the steps outlined in Milestone 2 (Subsection 3.6.3) above would apply. If an operator is looking to increase the capacity and capability of an existing operation, an environmental assessment may need to be completed to determine what the environmental impact will be with an increase in production rates. This need will be determined by the requirements of the regulatory framework. Impacts to land, water and air, and their receptors, will have to be assessed and compared to both the original environmental impact assessment as well as historical performance. Some key environmental aspects that need to be considered when increasing production capacity and capability include:

— The impact on effluent loadings to near and far field environmental receptors;
— The impact on the tailings volume and performance and capacity of the tailings facility (geotechnical and geochemical);
— The mass of mine rock that will be produced and a management strategy to ensure minimal environmental impact from mine rock (segregation, proper storage, geochemical controls to prevent leaching of contaminants);
— The impact of additional radon and long lived radioactive dusts on air;
— The cumulative impact to the current decommissioning and remediation programme, and the objective to meet a long term institutional control outcome.

The goal of an environmental assessment at this stage is to determine if the operation will have an increased environmental impact with an increase in production capacity or capability. If the environmental assessment does show a statistically significant increase in the environmental impact on land, air or water, or its receptors, then the operator needs to be challenged to ensure that it has done everything that is reasonable to mitigate the environmental impact. This could include the implementation of new technologies or different operating strategies (e.g. recycling of effluent back to the process rather than using additional fresh water) to minimize environmental impact.

Once all the terms and conditions of the environmental impact assessment have been met, assessed and approved by the regulator, an amended operating licence can be administered to the operator that includes any new licence conditions that will be in place.

3.7.5. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Uranium mines and processing facilities that are closed, in active decommissioning or advancing to a state of care and maintenance ought to have an updated comprehensive environmental management programme to ensure on-going protection of the environment and the public for both the short and long term during decommissioning, remediation or care and maintenance [63]. These plans ought to follow industry good practice for uranium mine decommissioning and remediation [64].

Mines that are closed or advancing into decommissioning need to have an approved and licensed decommissioning and remediation plan that is well structured and ensures that the site is decommissioned and remediated using industry good practices and that on-going monitoring programmes are implemented to track the effectiveness of the remediation programme. The decommissioning plan may be separate from the remediation plan and this will be determined by the detail in the regulatory framework of the relevant jurisdiction. Previous EA reviews and commitments need to be referred to in terms of decommissioning and remediation outcomes.

A comprehensive decommissioning and end of life plan complete with monitoring activities needs to be prepared by the operator and approved by the governing regulatory body. The decommissioning tasks that will be performed which could result in an environmental release (radioactive and non-radioactive pollutants) from the facility and which have an impact on the local environment need to be identified, along with details on the appropriate controls and mitigation measures that are foreseen should such an event occur. The potential pathways that could be involved with these releases need to be described and the potential discharge for each task evaluated.

Once remediation is complete and the subsequent monitoring and surveillance programme have shown that the remediation plans have met the desired results and the risks to human health and the regional environment have been mitigated the regulatory body ought to consider removing the some or all restrictions that have been placed on the operator for remediation. This may be a graduated approach where the requirements for surveillance and monitoring are reduced. The last stage would involve the site being fully transferred to institutional control.
Mines that are advancing toward care and maintenance also need to have a specific well established environmental management programme that may include treatment of mine water, effluent, tailings, and contaminated waste rock water. In addition, mines and processing facilities at this stage need to continue with a well-defined environmental monitoring programme commensurate to the risk of the site status, and also advance active reclamation of areas of the operation that will not be used again. Finally, regulatory oversight ought to continue at an appropriate frequency to ensure compliance with the license conditions prescribed for this stage of a mine or processing facility’s life.

3.8. PROTECTION/ENHANCEMENT OF CULTURAL, TOURISM, FARMING, PASTORAL AND SIMILAR INTERESTS

The social and economic interests in an area of uranium exploration, and possible later mining and processing, need to be well understood early in the process. The potential impacts, both positive and negative, become greater if a project proceeds to the mining and processing stage.

While the amount of detail, effort of the regulatory body and operator and interaction with relevant stakeholders is greater for more advanced projects, the aspects to be considered at all stages include:

— Population density and distribution;
— Social infrastructure, including education and health services, formal and informal governance, and availability of variety of workers and professionals from the workforce;
— Physical infrastructure, including transport, water supply, electrical, communication and other;
— Local economic pursuits, such as farming, pastoralism, forestry, manufacturing and other industries, including other mines and tourism;
— Conservation and cultural heritage areas and sites.

3.8.1. Milestone 1: Ready to make a commitment to explore for uranium

In some cases, the earliest stages of exploration, such as desktop studies and limited remote sensing, may have little local impact. Once an exploration licence/permit is obtained, however, and on-ground and airborne studies are required, working with local interest groups and communities becomes essential. The housing of exploration crews and their equipment may take up local accommodation resources, or strain recreational, communication, electrical or other facilities, as well as bringing income into an area. The presence of exploration activity in agricultural, pastoral, cultural or touristic scenic areas may also need to be considered.

At this stage there is the need to interact closely with landholders when the exploration lease extends over pastoral/agricultural land to ensure that the foundations of a good working relationship are set and expectations for impact and remediation are well understood before work commences. Damage to fences, crops and pasture ought to be avoided, and suitable repairs or compensation for crops or pasture that need to be disturbed to allow exploration need to be negotiated and implemented. In some cases, exploration can contribute to the upgrading of existing roads or the creation of new ones or temporary ones that are available to the community. Heavy use of existing roads or stream crossings may cause damage, requiring additional maintenance work, which needs to be taken into account, and traffic hazards (possibly including collisions with stock or wildlife) may also need to be considered. Although the demand for water is not high during exploration, in arid areas the supply of water for drilling
or an exploration camp also needs to be taken into account. Similarly, in more densely settled areas, disturbance to other infrastructure or activities needs to be considered.

During the exploration period, many exploration teams may interact with the local community and commence some local support activities. The extent of interaction and other support will be related to the size and duration of the exploration project. If a deposit is found, advanced exploration and delineation of the potential orebody typically requires significantly more personnel and physical resources than early exploration and would typically be associated with increased support to the local area.

When planned well, some infrastructure improvements implemented for exploration might become assets for the local community, which might include improved roads, water supplies, improved communications or an airstrip.

Exploration projects may consist of several short, seasonal campaigns, utilizing only local existing infrastructure, or long term projects with a camp with accommodations, vehicle maintenance facilities, sample processing and storage buildings or yards, fuel storage areas, and sometimes an airstrip. Even when a long term facility is constructed or rented, the amount of activity can vary, from active drilling campaigns to low key exploration or periods of care and maintenance.

3.8.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Should a uranium project proceed to construction and operation (mining and processing), the effect on local infrastructure and society may become more pronounced. In some instances, a new uranium mine may be the main economic activity in an area and needs to coexist with existing land uses, such as farming, forestry, pastoralism, recreation or conservation. The spread of contaminants via streams draining the uranium mining and processing site to potential agricultural plains, where the water is used to irrigate crops, ought to be prevented and considered in the early planning stages of any new mine project.

When landholder agreements are done well, commitments to local communities and arrangements with the government and regulator will be successful. Unavoidable impacts are appropriately compensated (e.g. compensation for lost farmland or houses, provision of alternative roads, diversion of watercourses, replanting of trees or wildlife habitat elsewhere) and an appropriate package of community and societal development is delivered. The Rössing Foundation is an example of sustained stakeholder involvement and the website associated with the Rössing uranium mine in Namibia provides an insight into specific aspects of the Foundation [65]. Additional details on this subject may be found in the case study in Appendix I.

The size and budget of a community development package will depend on the size of the mining and processing project and local circumstances. Even small mines and processing facilities that cannot support a programme like that of the Rössing uranium mine can have a positive impact on the communities around. This is in addition to providing some employment and small business opportunities and contributing financially to government income at different levels.

3.8.3. Milestone 3: Ready to operate a uranium mine and processing facility

Much of the discussion for Milestone 2 (Section 3.8.2) also applies here. However, there may be legacy problems from earlier mining and approaches that require renewed negotiation at long lived mines such as the Rössing uranium mine in Namibia or the SOMAIR and COMINAK mines in Niger. In other circumstances there may be legacy sites that have not yet been satisfactorily remediated or were remediated to the standards of some decades ago that are no longer considered suitable. Satisfactory resolution of outstanding legacy sites, or the
upgrading of the regulation, operation and preparation for eventual closure of existing (especially long lived) mines, may be an important component in establishing confidence in the capacity of the Member State to enhance its existing capability.

3.8.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

As described in Milestone 3 (Section 3.8.3), satisfactory resolution of outstanding legacy sites, and aftercare of remediated sites, is important at this stage. Based on national regulatory requirements some Member States completely decommission and remediate former uranium mining sites (e.g. France and Germany). Others opted to make selected sites safe and maintain them in a condition such that mining could be recommenced in the future, should circumstances become favourable (e.g. Portugal).

Decommissioning and remediation projects can also lead to improvements in local conditions to at least partly compensate for the loss of mining employment and income. Some former mining sites retain a heritage value and become education or tourism centres, whilst others are returned to previous land uses (e.g. farming, pastoralism, forestry) or switched to alternative uses (e.g. recreational, conservation, further industrial use). Clearly understanding what the expected end state obligations or expectations are, before the project proceeds or is expanded, is an important factor. The communities and governments goals in reaching a long term institutional control status need to be in alignment.

3.9. FUNDING AND FINANCING

The funding and financing requirements for the development of uranium mining and processing including decommissioning and remediation are significant\(^2\) and the funding for legislative and regulatory infrastructure development will likely need to come from government sources. Governments need to understand the commitments involved in developing a uranium mining and processing regulatory programme and they need to begin to develop the broad range of human expertise required to manage and regulate uranium mines and processing facilities. This will be of prime importance for subsequent efforts to obtain financing for these operations. Developing the confidence of the financial community requires stable and sustained determination to competently manage the construction, licensing and safe operation of a uranium mine and processing facility.

Initial financing can be pursued in several ways. Total financing and ownership by the government is an option if the nation’s economic portfolio provides revenue that can be dedicated to the associated capital and operating costs. This approach may not be feasible for all countries. Export financing is another option for funding, but it will only provide for a portion of the overall investment. Local or foreign commercial financing will be required for the balance of the capital cost and to cover the interest accrued during construction. A common approach is to obtain private financing backed by specific government guarantees. Another possibility is to secure private funding by a consortium of partners seeking a return on their investment through revenue generated from the sale of the uranium concentrate produced. Credit worthiness is the first priority for obtaining any project financing. Economic policy, debt management and legal risk sharing mechanisms are all important aspects to be considered when working to secure financing.

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\(^2\) In general, the term ‘funding’ refers to aspects that are the fiscal responsibility of a government in establishing uranium mining and processing, e.g. ensuring that the necessary resources for regulation are provided. The term ‘financing’ refers to aspects that are the fiscal responsibility of the owner/operator (government or private entity).
Initially, a Member State will need to consider that the impact of low prices can be highly disruptive to sources of capital and mining operations. Uranium is not priced like other commodities on open exchanges. With only a few buyers and sellers, at the time of this publication uranium is commonly marketed through undisclosed long-term contracts.

Private sources of capital (money) seek the best return on investment and time. Although the chief executive officer (CEO) or managing director works for the company, he or she is appointed by the board of directors, who work for the shareholders. Thus, the shareholders, especially those with voting control, have significant influence and the motives of these investors need to be understood. Some investors perceive that the underlying value of the commodity will go up and are buying a chance or option on that happening. Caution ought to be exercised, for they are not truly investing in a technical programme. A second type of investor is legitimately interested in the business; some have a penchant for risk in exploration and some seek a return from the mining operations. In general, the latter will buy shares of large, dividend-paying companies, while the former are primarily interested in capital gains through the appreciation of the company’s share price, although they are also partly interested in the underlying option effect. Regardless of motives, investors have a fundamental interest in ‘liquidity’, which allows them to exit easily without greatly changing the value of the investment.

Partnering with listed companies allows governments to see quarterly financial statements and project descriptions. However, governments partnering with listed companies ought to be aware of the legal filing requirements of listed companies. Consider, for example, a company listed on the Toronto Stock Exchange that a government partnered with to explore a new terrain for uranium deposits. The Member State considers uranium to be a highly sensitive but strategic asset, but its Canadian partner needs to issue press releases announcing material changes and eventually file a geological and later engineering reports with the web site SEDAR [66]. These reports are made available to the public. Some of the company’s contracts may even be filed. In all aspects of disclosing exploration information, transparency is of prime concern such that potential investors can make reasoned and informed decisions regarding the nature of a project and the risks associated with it.

Exploration and junior mining companies, whether listed on a stock exchange or private (not listed), raise capital by selling partial ownership (equity) in the form of ‘shares’ to investors under the rules of their jurisdiction. Because of the inherent risk in exploration, some regulators apply strict rules to protect investors. For example, in the United States of America, the Securities Exchange Commission only allows explorers to state a reserve (the part of the resource determined to be profitable to mine). Companies are not allowed to state a resource unless required by another jurisdiction. For example, a Canadian uranium listing that co-lists in the USA can state a resource. As a result, the primary listings for companies start on the well-known mining exchanges in Canada (TSX, TSX-Venture and recent start up exchanges such as the CDM), Australia (ASX), South Africa and the United Kingdom of Great Britain and Northern Ireland (AIM) [67–72].

The evaluation of a mining project happens in stages because of the inherent risk and capital requirements. At each stage of exploration, scoping studies, pre-feasibility and feasibility, there is a ‘go’ or ‘no go’ decision: whether to proceed to the next stage, put the project on hold or abandon it. The Committee for Mineral Reserves International Reporting Standards Code (CIRIRSCO) [11] measures the error at the first stage (scoping) at 30–40% and that at the second stage (pre-feasibility) at 20–25%, while the error for a feasibility study is +/-10 to 15%. In a longitudinal study of mining projects, Bullock [73] found that feasibility studies had errors between -20 to +27% and cost overruns had a weighted average of 27%.
### Milestone 1: Ready to make a commitment to explore for uranium

From a financial perspective, exploration is a high-risk activity within the uranium production cycle. Exploration involves many stakeholders, including governments, geological survey organizations, geoscientists, consultants, exploration companies and mining companies. Project funding will be different from one actor to another within the project development, and at different levels. For example, geological survey organizations will play an important role in attracting investment in the exploration activity by providing a favourable environment and gathering geoscientific information. Exploration companies will focus on the identification of prospective properties or potentially economic deposits, and their sale to major companies. Major mining companies will focus on exploration and mining of deposits in order to generate profits in a sustainable manner.

**FIG. 3. Risk and financial expenditure for various phases of a life of mine (modified from Eimon 1988)**

Before embarking on uranium exploration, the Member State ought to understand that mineral exploration is inherently risky and the probability of finding an economic deposit is very low. For example, Marlatt [75] estimates that for every 1000 exploration projects, approximately one economic uranium deposit will be discovered (a probability of ~1%). Of these deposits, only one in three will advance to mining through the feasibility stage [76]. In 2016, the estimated 46 year (1970–2016) weighted average base rate for the cost of exploration per kilogram of uranium (indicated) in the ground was about US $10 [77].

Figure 3 illustrates the risk and financial expenditure profile for the stages of mining from exploration through to decommissioning and remediation. Financial risk is present at all stages of the life cycle of a uranium exploration and production programme and these risks ought to
be identified and mitigative measures put in place. As noted above, there is a low probability that an area with defined mineralization will advance to an active, positive economic margin mine. Overall, exploration is a high risk and costly endeavour, often with results that do not show a return on investment. A Member State needs to recognize this concept prior to advancing exploration activities. Once a deposit is located and resources are well defined, the project may advance to an active mine. At this stage the costs increase as a mine advances into production; however, strong due diligence during the resource evaluation and mine planning stages will greatly reduce the risk of financial loss. Once a mine resource is fully depleted, the Member State needs to recognize that revenue generation will cease and, as such, funds need to be in reserve to support and sustain decommissioning and remediation efforts through to completion.

While limited funds from international development agencies may be available, Member States ought to expect to provide initial funding in Phase 2. In many countries, regional airborne geophysical and satellite-based data have been collected in the past four decades. The government in this situation ought to work to organize these data to build archives that are useful for internal review and perhaps for commercial users if available in a secure digital format. On-line cadastre systems allow for governments to provide early stage explorers and prospectors with land ownership and mining tenement information, and in some cases geological data.

3.9.2. **Milestone 2: Ready to commit to develop a uranium mine and processing facility**

As a minimum, the Member State needs to be funded to fully develop an understanding of the commitments required for the introduction of uranium mining and processing. At the same level of importance, the Member State ought to secure funds early in order to draft and promote the necessary legislation and the expansion of an existing, or the establishment of a new, regulatory body with the necessary resources to ensure competence. An understanding of the complete life cycle of uranium mining and processing is needed, with specific knowledge of the funding and legislation required for waste management and decommissioning activities. Establishing this regulatory foundation will demonstrate the Member State’s commitment to advancing uranium mining and processing and will likely be a prerequisite for beginning to explore financing options for these facilities. Construction of a uranium mine and associated processing facility requires significant capital funding. The operator is responsible for securing such funding to construct and commission the mine and processing facility. In some cases, the costs associated with shared or common infrastructure (e.g. roads, electrical or water distribution infrastructure) may be cost shared between the government and the operator.

The following strategies ought to be developed to support a viable financial plan for uranium mining and processing:

- Funding the efforts to create the basic infrastructure necessary to prepare for the introduction of uranium mining and processing;
- Developing and maintaining a reasonable level of stakeholder involvement;
- Funding the creation or hiring of expertise to develop the necessary legislative framework;
- Funding the expansion or creation of a competent and independent regulatory body, and its operation;
- Long term financing to ensure the ability to sustain regulatory oversight for decommissioning and remediation of these facilities;
- Financing the efforts to support a Long Term Institutional Control Framework, that includes land controls and document registry of the decommissioned and released sites.
There are various options to source capital after Milestone 1, depending on the levels of risk embedded in both the project and the jurisdiction. This could involve spending on the order of $US 30 million, depending on the extent of infill drilling required (value from the mid-2010s). Accordingly, some flexibility is required regarding the best path and generally the financing is best structured in the private sector under industry standard terms. However, some State involvement may be required to facilitate an optimal structure. Governments ought to involve experts from the ministry of finance as well as outside independent consultants to properly develop a financial model that can be tuned to consider the stakeholders.

Sources of capital with minimum requirements from a history of case studies and varying market conditions ought to be considered. Banks and private pools of capital are only appropriate in development projects that are significantly de-risked. Summarized below are the key sources of capital relevant to the uranium industry. The general ‘tolerance’ for risk based on a history of deals is indicated. Most commonly, capital financing is implemented through a combination of sources, which is referred to as structured financing. The weighting between sources depends heavily on market conditions. For example, in periods of rising uranium prices the equity market will be more productive.

Some large capital expenditure (CAPEX) financings in uranium on the order of US $100 million (value from the mid-2010s) have been affected through convertible debentures combining equity and debt, as the value of the loan can be swapped for shares in the company at a future date. Convertible debenture can be highly destructive to a publicly traded company’s share price.

In the next subsections, the following qualifying abbreviations are used:

- E — exploration tolerant;
- R — resources required;
- RR — reserves required;
- OFT — secure offtake\(^3\) desired/required.

### 3.9.2.1. Exploration

- Capital markets (E):
  - (i) Sophisticated investors;
  - (ii) Public companies with capital.
- Producers (E):
  - (i) Major uranium mining companies (e.g. Cameco Corporation, China National Nuclear Corporation, Orano, Uranium One).

### 3.9.2.2. Resource evaluation

- Private equity (R):
  - (i) Specialist funds will require eventual listing.
- Trading houses (R):

\(^3\) An offtake agreement is a contract between a producer and a buyer to purchase or sell portions of the producer’s upcoming products. An offtake agreement is normally negotiated prior to the construction of a production facility — such as a mine or a processing plant — to secure a market for its future production. Offtake agreements are used to help the producer acquire financing for future construction, expansion projects, or new equipment through the promise of a future income and proof of existing demand for the production.
(i) Commodity traders, for example, buy long term and sell in the spot market.

— SOE\textsuperscript{4} agencies (R):

(i) State-owned enterprises can be mining or other sectors.

— Royalty and streaming companies:

(i) Investments made for future royalties and pre-purchase arrangements.

3.9.2.3. Reserve evaluation

— Fuel cycle participants (OFT):

(i) Historic interest from enrichment services.

— End-users (OFT):

(i) Utilities.

— Banks (RR/OFT):

(i) Generally high interest will require offtakes.

— Merchant banks (R, RR/OFT):

(i) Boutique firms specializing in mine project financing.

— Development banks (R, RR):

(i) China, South Africa and State owned.

In general, governments ought to allow the natural forces of the market to finance mining activities. However, there is a role for government in the following activities:

— Coordinating local participation with community leaders early in the project;

— Structuring taxes, royalties and SOE\textsuperscript{3} participation;

— Providing State data and policies during third party due diligence.

3.9.2.4. State owned enterprise (SOE) participation

Historically, Member States have had varying levels of participation in commercial mining, both at the national and provincial levels. However, over time, various governments found that they could only weather the typical boom and bust economics in the mining industry if they had a controlling market share through consolidated mine ownership. This happened, for example, in copper, potash and iron ore. Currently, most countries look to participate in the mineral sector do so through a State owned enterprise (SOE). While a minority equity ownership looks appealing politically, it often has no meaningful contribution to the State unless empowered to offtake at cost and market production.

SOE companies can be involved in exploration, but typically only if self-financed through joint ventures and sales.

A SOE participant with an active balance sheet may be able to finance an equity position, but Member States need to consider if they can carry the cost of such capital through to the proceeds of mining. Otherwise SOE participation is usually through a negotiated carried interest that is sensitive to the specific factors in the planned mine. Finally, SOEs with a portfolio of assets may be listed on the stock exchange, with the government retaining a significant holding. For legal reasons the SOE needs to function independently of government.

\textsuperscript{4} SOE (state owned enterprise) refers to a corporation wholly or partly owned by the national or provincial government. Also referred to as a ‘crown corporation’ or parastatal in some countries.
3.9.3. Milestone 3: Ready to operate a uranium and processing facility

Much of the discussion for Milestone 2 (Section 3.9.2) also applies here as the mining company needs to ensure efficient funding or financing for initial operating costs and provisions in place for sustaining capital funds. Once the uranium mine and processing facility reach nameplate capacity the operation ought, in theory, be fiscally self-sufficient and generate revenue that supports on-going operational, developmental and sustaining capital costs. At this stage funding or bonds for decommissioning and reclamation ought to be secured from the operator (proponent) and placed in a national trust fund (or similar mechanism) to ensure that financing is available for these activities. Additional detail is provided in the next Section.

3.9.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Industry best practice for social responsibility in the uranium mining industry requires the operator of their respective uranium mine to continue to operate until the resource is depleted. The operator ought to have protected funds in trust or revenue reserved from production to finance the several years required to effectively decommission and remediate the site. However, several recent events have shown that operators are forced by low metal prices or technical problems to abandon a mine before proper closure. Some recommendations to lessen the risk of this situation occurring include:

— Requiring companies to finance closure bonds as part of the capital requirement up front;
— Independent audit of estimated decommissioning and remediation costs, including the option of the operator abandoning the site and the decommissioning and remediation work undertaken by an offsite contractor;
— Revisiting the closure commitments and, during periods of improved profit margins, requiring the operator to top up the closure funds;
— Inspecting operator filings with overseas regulators (financial statements, technical reports, news releases);
— Analysing mining operations to detect any changes in operations that might indicate financial problems, a faltering operation, or changes that could affect the cost of closure;
— Requiring companies to finance or secure a bond for any long term institutional control costs, once the site is released from licencing.

3.10. SECURITY

The government within a Member State plays an important role to ensure nuclear security. The fundamental responsibilities of the government include [28, 78, 79]:

— Establishing a national security policy and strategy for uranium ore concentrate (UOC);
— Establishing a legal and regulatory framework for security of UOC;
— Developing a risk based approach to regulation of security of UOC;
— Establishing, implementing and maintaining a physical protection regime;
— Ensuring adequate protection of UOC in use, storage and transport;
— Establishing and maintaining a legislative and regulatory framework for physical protection;
— Establishing a competent authority responsible for implementing the legislative and regulatory framework.

Security including physical protection are intended to prevent malicious acts by internal or external adversaries that might endanger the public, mine/process facility employees or the environment. A strong management programme for security including physical protection is required for uranium mines and processing facilities. This programme ought to include evidence of a comprehensive review of threats and vulnerabilities and subsequent actions taken to mitigate security risks. Section 8 of the IAEA Safety Standard “Management of Radioactive Waste from the Mining and Milling of Ores” provides guidance on monitoring and surveillance for facilities that store radioactive materials and wastes [80].

In general, it will go a long way to satisfying the security needs by designing and implementing an effective security programme appropriate for any industrial site containing valuable equipment like vehicles, high tech equipment, fuel, reagents, explosives, warehouse supplies, etc. This includes control or security points to enter the site, and a security gate exiting the site(s). This will ensure that all personnel, goods, or vehicles entering or exiting the sites are verified. Any material leaving the site will also have to be cleared by the radiation protection department as not being contaminated or has been packaged properly.

3.10.1. Milestone 1: Ready to make a commitment to explore for uranium

Exploration is typically conducted in remote areas and this in itself provides a means of security. Some valuable equipment and supplies will be on site, so some level of security against theft may be required. Exploration sites ought to maintain a level of security to also ensure that radioactive core material does not go missing and create a potential contamination/dose risk to the general public or regional biota. During active drilling campaigns, drill core boxes should not be left unattended at the drill site in the field because this practice would introduce concerns about the security of the drill core since the core would not be guarded and would be vulnerable to damage by passing domestic animals, human tampering or even destruction by individuals who may oppose exploration work in their territory. A secure drill core box storage facility (e.g. fenced area, storage room or container under lock and key) ought to be arranged to ensure sample security. As part of the developed regulatory processes security procedures need to be in place to track core samples when they are transported between the exploration site and geological or analytical laboratories. Further, the geological and analytical laboratories ought to have a licence to receive, handle and store radioactive substances (e.g. uranium-bearing core samples).

3.10.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Once a Member State has made the decision to support and advance uranium mining and processing to the production stage, the requirements for security increase and the following security conditions need to be established:

— Legislation providing appropriate authorities for security including physical protection;
— Laws and penalties for criminal activity and malicious acts in or around uranium mines and processing facilities, including theft of nuclear materials or radiologically contaminated materials (e.g. tools, electrical components, vehicle parts);
— A site-specific security programme that has evaluated security threats and risks and has well defined actions to minimize risk;
— A physical protection system that has been tested and received final acceptance from the owner/operator;
— A security protocol (including physical protection) for the transportation and storage of uranium concentrate;
— Trained security personnel;
— A security culture that recognizes the importance of security requirements for nuclear materials.

At this stage the Government and regulatory body need to develop the framework for the protection of UOC [78]. Security considerations include:

— Defining the state responsibility;
— Identifying the competent authority;
— Developing the legislative and regulatory framework;
— Identification and assessment of threats;
— Ensuring transportation security is included;
— Defining the responsibilities of the licence holders.

At the initial stages of mine and processing facility development, the owner/operator ought to develop security measures for the protection of UOC [78]. Using a risk based approach the owner/operator ought to identify the threats and targets and develop mitigation strategies to ensure the security of UOC. The owner/operator ought to develop a security policy and a corresponding strategy that includes the following considerations of security management:

— Security functions;
— UOC security culture;
— Security plan;
— Administrative controls and procedures;
— Inventory control procedures for nuclear materials;
— Quality assurance;
— Information and cyber security.

In addition to the above points, management programmes and procedures need to be developed by the owner/operator that include physical protection measures, inventory control measures and transport security measures. Consideration also ought to be given to security standards for reporting on uranium production, inventory and exports, as well as security for uranium mines and processing facilities and their workers. A commitment to establishing a strong reporting and security culture ought to be established prior to making a commitment to pursue uranium mining and processing.

3.10.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage, the Government and regulatory body need to have security policies, legislation and regulatory framework developed and implemented as identified above for Milestone 2. The regulatory body ought to have staff fully trained and knowledgeable of the regulatory aspects of UOC security. These aspects ought to be implemented and regulated in a practical way, so that they are an integral part of the licencing to operate a uranium mine and processing facility. In addition, regulatory inspections and enforcement mechanisms ought to be in place that support the regulations prepared for security of UOC [81].

The owner/operator needs to have all security measures identified in Milestone 2 fully developed, relevant procedures developed, and staff trained to ensure security of UOC at the
start of production. In addition, modern uranium mines and their associated processing facilities are highly automated and contain elaborate process control systems. Computer security of infrastructure and control systems is essential. The owner/operator of these facilities ought to develop programmes, systems and procedures to ensure computer security of instrumentation and control systems in the mine and processing facility [82, 83]. Security threats may be both external and internal to the uranium mine and processing facility. Prior to starting the operation, the owner/operator ought to conduct a detailed risk assessment of both external and internal security threats and develop mitigative measures [84]. Some examples include theft of uranium in any form found in the mining and processing stages, sabotage of mining and processing equipment or related computer control/instrumentation systems and sabotage of relevant security systems.

3.10.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

The points defined for Milestone 3 above are also applicable to this scenario, with the exception that uranium will no longer be mined or processed, while noting that during remediation, uranium can still be recovered from water treatment or other related activities. During decommissioning and remediation there are reduced staff on site and likely new contract employees brought in for decommissioning or demolition work. This further increases the risk of theft of UOC, mine, process or salvaged equipment and infrastructure that has the potential to be contaminated from a radiation perspective. Unapproved removal of these materials needs to be constituted as theft and if radioactive contaminated materials were to leave the site then this becomes a regulatory incident and potentially a media related issue. As such, specific regulations and site-based operating procedures for site security during decommissioning and remediation are required.

Once the site moves to post-decommissioning and monitoring, and then to institutional control, the level of active security will also diminish. In fact, a well-designed closure plan will have passive barriers in place (backfilled pits, closed mine workings, demolished and buried structures, etc.) and on-site security personnel or secured gate access should not be required.

3.11. TRANSPORTATION/EXPORT ROUTE

Uranium ore concentrate (UOC) produced in uranium processing facilities is considered low specific activity (LSA-1) type material based on the Section 4 of the IAEA Safety Standard “Regulations for the Safe Transport of Radioactive Material” [85]. Further, UOC is transported in IP1 packaging. In the uranium production industry uranium ore concentrate is typically packaged in standard 210 litre open head steel drums with a tight fitting lid that is secured to the drum with a steel locking ring that is clamped by a locking ring bolt. When full, the steel drums can each weigh between 400-500 kg. The UOC is shipped domestically and internationally by road, rail and sea as the UOC advances to facilities that refine and convert uranium. Transport of UOC by sea utilizes engineered twenty foot International Organization for Standardization (ISO) sea containers [86]. These engineered sea containers ensure that the UOC is protected while handling and loading the cargo and is further protected from the conditions experienced during sea transportation.

Uranium ore concentrate is classified as a dangerous good (Class 7). As such, an international standard for shipment of this material needs to be followed. Each specific country that transports this material needs to have regulations developed to ensure compliance with these international shipping standards. Section 5 of the IAEA Safety Standard “Regulations for the Safe Transport of Radioactive Material” provides guidance on the requirements and transport of UOC [85]. Both regulators and operators who are involved with regulating or
transporting uranium ore concentrate need to be trained on these regulations. This also includes transport of dangerous goods (TDG) training. Regulations and transport procedures ought to include the requirements and procedures for emergency response in the event of a transportation incident involving UOC.

If industry standard packaging and handling procedures are followed, radiation exposure to packaged UOC is minimal. This is due to the low level of radioactivity of UOC, the short time that handlers are exposed to the shipping container and the stringent packaging requirements. There may be reluctance from transport companies and shipping port personnel to handle Class 7 UOC. Clear and transparent regulations and effective communication and training (including radiation safety and emergency response) plans need to be developed to provide confidence and support from these personnel.

Overall, Member States looking to advance into uranium production and subsequently shipping ought to have an understanding of the current industry practices for packaging of uranium ore concentrate (drums and sea containers), labelling, documentation (dangerous goods declaration, radioactive monitoring record, export licence, import licence, transport documents, safety certificate and required transit licences), container security seals and transport logistics. Regulations need to be in place for transport of UOC and comprehensive training programmes to ensure that regulators, operators and shippers/handlers are appropriately trained.

In regard to transport route, uranium mines are located where the uranium deposit is, and the processing facilities are usually nearby. This may be in a remote location and significant distances from standard transportation routes. As such, transportation routes and licencing conditions ought to be considered prior to development of a uranium mine and processing facility. These considerations include accommodations for road or rail transport from the processing facility as well a shipping port capacity for shipment of UOC by sea.

3.11.1. Milestone 1: Ready to make a commitment to explore for uranium

Exploration for uranium typically occurs in immediate proximity to where the uranium is geologically located. Exploration sites are often located in remote sites where there may be insufficient road infrastructure or other transportation infrastructure. As exploration projects occur in remote locations, they are typically self-supported. Therefore, well developed transportation routes are not required for early stage exploration projects. Exploration projects can rely on air support to transport materials and equipment required to explore for uranium. In addition, off-road vehicles may be utilized to access remote exploration areas. Consideration and planning for an exploration project ought to include the transportation of materials and equipment in and out of the exploration area. Tree clearing, stream crossings, or ground disturbance permits may be part of the licence to explore and an exploration company may be required to define areas impacted during transport of equipment and the site itself prior to issuance of an exploration licence. Better developed transportation routes including tree clearing and installation of dirt roads and bridges may be required for advanced exploration projects and this may require enhanced environmental reviews and permitting.

3.11.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

An increased focus on transportation and exportation routes is required at this stage. If land preparation to develop either an underground or open pit mine is needed, then large earth moving equipment will be required. Suitable ground or sea freight transportation will be required to transport such large mobile equipment. In addition, the development of an underground mine and processing facility will require the transport of large process equipment and infrastructure (including cranes to facilitate the unloading and placement of equipment and
As such, well defined transportation routes will have to be in place prior to advancing to the development and construction of a uranium mine or processing facility. Effective and sustained transportation and export routes will also be required to move materials and bulk commodities to the site during operation. This includes importing bulk commodities and materials from outside the country, if required. In addition, a mode of exporting the final uranium concentrate from the site that is in keeping with national and international standards will have to be considered in advance of the design and development of a uranium mine or processing facility. Finally, the operator and Member State need to ensure that transportation carriers (trucking, rail, shipyards/ports and shipping companies) are licensed and certified to handle and transport uranium ore concentrate.

3.11.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this point the required transportation routes for materials, supplies and bulk reagents to site and uranium ore concentrate from site need to be well defined and construction complete. Licensing and training requirements for shipment and handling of UOC needs to be well defined and in place.

A Member State that has a long history of uranium processing and wishes to enhance existing capacity and capability will have to assess current transportation and exporting infrastructure and determine if it can support from a capacity and logistics perspective the current and future uranium production requirements. This will include roadways, shipping ports, transport hubs, off site warehouse or storage areas, or rail facilities. Uranium mine and process facility operators and Member States ought to work with local transportation companies to ensure support for the transport of materials and bulk commodities based on current and future needs.

3.11.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Transportation and exporting infrastructure that was in place during the operation of the uranium mine or processing facility ought to be sufficient to support decommissioning, remediation or care and maintenance activities. Consideration ought to be given to this type of infrastructure during planning for decommissioning, remediation or care and maintenance. During the final stages of decommissioning, some site access roads may in fact also be decommissioned, if that forms part of the site closure plan. Access roads, air strips, stream crossings, and even dedicated seaports to that project need to be reassessed to determine if they should stay or be removed. The needs of the community and the government will be an important part of those final decisions.

3.12. HUMAN RESOURCE DEVELOPMENT

The knowledge and skills necessary to locate a uranium deposit and then design, construct, license, operate, maintain, decommission and remediate a uranium mine and processing facility include all aspects of scientific, engineering, administrative, financial and management disciplines. While much of the knowledge and many of the skills required are the same for any exploration project, mine or processing facility, there are specific considerations and a higher profile for a uranium mine and processing facility [87]. Additional knowledge and appreciation of the increased attention to detail are necessary to ensure operational safety, security and radiation protection, in particular as the uranium becomes more concentrated as processing moves upstream, and the radioactive waste accumulates. Specific expertise, in the
aspects of design, operations and maintenance are required to ensure effective radiation protection for mine and processing facility workers.

Human resource development is a complex task and may vary widely, depending upon the national decision at each stage of exploration, construction and operation as to whether to fulfill needs through indigenous development or by procuring capabilities from outside the country. Even if procuring outside human resources is the preferred approach initially, developing domestic capabilities may be considered for the long term. The development of such domestic capabilities may require a significant focus on education and training. This may include education and training programmes that are supported through governmental or academic institutions.

Industry good practices for workforce development and training at a uranium mine and processing facility ought to be followed to ensure safe and efficient production [88]. This includes development of the management and worker structure of a uranium mine and processing facility (mining, processing, maintenance, engineering, environment, health and safety, human resources, security, administration). Pre-employment and site-based training strategies need to be developed and implemented prior to commissioning and operating a uranium mine and processing facility. Site-based training includes new employee orientation, environment and safety training, radiation protection, first aid, emergency response, mine rescue and firefighting, mine operations training, processing facility training and trades and technical training.

Accordingly, the knowledge, skills and training required to effectively regulate uranium mines and processing facilities need to be developed in a Member State prior to construction, commissioning and operation. Once the standards and regulations for uranium mines and processing facilities have been put into place the national regulatory body needs to be managed and staffed by competent technical personnel [42]. A wide variety of activities are involved in regulatory oversight from exploration to decommissioning and the regulatory staff need to be competent in a number of technical disciplines. This includes setting of standards, administrative procedures for licence applications and reviews, oversight of operations, inspections of facilities, enforcement, requirements for confidentiality, record keeping and public/stakeholder information. As such, the regulatory body will need to have diverse educational backgrounds and have general to expert knowledge in a number of disciplines, including health physics, radiation protection, conventional safety, mining, hydrometallurgical uranium processing, environmental management, geochemistry, hydrogeology, inspectional protocols, legal, and record keeping, amongst others. In addition, as part of the on-boarding process, regulatory body knowledge will have to be enhanced through specialized training that includes some form of certification (due to potential legal challenges), in order to effectively administer and enforce the regulatory programme. This requires significant organization, time and funding and development of a well qualified regulatory body is something that should not be underestimated. Soliciting expertise from the IAEA to assist in the development of this regulatory training ought to be considered.

3.12.1. Milestone 1: Ready to make a commitment to explore for uranium

In general, exploration for uranium can be conducted either by a dedicated exploration company or by a uranium mining company that has a dedicated exploration department, or a government run geological survey. If a Government geological survey employs its own dedicated exploration team and a decision has been made to explore for uranium, then they need to ensure that they have competent and trained personnel required to conduct all phases of exploration activities including the highly technical resource modelling and estimation.

If a private exploration company locate an economic and recoverable uranium deposit, it will typically look to sell the deposit to an existing uranium mining company, or a start-up
mining company that is looking to begin mining and processing of uranium, or a Member State that is looking to extract the resource for domestic nuclear fuel sources and might potentially look to manage and conduct the operation through a division of the government. Under these circumstances the Member State does not need to focus on the development of human resources, as exploration is typically a project-based activity and ought not to be viewed as an activity that sustains employment. In terms of regulatory oversight, the Member State’s existing mineral exploration review and approval programme should suffice with only some minor enhancements.

A third option may be where a Government run geological survey completes exploration activities for uranium. If a Government geological survey employs its own dedicated exploration team and a decision has been made to explore for uranium, then they need to ensure that they have competent and trained personnel required to conduct all phases of exploration activities including the highly technical resource modelling and estimation. Finally, human resource development required for the development of regulations and for regulatory oversight of uranium exploration activities ought to be considered.

3.12.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

If an economic and recoverable uranium resource is identified within the Member State, a uranium mining company or Government may look to develop that mine. At that point there ought to be a review of local human resource capabilities and evaluate whether suitable domestic resources are available for construction, commissioning and, ultimately, operation. If the Member State does not have domestic human resource capacity capable of designing, constructing and operating a uranium mine or processing facility then the mining company will have to recruit employees from other relevant national industries or recruit employees from outside the Member State. In consideration of the life of mine, the Member State may work with the mining company early in the project to develop a domestic workforce through training and development programmes. This is one of the key aspects of sustainable development that a Member State may consider as a core foundation.

At this stage consideration ought to be given about the physical setting and logistics associated with the workforce at the mine and processing facility. This includes the determination if the employees will be housed in a camp facility directly at the mine or transported to site at some pre-determined frequency. It is important that human resource issues be considered at the same time that the mine and processing facility are being designed [88]. This will provide sufficient time for recruitment and training to ensure that a well qualified work force is in place when the facility advances into the commissioning phase and ultimately full operation.

At this stage, the Member State also needs to have well qualified regulatory personnel who will develop the regulations, codes and standards by which the uranium mines and processing facilities will be licensed and regulated. The regulatory team ought to have some basic working level knowledge of uranium mining and processing, and through the different stages including siting and construction, operation and decommissioning. This competence is required to ensure effective regulatory oversight.

Some other aspects of human resource needs that ought to be considered as a Member State advances into uranium mining and processing include:

— Political and social expertise for public communication and consultation;
— Technical and regulatory expertise to develop and implement regulations, codes and standards for uranium mines and processing facilities. This includes the licence to construct, the licence to operate, radiation protection, conventional safety, emergency
planning, oversight of management programmes, environmental management, waste management and decommissioning;

— Expertise to conduct training programmes for operations and maintenance personnel as the uranium mine and processing facility transition from construction to commissioning to operation. A training needs analysis needs to be prepared that summarizes the training requirements for each position in the mine and processing facility. A decision needs to be made as to whether ancillary services will be conducted at the mine/processing facility or if outside services will provide support (e.g. payroll, accounting, procurement, engineering, non-routine maintenance functions);

— Strategy and plans to develop and train the regulatory body required for construction and then operational oversight.

3.12.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage a Member State ought to have recruited and trained regulatory staff in order to effectively regulate the uranium mining industry. In addition, the regulator ought to ensure that an effective training programme has been developed by the operator and that mine and processing facility employees are fully recruited and trained to ensure safe commissioning and operation. Evidence of an effective training programme and trained and certified mining and operational personnel ought to be demonstrated as part of the issuance of the licence to operate. As part of the continual improvement cycle, an operator needs to continuously evaluate the requirements of the facility and refine their human resource requirements and training plans based on both internal and external factors, like audits.

Finally, a Member State that wishes to enhance its existing capacity and capability ought to complete a gap analysis to determine what additional human resources, if any, are required to increase capacity and capability. If the production capacity at an existing operation is accomplished through the installation of larger equipment, then an increase in employment numbers may not be required. If a current mine is being expanded or a new mine is being developed, then additional human resources may be required. Under this circumstance, a Member State ought to look at opportunities to transfer some of their experienced employees to the new facility to assist with training, commissioning, start-up and operation.

3.12.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

A Member State with sites that are either closed, in decommissioning or remediation, or moving into care and maintenance with the intention to restart at some point will require a different level of expertise than an operating site. A significant proportion of the skills that are developed during operation are transferrable to this stage and workers with this operational experience can assist in decommissioning or reclamation activities. A needs analysis ought to be completed to assess the quantity of workers that are required and the skills that they require to support this stage. Next, a gap analysis needs to be completed on the workers that are selected to support this stage and a training programme needs to be developed to ensure that they have the required competencies. Some decommissioning activities, like demolition, require specialist skills that may be brought to the site by a contractor. Typically, a smaller workforce may be required for decommissioning and reclamation than was required during the operational stage. A mine or processing facility that is going into care and maintenance will likely still require some operations, maintenance, technical, administrative and managerial personnel in order to keep the operation in a state where it can meet the regulatory requirements for an operation at this stage. In addition, active remediation of areas of the operation that will no longer be used
could be mandated by the regulatory body which may require specialized personnel or consultants to complete design and implementation.

3.13. SITE AND SUPPORTING FACILITIES (INFRASTRUCTURE)

Site selection and the evaluation of an exploration area or uranium mine/processing facility are constrained by the location of the uranium ore deposit. Under these circumstances the supporting facilities typically need to be developed to support the uranium mine or processing facility. This can add complexity from a financial (e.g. roadways and transportation links) and a geopolitical (e.g. source of water for the mine and processing facility, potable water, disturbance of pastoral land) perspective. A Member State needs to consider all aspects of supporting infrastructure prior to providing a licence to construct a uranium mine and processing facility. Because mining is a temporary use of the land, the government ought to be very cautious about locating a new permanent town site near the facility, as one industry towns are very vulnerable. Some specific aspects are described in more detail below.

3.13.1. Milestone 1: Ready to make a commitment to explore for uranium

An exploration project for uranium is generally self-sufficient with regard to its needs for infrastructure. Most exploration projects operate in remote locations and thus need to be self-sufficient with regard to power, fuel, water, communication, food and shelter. In addition, access to an exploration area is usually accomplished using off-road vehicles or transport via helicopter.

3.13.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Preliminary considerations regarding the required infrastructure and supporting facilities need to be made during the mine and processing facility design and should be further considered during detailed engineering. Some of the fundamental considerations include electrical requirements and the availability of electricity at the mine site during construction and operation. An assessment of electrical demand for the mine and processing facility ought to be completed, and whether it would be generated on site by generators, as either an initial option, and/or later as backup power. If the state electrical grid system will be used to service the mine and processing facility upgrades to the power station, substations and transmission lines may be required if determined to be inadequate. In addition, road or rail infrastructure is important in order to transport construction and operating materials (including bulk reagents and fuels) to the mine site. Water supply from both an industrial and a potable perspective is also an important consideration. Fire protection systems are required for protection of infrastructure, human health and the local biota. Permanent maintenance, materials receiving, and warehouse facilities ought to be considered to support construction activities as it can be costly and generate waste to remove such facilities following construction and then construct permanent facilities.

Access to health care for ill or injured workers also needs to be considered during initial mine design. In certain jurisdictions, access to adequate health services is part of a mine’s operating licence. The proximity of the mine to local communities will dictate whether a mining camp facility or dedicated mining town complete with services will be erected. Mining camps or subsidized mining towns can add considerable complexity and cost to a mining operation and may only be temporary. The operator and the government ought to consider these options carefully early in the mine development as part of the life cycle costs for the operation.

One other consideration is the need or benefit of having an airstrip nearby. Depending on how isolated the site is and the quality of the roads and distance to transport workers to the site,
an air strip or airport ought to be considered. As this may also benefit the local communities nearby, an airport could become viable, and could remain even after the mine’s life is over.

3.13.3. Milestone 3: Ready to operate a uranium mine and processing facility

By this stage all site and supporting infrastructure ought to be in place and testing completed to ensure that all infrastructure is functional and meets the peak demands.

A uranium mining or processing operation that is looking to increase its current capacity needs to review the capacity of its current infrastructure. One immediate aspect to review is the current electrical supply and comparing it to the forecasted peak demand should there be a change in operating infrastructure that places additional electrical demand on the local grid. Additional generator capacity may be required, or the operator may have to discuss forecasted electrical demands with the local utility to ensure that future demands can be met. Another important aspect is water demand from a processing perspective. An operator will have to determine if an increase in capacity equates to an increase in freshwater requirements, as well as wastewater volumes or waste management volumes, like tailings. If so, modifications to the regulatory permitting may be required prior to utilizing additional fresh water in the operation, or expansion of the waste management system. If the increased capacity results in additional mine or process facility employees, then the operator needs to assess the capacity of the mine camp or local community. Additional housing may be required to house the additional employees.

Overall, the operator would have to complete a condition-based analysis of all infrastructure that is in place and determine if it requires upgrading or replacement prior to resuming operation or increasing production. In addition, for operations that were in care and maintenance, the regulatory or socioeconomic standards may have changed, depending on how long the operation was off-line. The operator then needs to complete a gap analysis to determine if there are any shortcomings in infrastructure prior to restarting the operation.

3.13.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

A Member State that has uranium mines or processing facilities that are closed, at end of life or in care and maintenance, often requires the same level of infrastructure as an operating uranium mine or processing facility. There will be activities involving active remediation and water treatment and these activities require power, mobile equipment (fuel/spare parts) and trained personnel. Therefore, good road infrastructure is required to continue to transport parts, reagents and food to the site. In addition, the electrical grid and associated infrastructure will be required to sustain operation of any water treatment facilities under these conditions. Finally, a reduced version of the camp facility (if present) will be required to support the staff remaining during closure or care and maintenance.

In general, it is unlikely that any supporting infrastructures will be left in place during the post-decommissioning monitoring period, or the long-term institutional control phase. This would change if the government or the community has identified key features that they wish to maintain or utilize (e.g. airstrip, communications tower).

3.14. CONTINGENCY PLANNING

Contingency planning is important for exploration projects and operating uranium mines and processing facilities. Risks need to be evaluated from all perspectives and monitoring programmes and mitigation measures need to be developed and implemented to ensure the protection of the workers, the general public and the environment in the case of unusual natural
(e.g. a one-in-a-hundred-year high rainfall event, earthquakes, far ranging pandemic type health issues), socio-political conditions (e.g. security requirements for civil unrest) or catastrophic failure of mine or processing facility infrastructure.

3.14.1. Milestone 1: Ready to make a commitment to explore for uranium

Uranium exploration projects typically occur in remote locations and can occur in challenging climatic conditions, such as extreme heat or cold. An exploration project needs to be able to operate somewhat independently based on remote locations and therefore those involved need to have geographical, climatic and political knowledge of the location in which they are exploring. They therefore need to be prepared to deal with changing conditions and have contingency plans should any conditions change significantly, prompting an evacuation of the exploration area. In addition, contingency plans need to be in place should there be a significant health or safety incident at the exploration site that requires emergency medical attention or evacuation due to natural disasters (e.g. fire, flooding).

3.14.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

A mine that is under development needs to complete a detailed and comprehensive risk assessment and have detailed, well documented contingency plans in place to deal with significant process upsets (e.g. mine flooding), extreme weather conditions, loss of electrical power, forest fire, outbreak of illnesses at the site (e.g. pandemic), civil unrest, or fire at the mine site. Development of protocols for an emergency command centre ought to be considered for significant emergencies, with special attention to communication and updates to the regulatory bodies and other concerned stakeholders. The site ought to have a detailed contingency plan that clearly describes the mitigation measures in place to deal with emergency situations. A detailed description of the safe shutdown of the mine and processing facility ought to be included in the mitigation measures. The regulatory body ought to be interested in the operation’s risk identification and mitigation strategy as part of contingency planning and ought to consider that the operator shows evidence of this as part of the licencing requirement to construct and operate a uranium mine.

3.14.3. Milestone 3: Ready to operate a uranium mine and processing facility

The measures for contingency planning as described in Milestone 2 ought to be well documented prior to final commissioning and operation. A list of contingency issues ought to have been identified in the Environmental Assessment process and initial license siting licences. Once the mine and processing facility are active the facility operator needs to review its contingency plans on a frequent basis to ensure that the plan remains current and supports the needs of the operation. Changing conditions may introduce new operational or security risks to an operation and these risks need to be evaluated and mitigation measures implemented as part of the contingency planning process. Examples include installation of new mining or processing equipment or the impact a power failure would have on worker health and safety or impact to local communities (e.g. failure of tailings dam dewatering pumps). The active operations also need to test, with a pre-described frequency, their emergency response system and their emergency backup power generators. This ought to include evaluation of site management, site emergency response team, local authorities and communication processes with internal and external stakeholders.
3.14.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

The principles described above for an active uranium mine or processing facility also apply to an operation that is in active decommissioning, in care and maintenance or is under active remediation. Under these scenarios there are typically fewer site personnel present as compared to an active operation, and therefore security and control of the site need to be considered, in particular for emergency situations. An operation in care and maintenance or active remediation ought to have an updated contingency plan with mitigation measures that are ready to be acted upon in case of an emergency. In addition, with a potentially reduced workforce, site personnel may be required to play several roles during an emergency situation. The contingency plan needs to provide a detailed role description as well as required training for each position.

3.15. WASTE (INCLUDING TAILINGS) MANAGEMENT AND MINIMIZATION

Waste from uranium mining and processing presents a potential significant risk and long-term environmental liability to the operation if it is not properly managed. A robust, well financed and enforceable operations plan for the management (including segregation, storage, treatment and disposal) of waste generated by uranium exploration, mining and processing ought to be a mandatory requirement for the grant of a uranium licence by a regulatory body for uranium exploration, development, commissioning, operation, decommissioning and remediation. The operator ought to develop, and submit for approval where required, comprehensive and detailed guidelines for the management of radioactive wastes across a project life cycle. The operator needs to account for and report on the quantities of all types of radioactive and non-radioactive wastes produced, including the way in which they are being managed.

From a due diligence perspective, a comprehensive extraction approach ought to be considered, where an operator seeks to maximize the extraction of all resources that are economically beneficial, thereby maximizing the resource and endeavouring to minimize the waste produced. This concept ought to be aligned with an appropriate waste management policy developed by the operator that includes: minimizing the site footprint; disturbing the ground only once during mining and extraction; optimizing returns from all the valuable materials in an orebody; integrating primary and secondary resource management for resource conservation and waste prevention; segregating the waste materials and reusing clean mine rock materials for construction purposes; fostering other types of reuse; recycling and new product development (i.e. from recycling tailings or residues) in line with the waste minimization hierarchy where all waste needs to be properly managed to reduce long term negative environmental liabilities.

The government ought to have a clear understanding of the requirements for the management of wastes generated from uranium exploration, mining or processing activities. If this regulatory framework has not been established within the Member State, then the government ought to look at regulatory requirements for the management of wastes in countries that have active uranium exploration, mining or processing operations and use industry-accepted best practices for the management and regulatory oversight of the various types of wastes from these activities.

3.15.1. Milestone 1: Ready to make a commitment to explore for uranium

A Member State that currently has exploration activities or will be looking to explore for uranium ought to develop regulatory-based waste management standards based on international
good practice. An exploration company that is actively drilling to identify or delineate uranium deposits ought to strive to restore the exploration site back to its original uninterrupted state. This includes management of non-radioactive wastes and infrastructure. It also includes any radioactive wastes associated with this type of activity. This could include radioactive drilling muds, processing water that is contaminated with radioactive elements, or drill core that is radioactive. The regulatory body needs to develop guidelines as to how to manage and dispose of these types of wastes and provide oversight to ensure that exploration companies remain compliant.

3.15.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

Management of radioactive wastes at a uranium mine or processing facility is a complex activity and requires a high level of technical competence within the mine or process facility operations staff as well as focused and knowledgeable personnel from a regulatory perspective. Several types of radioactive wastes can be generated from uranium mines and processing facilities and those with the largest volume are typically mine rock, tailings, and contaminated waters. These types of wastes present the greatest environmental liability to a uranium mining and processing facility and therefore contaminated waste rock management, wastewater management, and tailings facilities need be engineered using industry good practice to ensure long-term (e.g. 10,000 years) geotechnical and geochemical stability. Further, these facilities need to be managed and regulated very carefully from a civil, geotechnical, geochemical, environmental and hydrogeological perspective. External technical support for both the operator and regulator may be required to ensure that these significant environmental liabilities are well designed, monitored, and managed [58].

During the design of the mine and processing facility careful attention needs to be made in regard to handling and containment of radioactive process slurries and liquid process solutions. Engineering designs need to be carefully thought out for proper containment and include considerations for both primary (e.g. tanks, piping) and secondary containment (berms, bunds, sumps). In addition, control of radioactive dusts from areas such as mine rock piles, ore stockpiles, tailings facilities, crushing and grinding plants and uranium dryers/calciners need to be considered in the engineered design. Effective monitoring and maintenance programmes for all of this infrastructure ought to be developed prior to commissioning and operation.

Other types of radioactive wastes may also be generated from uranium mining and processing, including radioactive mine and process facility infrastructure (e.g. process piping, tanks, pumps, electrical components, building infrastructure, wooden pallets, etc.). Industry good practice is to remove the radioactive contamination (where practical), so the materials can be recycled or disposed of in a domestic landfill facility. The regulatory body ought to develop standards and criteria for the management (including reuse or recycling, where applicable) and disposal of these types of wastes [58]. Finally, radioactive slimes, sludge and residues will also be produced while mining and processing uranium. The operator needs to be regulated to manage these types of wastes by working to incorporate them back into the process, storing them in the mine workings or geochemically stabilizing them and storing them with the final tailings, or, if appropriate and practicable, in an approved low level waste repository.

Overall, the management of radioactive wastes is a complex process in uranium mines and processing facilities and requires considerable attention during the environmental assessment process. The operator needs to demonstrate to the regulatory body that they have appropriately qualified staff and, if required, technical consultants working collaboratively to ensure that radioactive waste materials are properly managed and disposed of. Radioactive wastes originating from a uranium mine and processing facility present the greatest long term environmental and social liability associated with these types of activities. Finally, the regulatory body needs to be appropriately resourced with technical expertise to ensure that the
risks associated with waste streams generated on a site have been correctly identified, strategies for radioactive waste management are scientifically competent, that monitoring programmes are effective and that risks are being effectively mitigated to ensure that people and the environment remain protected.

3.15.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage there ought to be a technically competent regulatory body in place that has a well developed set of effective radioactive and non-radioactive waste management standards and regulations based on industry good practice. The facility operator at this stage needs to have a comprehensive waste management programme, plans and associated infrastructure in place prior to final commissioning and operating the mine and processing facility. From a regulatory perspective evidence of these aspects need to be clearly demonstrated before a licence to operate is issued, and the regulatory body needs to have a compliance program in place, commensurate to the identified risks from the operation in regards to waste management, to support this approval.

A Member State that wishes to enhance existing capacity and capability with uranium mining and processing ought to evaluate current practices and regulatory standards. These ought to be compared to international industry good practice for the management of radioactive wastes. Operators that are looking to increase capacity and capability ought to look for opportunities to mitigate the risk of long term environmental and social liability associated with the management of radioactive wastes. This again ought to be based on international industry good practice. The operator needs to implement these good practices if they are reasonably and practically achievable.

3.15.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

Safe management of all radioactive wastes generated from uranium mining and processing is critical at this stage. Ineffective management of these types of wastes can result in significant environmental and social liabilities that may require significant costs and several generations to ameliorate [34]. Decommissioning and remediation plans that are technically competent and executable need to be developed by the operator and approved by the regulatory body before decommissioning and remediation can begin. Opportunities to decommission and or remediate inactive mine or waste areas during the operating life of the facility ought to be encouraged, as this begins to minimize the decommissioning and remediation liabilities and costs sooner. Reviewing the recommendations from the environmental assessment for the application to develop the operation ought to be performed by the operator and the regulatory body. If the project was started with the end in mind, the final planning objectives will be easier.

Decommissioning of mine rock piles, mine workings (open pits or underground mines), ISR well fields, and tailings facilities is a complex activity that requires an expert level of knowledge and coordination from a civil, geotechnical, geochemical and hydrogeological perspective. The operator needs to ensure that they have the necessary technical expertise within the organization or has hired competent consultants to facilitate these activities. The operator needs to classify all radioactive wastes and develop management options for these wastes. Similarly, the regulatory body also needs to have the technical competence to critically review the decommissioning and remediation plans proposed by the operator including radioactive waste management strategies. The regulatory body will also have accountability to the government for effective oversight of the decommissioning and remediation of the uranium mine or processing facility, as they will ultimately be approving the decommissioning and remediation plans.
Mines or processing facilities that are considering care and maintenance with the intention to restart production later need to effectively manage their radioactive wastes and waste waters. This may include active dewatering and treatment of contaminated waters originating from contaminated waste rock piles, processing plant, mine waters, and tailings facilities to ensure that the impact on the environment from these facilities is mitigated. In addition, operators ought to be strongly encouraged to either clean up or remediate all sources of radioactive waste during a care and maintenance period to ensure that the environmental liability remains as low as reasonably achievable.

3.16. INDUSTRIAL INVOLVEMENT, INCLUDING PROCUREMENT

Many commodities (including bulk reagents and fuels), operating and infrastructure components, and services are required to construct and support the operation of a uranium mine or processing facility. Mining equipment, both fixed and mobile, processing piping and equipment, spare parts, consumable supplies, fuel, safety equipment, specialist contractors, and instrumentation components are some examples where industrial involvement supports a uranium mine or processing. Several of these examples are common to the mining and processing industry from a general perspective and if a Member State has a history of mining and processing of other metals there is the potential that this type of support is already present. Industrial involvement can be a source of employment and economic growth within the country and region where the mine or processing facility is located.

3.16.1. Milestone 1: Ready to make a commitment to exploring for uranium

Exploration organizations are generally quite self-sufficient but may require some industrial involvement during all stages of exploration activity. This may include procuring aircraft services for airborne surveys, support for exploration camp operation (local contractor), rental vehicles, or supplies for drilling programmes (drilling equipment, oils or drill mud).

3.16.2. Milestone 2: Ready to commit to develop a uranium mine and processing facility

At this stage the Member State and facility operator ought to jointly assess the local and national industrial support capabilities for the uranium mine and processing facility. The Member State ought to encourage the mine or process facility developer and operator to procure industrial supplies, services and commodities from local or national suppliers as a means of retaining both the indirect and direct economic benefits of uranium mining and processing within the Member State. This may include timely delivery of high quality construction materials required to construct a uranium mine or processing facility and keep the project on schedule. The owner/operator needs to determine the level of industrial support required during operation and work with local and national suppliers to determine if they have the capability to consistently supply commodities, components and services to the uranium mine or processing facility. Unique activities will arise, and may include items such as: in-situ recovery (ISR) well field construction; shaft sinking for underground mines; hoisting operations; pressure leaching vessels for processing, etc. The owner/operator procurement department will have to meet with individual local and national suppliers and evaluate their capacity to support the construction and operation of a uranium mine or processing facility. Once a decision is made to construct a uranium mining and processing facility within the country, the Member State ought to encourage local and national suppliers to be proactive and develop strategies to support these operations, including co-partner relationships with external suppliers. This will ultimately support employment and provide economic benefits to the local and national economies.
3.16.3. Milestone 3: Ready to operate a uranium mine and processing facility

At this stage, procurement supply strategies and contracts ought to be developed to support the operation at its nameplate capacity. This is an important aspect to ensure safe, reliable production including robust environmental management of the site (e.g., secure supply of water treatment reagents). Logistical challenges and increased demand/supply opportunities need to be considered as an operation may require more supplies than what was forecasted during original design, as well as ready access to replacement parts over the life of the operation. With some of these contracts comes the need for not only the materials, but the expertise to construct, commission and operate them. Once operational, the hand off to the operator from the contractor would fulfil the procurement and supply strategy.

3.16.4. Milestone 4: Ready to decommission and remediate a uranium mine and processing facility

The strategy for local and national industrial suppliers described in Milestones 2 and 3 of this section also applies to this scenario. Fewer mining and processing components, supplies and services will be required at this stage in the life cycle of a mine or process facility, though some unique decommissioning and demolition supplies may still be required. The owner/operator of the mine or processing facility ought to consult with the industrial supplier to determine what materials and supplies will be required for decommissioning, remediation or care and maintenance. In addition, fewer warehousing personnel may be present at the mine or processing facility under these conditions, so industrial suppliers may be required to provide increased inventory management support and just-in-time delivery based on customer requirements.

4. CONCLUSIONS

National infrastructure that is well established to support the development and life cycle operation of uranium mining and processing will facilitate safe and sustainable production as well as encourage strong stakeholder support. It is important to stress that construction, operation and decommissioning of a uranium mine and processing facility is complex and requires a well defined and implemented national policy, regulatory framework, safety, environmental and technical infrastructures. Uranium mine and processing facility development, operation and decommissioning may span several decades, and a Member State needs to ensure that appropriate financing and governance mechanisms are developed and sustained through the life cycle of such facilities. Addressing the activities identified across the five phases in the uranium production cycle to achieve the four Milestones identified in this publication in a systematic manner will ensure that uranium mines and processing facilities can be regulated and operated in safe, efficient and environmentally sound manner. This publication concludes with two case studies that highlight the development of national infrastructure for the uranium production cycle for Namibia and Tanzania.
Appendix I

NAMIBIA CASE STUDY

I.1. BACKGROUND OF THE URANIUM INDUSTRY IN NAMIBIA

I.1.1. Overview of operating mines and mines in development

Uranium minerals were first discovered in 1928 in Namibia in the vicinity of what would later become the Rössing mine [89–99]. However, it took until the 1960s before Rio Tinto acquired exploration rights in the area, and subsequently discovered a number of uranium ore bodies of a low grade on the north side of the rocky Khan River. Detailed beneficiation test work was carried out, and the results led to the opening of the Rössing mine in 1976. With more than 40 years of operation, the Rössing mine today is the longest operating uranium open pit in the world. A notable increase in the demand for nuclear fuel for power generation in the 1960s and 1970s, as well as the successful development of the Rössing mine led to an intensification of uranium exploration in the central Namib by a number of different companies. However, the slowly declining uranium price prevented the uranium deposits that were identified during the course of this exploration from being developed into operational mines for several decades. Increasing uranium prices at the beginning of the new millennium eventually resulted in the establishment of the Langer Heinrich Mine in 2007, a year that saw an all-time high in uranium prices that once again led to an exploration rush in the western Erongo Region. The Langer Heinrich mine produced 1526 tonnes of uranium in 2017. In the same year the Rössing uranium mine produced 1790 tonnes of uranium. The Geological Survey of Namibia’s excellent set of high-resolution airborne geophysical data assisted exploration efforts to detect the world-class Husab uranium deposit, which now supports the Husab mine, set to become the world’s third largest uranium producer. Following the production of its first drum of yellow cake on 20 December 2016, the Husab mine produced 1140 tonnes of uranium in 2017. The mine expects to reach nameplate capacity of 5680 tonnes of uranium by 2020. Figure 4 illustrates the Erongo Region and the developed uranium mines in Namibia. A summary of developed mines in Namibia is provided in Table 2 and a summary of advanced uranium exploration projects is provided in Table 3.
### TABLE 2. DEVELOPED MINES IN NAMIBIA

<table>
<thead>
<tr>
<th>Uranium mine</th>
<th>Location/region</th>
<th>Annual production capacity and recent production</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rössing uranium mine</td>
<td>12 km from Arandis, which lies 70 km inland from Swakopmund/Erongo Region</td>
<td>3820 tU t&lt;br&gt;1790 tU t (2017)</td>
<td>Operational for more than 40 years, longest running uranium mine in Namibia</td>
</tr>
<tr>
<td>Husab uranium mine</td>
<td>60 km from Swakopmund/Erongo Region</td>
<td>5680 tU&lt;br&gt;1140 tU (2017)</td>
<td>Started production at the end of 2016</td>
</tr>
<tr>
<td>Langer Heinrich uranium mine</td>
<td>80 km east of the major seaport of Walvis Bay/Erongo Region</td>
<td>2035 tU&lt;br&gt;1526 tU (2017)</td>
<td>In production since 2007, but placed on care and maintenance in 2018, due to low uranium spot prices</td>
</tr>
<tr>
<td>Trekkopje uranium mine</td>
<td>35 km north of Arandis/Erongo Region</td>
<td>2540 tU&lt;br&gt;373 tU (2013)</td>
<td>On care and maintenance since 2013</td>
</tr>
</tbody>
</table>

In addition, the projects of Zhonghe Resources, Valencia Uranium, Bannerman Resources, Reptile Mineral Resources and Exploration, and Marenica Energy are at advanced stages of exploration and optimization test work for uranium extraction. The full development of these projects awaits an increase in the price of uranium, as do the Trekkopje and Langer Heinrich mines, which had to be put on care and maintenance in 2013 and 2018, respectively.
FIG. 4. Map of the Erongo region indicating the location of the uranium deposits in Namibia (Source: Rio Tinto).

TABLE 3. ADVANCED URANIUM EXPLORATION PROJECTS

<table>
<thead>
<tr>
<th>Uranium exploration project</th>
<th>Location/region</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhonge Resources</td>
<td>90 km north-east of Swakopmund, north-east of the Rössing and Husab mines/Erongo Region</td>
<td>Exploration, metallurgical testing, 25-year mining licence granted in 2012, construction awaiting further exploration and market improvements</td>
</tr>
<tr>
<td>Valencia</td>
<td>95 km north-east of Swakopmund/Erongo Region</td>
<td>Exploration complete, 25-year mining licence granted in 2008, construction awaiting market improvements</td>
</tr>
<tr>
<td>Bannerman Resources</td>
<td>48 km east of Swakopmund/Erongo Region</td>
<td>Detailed feasibility study complete, heap leach demonstration plant, recovery process optimization study, additional drilling</td>
</tr>
<tr>
<td>Reptile Uranium</td>
<td>63 km south-east of Swakopmund, 42 km west of Langer Heinrich mine/Erongo Region</td>
<td>Exploration complete, metallurgical testing in progress</td>
</tr>
<tr>
<td>Marenica</td>
<td>87 km north-east of Swakopmund, 30 km north of the Rössing mine/Erongo Region</td>
<td>Exploration complete, patented new metallurgical process</td>
</tr>
</tbody>
</table>
Climate change and global warming have in recent years fuelled the world’s need for low CO₂ electricity generation, and today more nuclear power plants are under construction than at any other time in recent decades. It is therefore expected that uranium prices will rise. This will create a favourable climate for growth in the uranium industry, an industry that is very important for the socioeconomic development of the Erongo Region, as well as Namibia as a whole.

I.1.2. Employment

Mining in general is a significant employer in Namibia, a large country with a low population density and a population of only 2.4 million people. The importance of uranium mining for the economy of Namibia, and especially the Erongo Region, cannot be overestimated. Uranium mining has created a large number of job opportunities, not only in the mining industry itself, but also amongst suppliers and service providers. In 2018, the uranium exploration and mining sector employed some 4400 people. This figure represents some 17% of the total employment in exploration and mining. In addition, on average, every job in the minerals industry generates seven other jobs in the suppliers’ industry. Therefore, the sum of direct and indirect employment emanating from the Namibian uranium sector can be assumed to be approximately 35,000 people. Taking into consideration the fact that in Namibia every employed person has approximately five dependents, the sector supports some 175,000 people out of a total population of 2.4 million, which is a significant proportion.

I.1.3. Contribution to the local and national economies

The Namibian mining sector is the backbone of the Namibian economy. As with employment, the contribution to the local and national economies is substantial. It accounts for about 50% of Namibia’s export earnings. The overall GDP contribution to the economy has ranged between 11 and 12% since 2013 as summarized in Table 4 below. In 2017, the uranium sector comprised 0.7% of the Namibian GDP.

| TABLE 4. CONTRIBUTION OF THE NAMIBIAN MINING INDUSTRY AND URANIUM MINING INDUSTRY TO THE NATIONAL ECONOMY [95, 98] |
|-------------------------------------------------|----------|----------|----------|----------|----------|
| Year                                            | 2013     | 2014     | 2015     | 2016     | 2017     |
| Mining’s contribution to GDP                    | 13.2%    | 12.2%    | 11.7%    | 12.0%    | 12.2%    |
| Uranium sector’s contribution to GDP            | 1.5%     | 1.1%     | 1.1%     | 1.1%     | 0.7%     |

Namibia developed two significant uranium mines, Langer Heinrich and Husab, which opened in 2006 and 2016, respectively, which together with the Rössing mine contributed 5.3% of the world’s uranium mining output in 2017. Namibia was the fourth largest supplier of uranium in the world in 2017 and will be an even more significant uranium producer in the near future due to current active mine developments and exploration activities. The uranium mining subsector recorded strong growth in real value added of 23.4% during 2017 compared to 13.6% in 2016. The performance was due to the increase in the production of uranium, mainly through the ramping up of uranium production at the Husab mine, even though the price of uranium remained subdued in 2017.
Also, in 2017, N $1.5 billion was spent on salaries, and N $127.2 million was spent on exploration. Government coffers received N $164.3 million in royalties and levies. Should the uranium price increase to allow the operations to be profitable, this figure will increase substantially through tax payments. Notably, N $3.6 billion was spent on fixed investments, and N $4.84 billion went into local procurement. Indeed, the western Erongo Region, where the uranium activities take place, presents a different economic picture compared to the time before uranium mining started.

In addition, there are many indirect benefits generated by uranium mining and exploration, such as the personal taxes of employees; salaries available for spending; employment created; value added tax; corporation tax and personal taxes paid by the service industry; revenue collected and jobs created by parastatals (Namwater, Nampower, TransNamib, NamPort); support to the Namibian Institute of Mining and Technology; in-house training; revenue collected and jobs created in other industries (teachers, doctors, nurses, medical facilities, restaurants, shops, etc.); municipal charges; infrastructure development (desalination, pipelines, powerlines, roads, housing); housing sold to create ownership; and environmental programmes.

I.1.4. Overview of Namibian national policy and government/industry relations

In Namibia, the fundamental principle of the minerals sector is the fact that all mineral rights are vested in the State. Any right granted under any provision of the Minerals (Prospecting and Mining) Act No. 33 of 1992 in relation to the reconnaissance or prospecting for, and the mining and sale or disposal of, and the exercise of control over, any mineral or group of minerals, despite the ownership of any land, belongs to the State.

The Namibian Minerals Policy of 2003 outlines the guiding principles and direction for the industry and the values of the Namibian people in support of the development of the mining sector. It is currently under revision to provide for changes that have taken place in the last 15 years.

Royalties are levied in terms of the Minerals (Prospecting and Mining) Act as a percentage of the market value of the minerals extracted by licence holders in the course of finding or mining any mineral or group of minerals. A rate of 3% is payable on nuclear fuel minerals.

The Export Levy Act became effective from the 1 June 2016. The purpose of the Act is to provide for the imposition of an export levy on certain goods exported from Namibia to improve Namibia’s value share in its resource base and to encourage further processing and value addition to such goods to support national industrial development in Namibia.

While Namibia is an IAEA Member State that wishes to enhance existing capacity and capability, the Namibian Government had to impose a moratorium on the issuing of exclusive prospecting licences for nuclear fuel minerals in 2007, due to an exceptionally high number of applications. The moratorium was in place for 10 years and terminated on 15 December 2016 in order to provide an opportunity for further uranium exploration in Namibia.

In the mid- to late 2000s, when prices for fuel for civil nuclear reactors were rising fast, resulting in a worldwide boom in uranium exploration and mining, the Namibian uranium industry recommended to the Namibian Government to undertake a strategic environmental assessment (SEA) of the Namibian uranium province, where exploration for uranium was also expanding rapidly. Subsequently, such an assessment was carried out by the Ministry of Mines and Energy and provided vision and generated a culture of cooperation between the uranium mining industry, Government and the public.

The Strategic Environmental Management Plan (SEMP) was developed as a result of the SEA. It is an overarching framework and roadmap within which individual projects need to be planned and implemented. It addresses the cumulative impacts of existing and potential
developments and the extent to which uranium mining is impacting on the central Namib. The SEMP has 12 themes, the so-called Environmental Quality Objectives (EQOs), with each articulating a specific goal, providing context, setting standards and having a number of key indicators that are monitored. These themes include socioeconomic development, employment, infrastructure, water, air quality, health, effect on tourism, ecological integrity, education, governance, heritage and future, and mine closure and future land use. Annual SEMP reports measure the performance of the 12 EQOs. The industry is actively contributing to the compilation of the annual SEMP reports.

I.1.5. Namibian regulatory bodies

The Namibian Ministry of Mines and Energy regulates the mining industry, including uranium mines, to enforce compliance. It is responsible for the administration of prospecting, exploration and mining licences and for monitoring the performance of licences with respect to work carried out, production, health and safety, the environment and royalty payments.

The Minerals (Prospecting and Mining) Act 33 of 1992 is the principal legislation for the granting of exploration and mining licences.

Other Acts with relevance to uranium exploration and mining are the Environmental Management Act No. 7 of 2007, which regulates the sustainable management of the environment and the use of natural resources, and the Atomic Energy and Radiation Protection Act No. 5 of 2005, which provides for adequate protection of the environment and of people in current and future generations against the harmful effects of radiation by controlling and regulating the production, processing, handling, use, holding, storage, transport and disposal of radiation sources and radioactive materials, and controlling and regulating prescribed non-ionizing radiation sources.

Reporting is a statutory requirement in terms of the Minerals (Prospecting and Mining) Act. Uranium exploration projects are required to submit quarterly progress reports, while operational mines are obliged to submit reports in a prescribed format, as listed in Table 5.

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<thead>
<tr>
<th>TABLE 5. REPORTING REQUIREMENTS</th>
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<tr>
<td>Report</td>
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<td>Monthly return</td>
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<td>Annual return</td>
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<tr>
<td>Annual financial statements</td>
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<tr>
<td>Material exported pursuant to 33(a)</td>
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<tr>
<td>Accident report</td>
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<td>Material stock balance report</td>
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</tbody>
</table>

Namibia enforces a multi-agency approach when conducting inspections at the uranium mines and among the Government institutions that conduct inspections and administer different regulatory frameworks and legislation. The Ministries of Mines and Energy, of Health and Social Services, and of Labour, Social Welfare and Employment Creation work together closely to ensure that inspections and enforcement of the provisions of the various legal provisions and
requirements related to uranium prospecting, exploration and mining are implemented effectively and efficiently.

Inspections and verification visits to uranium prospecting, exploration and production sites are devoted to visiting critical areas, the provision of advice and education, observation of containment and surveillance measures around the mines, and follow-up visits to verify and ensure compliance. The inspections and verifications assist licence holders and operators to comply with relevant legislation and regulations, and to implement the licensing conditions as per the original authorizations issued by the Government ministries and institutions. Furthermore, the inspections also:

— Provide information and support to ensure compliance with the applicable acts and regulations;
— Inspect, monitor and analyse data, and conduct investigations to measure compliance;
— Recommend options for compliance;
— Implement actions deemed necessary to prevent or minimize danger to the environment and the public, and to prevent the smuggling and theft of radioactive source material.

Other bodies of relevance to uranium exploration and mining are the National Radiation Protection Authority and the Atomic Energy Board of Namibia. The National Radiation Protection Authority (NRPA) serves as the administrator of the Atomic Energy and Radiation Protection Act. The main duties of the NRPA are to maintain an inventory and record of activities (production, processing, handling, transport, use, storage, disposal) involving radiation sources and radioactive and nuclear material in Namibia; regulate all activities (production, processing, handling, transport, use, storage, disposal) involving radiation sources and radioactive and nuclear material in Namibia; inform the Atomic Energy Board (AEB) about the extent of radiation exposure in Namibia; and generally enforce all provisions of the Atomic Energy and Radiation Protection Act.

The NRPA was established as an independent regulatory body. It needs to act independently in the exercise of the functions under the Act and only considers the relevant provisions of the Act and such scientific and technical matters as may be relevant to the issue concerned. The NRPA has not been created as a juristic person and therefore does not have administrative autonomy as is the case with other State enterprises. The organizational requirements for the NRPA and that of the staff performing the work of the AEB are contained in the Directorate Atomic Energy and Radiation Protection Authority, an administrative entity in the Ministry of Health and Social Services. The NRPA therefore functions independently in as far as it concerns technical and scientific matters within the scope of the Act, but administratively functions as a Directorate in the Ministry of Health and Social Services.

The AEB was established in 2009 pursuant to the requirements under Section 3 of the Atomic Energy and Radiation Protection Act 2005. The AEB is an advisory body reporting to the Minister of Health and Social Services. The secretary of the AEB is the director of the NRPA, which is the technical arm responsible for the administration of the Act. The AEB endeavours to manage Namibia’s nuclear and radioactive materials in a manner that safeguards people and respects and protects the environment today and in the future. Through the provision of appropriate advice, the AEB ensures that the use of radiation and nuclear energy in Namibia does not cause unacceptable impacts on the health of workers, members of the public and on the environment.
I.1.6. International commitments

Namibia is party to several international agreements for nuclear safety, security and safeguards, and recognizes international principles and standards. Namibia has committed to adopt the highest levels of industry performance to regulate its uranium industry. The country subjects its uranium industry to proper regulation due to the nature of the uranium sector and the resulting level of public interest. As a State Party to the Non-Proliferation Treaty (NPT), Namibia also fully implements its obligations under the Treaty.

Government furthermore ensures that all industry stakeholders are aware of the country’s international reporting requirements as per IAEA guidelines and standards through regular information sharing workshops.

Namibia is committed to providing the IAEA with accurate and timely information concerning nuclear material subject to safeguards under this Agreement and the description of facilities relevant to safeguarding such material.

Thus, it is important for Member States to provide accurate and timely data to the IAEA to enable it to draw safeguards conclusions and provide assurance that nuclear materials in its possession are properly classified and accounted for.

I.1.7. Overview of the Namibian Uranium Association and the Namibian Uranium Institute

The Namibian Uranium Association (NUA) believes that uranium has a lot of merits which make it an appropriate source of energy in the 21st century, especially because of its low carbon footprint. NUA members are the uranium producers, the majority of uranium exploration companies active in Namibia, and contractors, suppliers and service providers.

The Namibian Uranium Institute (NUI) was established by the NUA as part of the stewardship mission. NUA’s Scientific Committee comprising of respected and independent scientists oversees the work of the NUI. NUI provides for a communication hub for the Namibian uranium industry and its suppliers and service deliverers. The institute provides training in radiation safety, health, environmental management and occupational hygiene. Through identification of world-call leading best practices and provision of information about their implementation, it gives members an opportunity to collectively advance safety and health performance. NUI cooperates with Namibian government ministries and state agencies, as well as with the Namibian University of Science and Technology.

In 2013, the directors of the NUA established a Sustainable Development (SD) Committee, which assists the industry in up-keeping its reputation of being safe and responsible. The committee aims to ensure that uranium for the nuclear fuel cycle and produced in Namibia is explored for, produced, transported stored and managed in a socially economically and environmentally responsible manner. The Committee identifies risks for the Namibian Uranium Brand and has put in place a number of supporting technical working groups who address and advise on emerging issues. It also advises NUA on policy issues, especially with reference to sustainable development.

Special emphasis is given in this context to public participation, inter-generational equity, sustainable use of natural resources, and public access to information. Risk assessment and monitoring with reference to health, environment, radiation safety, and security are other duties of the SD Committee. It is also involved in the advancement of internal compliance and control systems, in measures to manage risks, in the assessment of the efficiency of controls in place, and in making recommendations to NUA concerning risk management.

The International Council on Mining and Metals’ understanding of sustainable development for the mining and metals sector guides the Namibian uranium industry. This understanding means that investments need to be technically correct, environmentally sensible,
commercially viable, and socially sensible. Standards for operations that guarantee a good international standing and reputation are set, as they are critical for any mining company to obtain and maintain its “social license to operate” in a given community. It is indispensable to address environmental, economic and social aspects throughout all stages of mineral projects from exploration, construction, operation to mine closure. The SD Committee plays an important role in maintaining these standards.

I.2. OVERVIEW OF MILESTONES ASSOCIATED WITH NAMIBIAN URANIUM PROJECTS

I.2.1. Rössing mine

Rössing Uranium, which is majority owned (68.62%) by China National Uranium Corporation Ltd (CNUC), is one of Namibia’s two currently producing uranium mines. In 2019, Rio Tinto sold its controlling stake to CNUC. The Rössing mine is co-owned by the Iranian Foreign Investment Company, the Industrial Development Bank of South Africa, the Namibian Government (which in addition has 51% voting rights) and a number of private shareholders.

At Rössing, uranium mineralization is hosted by early Paleozoic alaskites. Mineralization occurs in veins and disseminated grains within and adjacent to the alaskites. As of 1 January 2017, recoverable resources amounted to 77,956 tonnes of uranium at an average grade of 0.025% U [2]. Rössing is the world’s longest running open pit uranium mine and celebrated 40 years of working for Namibia in 2016. The Rössing mine has a nameplate capacity of 3820 tonnes of uranium per year and by 2017 had contributed a total of 112,450 tonnes of uranium to the worldwide nuclear fuel cycle.

The mine (Fig. 5) is situated in Namibia’s Erongo Region, some 12 km from the town of Arandis, which is some 70 km due north-east of the coastal town of Swakopmund. The mining licence and accessory works areas measure some 180 km², but only 25 km² of the total area is used for mining, processing, and overburden and tailings storage facilities. The mine is an open pit operation with conventional blasting, loading and hauling. The open pit currently measures approximately 3 km by 1.5 km and is ~390 m deep.
I.2.1.1. Stakeholder involvement

Rössing Uranium’s stakeholders include its shareholders, employees and contractors, the communities of Arandis, Swakopmund and Walvis Bay, Namibian Government institutions, service providers and the mine’s customers. Regular information sharing with both internal and external stakeholders is considered to be a key enabler of the company’s business success. The Corporate Communication Section uses various platforms, initiatives and activities to establish, nurture and maintain good relationships and promote the sharing of information with all stakeholders, as well as receiving concerns, if any. For internal stakeholders this includes newsletters, intranet, and various written and verbal communications, while external stakeholders are engaged via the annual publication of a stakeholder report, a website, a visitor’s programme and regular communication with key stakeholders and the media. Furthermore, the company supports the Rössing Foundation, an institution with numerous community and educational activities, such as a mobile laboratory in support of educational programmes.

I.2.1.2. Safety and radiation protection

Rössing Uranium is committed to zero harm and has put in place rigorous processes to ensure the safety of every employee and contractor. The identification and management of material risks are crucial in Rössing Uranium’s business approach, and a formalized, integrative health, safety and environmental (HSE) management system is utilized to optimize, coordinate and manage the operations, personnel, plant and equipment. The structure of the HSE management system generally follows the layout of common international standards such as the International Organization for Standardization (ISO) 14001,
and the Occupational Health and Safety Assessment Series (OSHAS) of the British Standard (BS) 18001. An auditing programme periodically evaluates the effectiveness of the HSE management system.

Rössing Uranium’s radiation management plan provides a comprehensive summary of the risk assessments, sources and receptors, and the controls implemented. It is updated annually. The Namibian Radiation Protection Authority audits the implementation of the radiation management plan. Workers who are considered to be at an elevated risk for radiation exposure, that is anyone who is at risk to receive an annual dose of 5 mSv or more from all exposure pathways combined, are termed ‘radiation workers’. Such workers receive continuous gamma monitoring in the form of a dosimeter and undergo monthly urine testing to check for accidental ingestion of uranium. Female radiation workers must undergo monthly pregnancy tests to enable prompt removal from any exposure in the case of a pregnancy.

![Graph](image)

**FIG. 6. Annual personal worker radiation exposure for Rössing Uranium Mine workers.**

Figure 6 illustrates the personal radiation exposure dose by similar exposure group (SEG) in relation to the regulatory annual dose limit of 20 mSv.

**1.2.1.3. Environmental protection**

Rössing Uranium is committed to protecting the environment in which the company operates. Measures include a wide range of preventative monitoring activities, with a particular focus on water management and monitoring, especially in the light of the extremely low rainfall associated with the Erongo Region’s water-scarce, hyper-arid climate. Rössing Uranium has a strong history of engagement and co-operation with the regulators and other stakeholders to ensure that the environment remains protected.
Environmental impacts are managed with guidance from, amongst others, Namibian legislation, the ISO 14001 environmental management system, Rio Tinto’s performance standards and international best practices. Transparent reporting allows stakeholders to be assured that the company’s environmental impacts are monitored, and the necessary mitigation measures are in place to keep these impacts as low as reasonably achievable.

I.2.1.4. Protection/enhancement of cultural, tourism, farming, pastoral and similar interests

The Rössing Foundation was established in 1978 through a Deed of Trust as a vehicle to oversee and implement many of Rössing Uranium’s corporate social responsibility activities in Namibia. All the activities that the Rössing Foundation drives or supports are formulated in a Memorandum of Understanding between the Foundation and partner organizations, but in particular the seven education directorates. These critical partners include the Ministry of Education, Arts and Culture, the Ministry of Mines and Energy, the National Institute for Educational Development (NIED), the United Nation’s Children Emergency Fund (UNICEF), the Erongo Regional Council and the Arandis Town Council.

The Foundation focuses mainly on programmes that target:

— The realisation of different teachers’ and pupils’ support programmes in order to improve primary and secondary education;
— The provision of bursaries and part-time study opportunities to deserving Namibians in order to develop the local workforce and specialized vocational skills;
— The support of medium- and small-scale enterprises in order to broaden and reinforce the local economy.

In the best interest of the company and its shareholders, the diverse board is made up of members with a wide range of skills and experience. The Rössing Foundation and the Rössing Environmental Rehabilitation Fund are managed independently from Rössing by their trustees and were created for special purposes. Some trustees also serve on the board of Rössing Uranium.

The responsibility for monitoring and sanctioning the financial statements to ensure that they properly represent the company’s business and its profits and losses at the end of each financial year lies with the directors. An opinion whether the financial statements fairly represent the company’s financial position is obtained from independent auditors. In preparing the financial statements, Rössing Uranium’s management adheres to the International Financial Reporting Standards (IFRS) and the Namibian Companies Act (Act No 28 of 2004, amended in 2011).

I.2.1.5. Management coordination/facilitation

Rössing Uranium has a unitary board and the roles of chairperson and managing director are separate and distinct. In the best interest of the company and its shareholders, the diverse board is made up of members with a wide range of skills and experience.

The Rössing Foundation and the Rössing Environmental Rehabilitation Fund are managed independently from Rössing by their trustees and were created for special purposes. Some trustees also serve on the board of Rössing Uranium.
I.2.1.6. Funding and financing

The responsibility for monitoring and sanctioning the financial statements to ensure that they properly represent the company’s business and its profits and losses at the end of each financial year lies with the directors. An opinion as to whether the financial statements fairly represent the company’s financial position is obtained from independent auditors.

In preparing the financial statements, Rössing Uranium’s management adheres to the International Financial Reporting Standards (IFRS) and the Namibian Companies Act (Act No. 28 of 2004, amended in 2011).

I.2.1.7. Safeguards and security

Namibia is a signatory to all the relevant international instruments for safeguards and security of nuclear material, which also cover the operations of Rössing Uranium. Moreover, the company regards international best practice and product stewardship as a foundation for the way it conducts business. Regular reporting to the Ministry of Mines and Energy is carried out and regular IAEA inspections take place.

I.2.1.8. Transportation/export route

Uranium oxide is transported to the company’s customers in 205 litre drums that are in keeping with IAEA standards. To complete the packaging process, each drum is cleaned and decontaminated, and a contamination swipe taken to ensure it meets shipping requirements. Then the drum is labelled with the required transport information on two sides. The drums are loaded into a shipping container that is labelled on all four of its sides with labels that are required for shipment of uranium ore concentrate.

The consignment leaves the Rössing mine by rail to the port at Walvis Bay, which is a journey of about 90 km. Walvis Bay Harbour has an area designated for uranium exports, which has all the safeguard instruments required for the temporary storage and handling of radioactive material. The consignment is then loaded onto a ship and transported in accordance with the approved Safeguards and Security measures to an overseas port for onward transport to converters.

I.2.1.9. Human resource development

Capacity building at Rössing Uranium is a critical process aimed at enhancing productivity and organizational performance. A Training and Development Section supports the mine’s strategy to achieve its objectives by providing support and services to the various departments through collaboration and partnerships. Various initiatives, such as bursaries, employee engagement and apprentice job attachments, are implemented to achieve the goal of empowering and developing the workforce.

Technical training is pivotal to ensure that the knowledge, skills and attributes of the workforce are enhanced. Various training interventions are therefore conducted in order to drive skills upgrading, efficiency and effectiveness. Rössing Uranium also makes contributions to the Namibia Training Authority’s Vocational Education and Training Fund.

I.2.1.10. Site and supporting facilities (infrastructure)

The site is connected to the Namibian road infrastructure through a short access road joining the Trans Kalahari Highway, which passes the mine directly to the north. The Trans Kalahari Highway links the harbour of Walvis Bay with Namibia’s neighbours to the east and north-east. The site is also connected to the Namibian railway grid, which allows delivery of
goods and dispatching of the final product by train. For its water supply, the Rössing mine is connected via a 70 km long pipeline with the state operated Central Namib Water Scheme. The national electricity grid passes directly by the mine, which is connected via a substation. The mine has town offices in Swakopmund and Windhoek.

1.2.1.11. **Contingency planning**

Under the structure of Rössing Uranium’s HSE management system, contingency plans are in place for all areas and processes requiring contingency planning.

1.2.1.12. **Waste management and minimization**

Rössing Uranium’s waste management system distinguishes between uranium mineralized waste and non-mineralized waste. Mineralized waste is defined to include mine rock and overburden, tailings and spent heap leach ore from mineral processing. At Rössing, the mineralized wastes currently identified are mine rock, overburden and tailings. All ex-pit material below 100 ppm is classified as waste and are dumped as such. The waste dumps are not separated by rock type or any other geological property. The mineralized waste management system aims to decrease and manage risk from operations in terms of human health and the environment; identify and assess risks (worst case and normal operating conditions); implement measures to control and manage negative impacts of mineral waste disposal; and monitor pollutants to ensure that Rio Tinto standards and international standards are met.

The tailings storage facility to the northwest of the plant and mine was originally designed as an upstream ring deposition facility in a gorge and was operated like this until the early 1980s. By that time some surface seepage of tailings liquid developed another gorge towards the west, and a modified ring deposition layout was implemented, confining deposition to the catchment of the original gorge, in which is protected by a surface seepage collection dam situated in the main channel of the gorge, about a kilometre downstream of the facility. It is anchored on its eastern end against a north-east trending ridge of hills. Today, the tailings storage facility is the largest feature on the Rössing site, covering a footprint of about 730 ha. It rises to an elevation of about 100 m above the surrounding surface and is one of the largest uranium tailings facilities in the world.

All tailings from the uranium extraction process are conveyed and pumped to the tailings storage facility. Due to the low uranium content of the ore, the tailings material, which is quite coarse, consist of virtually the entire mass of input ore plus waste process liquids. Surface seepage from the tailings impoundment occurs through a filter drain in the embankment and the foundation materials. An extensive seepage control programme and monitoring system has been established to contain sub-surface seepage. In order to reduce the wetted surface area, tailings discharge is at any point in time confined to 40-ha paddocks, whereby only one paddock surface is wetted during tailings discharge, and thereby reducing the wetted area by some 90%.

A non-mineralized waste management plan is in place to ensure that regulatory and internal requirements have been addressed and to minimize the environmental, safety and health hazards associated with the handling, storage and disposal of the variety of waste products generated by activities, products and services at Rössing. The waste management hierarchy of eliminate, reduce, reuse, recycle and dispose is followed throughout.

The non-mineralized waste management plan outlines how and what Rössing is doing and has done to reduce the amount of pollution and the generation of waste. Goals for pollution prevention are measured by compliance with the established operating. When new waste types are generated, new disposal options for these waste types will be researched and included in the plan. The document is updated as the need arises. The procedure identifies all waste streams, indicates disposal requirements and outlines record keeping requirements.
At present, non-mineral waste materials include waste water not generated from the mineral ore, scrap materials, redundant conveyor belts, domestic waste, used oils and lubricants from maintenance activities. A waste contractor handles recyclable waste materials such as scrap metal, wooden pallets, paper, plastic and metal containers on site. Rössing also operates a bioremediation facility for oil sludge soil. Through an aggressive wastewater recycling programme, Rössing has continued to reduce its freshwater requirements continuously, thereby minimizing wastewater.

1.2.1.13. Industrial involvement, including procurement

Rössing Uranium is a Class A Founder Member of the Chamber of Mines of Namibia, and a Founding Member of the Namibian Uranium Association (NUA). The company makes substantial contributions to the activities of these two bodies. Rössing Uranium is also a substantial contributor to the economic development in the Erongo Region and indeed the entire Namibian nation, as it is a major employer and purchaser of goods and services. The mine’s annual procurement spend has a significant ‘multiplier effect’ — the phenomenon where spending by one company creates income for further spending by others. In 2017, procurement of goods and services for the mine’s operations amounted to N$2.3 billion, of which 73.5% was spent with Namibian suppliers.

1.2.2. Husab mine

Swakop Uranium, the owner of Husab mine, is a partnership between Namibia and China, of which 10% is held by the Namibian State owned Mining Company Epangelo and 90% by Taurus Minerals Ltd. Taurus in turn is jointly owned by China General Nuclear Power Group and China Africa Development Fund. The partnership culminated in China’s single largest investment in Africa to construct the world-class Husab mine. Swakop Uranium is a private company registered in Namibia.

The discovery of the Husab uranium deposit in February 2008 was one of the world’s most significant uranium mineral findings in decades. Husab is an alaskite hosted deposit, similar to Rössing. The deposit lies under a shallow alluvial sand cover. As of 1 January 2017, recoverable resources amounted to 187,546 tonnes of uranium, at an average grade of 0.033% U [2]. In 2011, Swakop Uranium was granted a licence to develop the Husab mine, which is set to become the third largest uranium mine in the world. Mine development commenced in 2014. The total investment for the Husab mine is about US$5.2 billion, and more than US$2 billion was required to build the mine. The mine will more than double current Namibian uranium production and propel Namibia into third place in terms of global uranium production. The mine produced the first drum of uranium for the export market in December 2016, a significant event in the history of Namibia.

The mine is located about 5 km south of the Rössing mine, and 45 km north-east of Walvis Bay, Namibia’s only deepwater harbour. The mine site encompasses mining licence and accessory works areas of about 110 km², of which about one-third is used for mining, waste disposal and processing. The tailings storage facility alone covers some 5 km². Mining is performed by blasting, loading and hauling from then open pit, before the uranium bearing rock is processed to produce uranium oxide.

Swakop Uranium supports and promotes the Government of Namibia’s National Agenda and Harambee Prosperity Plan. The company is the largest employer in the Namibian mining industry, with 1650 permanent employees and some 500 contractor employees, thus assisting the Government to reduce unemployment and alleviate poverty.
1.2.2.1. Stakeholder involvement

Swakop Uranium’s stakeholders include the Government as regulator; shareholders; employees; contractors; the communities of Arandis, Swakopmund and Walvis Bay; Namibian Government institutions, in particular the Directorate of Parks and Wildlife as the custodian of the Namib-Naukluft Park, where the Husab mine is located; the conservation and scientific community; the service providers; and the mine’s customers. In order to share information, regular visits of stakeholder groups are facilitated, and the work of the NUA, the Namibian Uranium Institute and the Chamber of Mines of Namibia is actively supported.

Employees are a very important stakeholder group, and Swakop Uranium and the mine Workers Union of Namibia signed a historic three year wage agreement in 2016 to regulate the conditions of the employment framework, including housing allowance to employees in the bargaining unit to purchase or rent accommodation units. Both parties have a cordial and constructive relationship, aligned to the vision of the company to work through its STARIC (safety, transparency, accountability, respect, integrity, collaboration) values to build the Husab mine into a world class operation.

1.2.2.2. Safety and radiation protection

Swakop Uranium’s Safety, Health and Environment Management requires employees to be safety conscious, encourage their fellow workers to work safely and diligently, reduce all incidents to zero base and keep this in mind as negligent behaviour leads to injuries and damage to company property, check machines and equipment or company assets before the start of work, report any defects immediately to the supervisor, work in teams and share work experience and any shift issues with colleagues in order to not make the same mistakes, focus on quality of work and ‘do it right the first time’.

Swakop Uranium has a radiation management plan in place, which is regularly audited to ensure compliance. A network of dust fallout measuring stations ensures the prevention of inhalation of radioactive material, and voluntary urine testing is available for the employees. Workers who are considered to be at risk of receiving an annual dose of 5 mSv or more from all exposure pathways combined receive continuous gamma monitoring in the form of a dosimeter. Environmental radiation monitoring consists of a soil sampling and radionuclides analysis baseline study completed at the end of 2016, and annual monitoring for and analysis of aquatic radionuclides as well as atmospheric radionuclides, thorium and uranium survey.

Swakop Uranium complies fully with the provisions of the Namibian Atomic Energy and Radiation Protection Act, Act No. 5 of 2005, and its regulations, and reports to the National Radiation Protection Authority, which has approved Swakop Uranium’s radiation management plan, on a regular basis. Swakop Uranium furthermore complies fully with all guidelines, standards and provisions of the International Atomic Energy Agency, of which Namibia is a member.

1.2.2.3. Environmental protection

Swakop Uranium has an environmental management plan committed to caring for all species of fauna and flora found near to or within its exploration and mining areas. Its Environmental Department provides guidance and advice on new projects, new activities, and environmental management plan commitments and legal requirements, and is guided by legislation, best practice, relevant environmental impact assessments and scoping reports and the operational Husab environmental management plan. The department conducts compliance monitoring by means of inspections and audits in the various work areas; implements and conducts environmental monitoring and baseline establishment; and acts as the link between
the authorities and Swakop Uranium management on environmental issues. It is the custodian of environmental permits and licences and is responsible for biannual reporting to authorities and external annual environmental management plan audits.

Welwitschia mirabilis, Namibia’s ancient national plant, grows in areas around the mine. Carbon dating shows that medium sized plants can be 1000 years old. Swakop Uranium has supported substantial research into this species.

The Husab mine is also challenged to ensure that limited nearby water resources are not adversely affected by mining operations. Long term records from the Rössing mine situated 5 km north of the Husab mine show an annual average rainfall of between 30–35 mm per annum. A hydrogeology report commissioned by Swakop Uranium concluded that the mining activities will have an effect on water levels. Although there are no settlements in the area, Swakop Uranium has drilled a number of groundwater monitoring holes around the pit, the mine rock dump, the tailings storage facility, the Welwitschia fields, and the Khan and Swakop rivers to determine the effect of mining activities in the area. Water levels in all boreholes are measured monthly and strategic boreholes are sampled every three months for water quality analysis by a third party (SLR Environmental Consulting). However, production boreholes have not been in operation, as the company has moved from construction to a mining operation and currently obtains its water from the Orano desalination plant. Finally, Swakop Uranium complies with all applicable international standards, as adopted for the Husab mine operational requirements.

1.2.2.4. Protection/enhancement of cultural, tourism, farming, pastoral and similar interests

The area of the Husab mine lies within one of Namibia’s National Parks, the Namib-Naukluft Park. Interaction with the conservation and tourism stakeholders therefore occurs on a regular basis, and some tourist routes are maintained by the mine. Furthermore, limited irrigation farming takes place in the Khan and Swakop rivers adjacent to the mine, and regular contact is therefore maintained with the farmers to ensure that there are no adverse effects of the mining and processing activities on the quality of the groundwater.

A heritage and archaeological chance find management programme is in place to ensure the safety of any item or structure protected under Namibia’s National Heritage Act.

As Swakop Uranium is committed to social and empowerment issues, the Swakop Uranium Foundation engages the poor and vulnerable communities living close to the park’s borders to address more critical needs, create a better future and ensure their growth together with the mine.

1.2.2.5. Management coordination/facilitation

Swakop Uranium’s board of directors provides strategic guidance, as well as having a compliance and auditing function. The executive committee of the mine is tasked with executing board directives to build an inclusive and high performance culture for all employees through the establishment of well structured departments with clear accountability levels. All employees are being coached to understand each other’s role in the company.

1.2.2.6. Funding and financing

The shareholders of the company were responsible for obtaining the necessary finance to construct the Husab mine and during ramp-up operations have continued to ensure that the mine operates with a positive cashflow for its continued existence.
1.2.2.7. Safeguards and security

Namibia is a signatory to all the relevant international instruments for safeguards and security of nuclear material, which also cover the operations of Swakop Uranium. Moreover, the company regards international best practice and product stewardship as a foundation for the way it conducts business. Regular reporting to the Ministry of Mines and Energy is carried out and regular National Radiation Protection Authority inspections take place.

1.2.2.8. Transportation/export route

Uranium oxide is transported to its destination in 210 litre drums. The cleaned drums are loaded into steel shipping containers. Consignments leave the Husab mine by road to the port at Walvis Bay, which is a journey of about 90 km. Walvis Bay Harbour has an area designated for uranium exports, which has all the safeguard instruments required for the temporary storage and handling of radioactive material. Further onward transport is by ship in accordance with the Safeguards and Security provisions.

1.2.2.9. Human resource development

Swakop Uranium is committed to the continuous improvement of its workforce through both formal training and on the job training. Bursaries are provided for young Namibians to realize their tertiary education goals. Through Memorandums of Understanding with the Namibian Institute of Mining and Technology, the Namibian University of Science and Technology and the University of Namibia, job attachments for students are facilitated.

The company is focusing in particular on skills upgrading at all levels within the organization and promoting cross-training to ensure that its employees are multi-skilled.

1.2.2.10. Site and supporting facilities (infrastructure)

The site is connected to the Namibian road infrastructure through a 22 km access road joining the Trans Kalahari Highway, which passes the mine to the north and links the harbour of Walvis Bay with Namibia’s neighbours to the east and north-east. The access road includes a 160 m long bridge, which is the longest bridge constructed in Namibia since independence in 1990.

Water is provided through a 65 km long purpose constructed pipeline, which links the mine with the Swakopmund water reservoir. The Swakopmund water reservoir is supplied by the Omdel Dam Scheme, as well as the Erongo desalination plant. The Husab mine is connected to the Namibian electricity grid via the 50 MVA Lithops substation. The site also produces a smaller amount of electricity from waste heat at its sulphuric acid plant.

Swakop Uranium has offices in Swakopmund, as well as in the capital city of Windhoek.

1.2.2.11. Contingency planning

Under the structure of Swakop Uranium’s HSE management system, contingency plans are in place for all areas and processes requiring contingency planning.

1.2.2.12. Waste management and minimization

Swakop Uranium’s waste management plan focuses on separation and recycling. While hazardous waste obviously needs to be sent to a hazardous waste disposal site, suitable hydrocarbon waste is reused before it is deposited at a hazardous waste disposal site. Radioactive contaminated material is kept on-site at the tailings storage facility, and rubble,
tyres and wood are reused, when applicable. Glass, plastics, metals, cans, cardboard and paper are transferred to a recycling facility. Only general domestic waste goes to landfill. Water is recycled to minimize wastewater and effluents that require management.

While the initial plan was to combine the mine rock facility and the tailings facility, this proved to be impractical, and the mine therefore has two different facilities. At the mine rock dump, the entire footprint is covered with a 2 m thick layer of calcretic overburden soils to maximise the potential for neutralisation of any acid seepage that might occur. This layer has a very high neutralising capacity and thus maximising the potential for neutralisation of seepage. Surface water in the form of run-off from the slopes is captured by a dirty water collection channel and directed to a storage pond for subsequent use as dust control or within the plant.

The tailings storage facility site was selected in order to minimise impacts on the ephemeral run-off channels and near-surface aquifer systems, and hence is in a location that is outside of the zone of ephemeral channels. It was furthermore placed at the lowest elevation possible in order to minimise the pumping costs and risks associated with high pressure pipelines. The tailings storage facility was designed and operates as an upstream raise, whereby a relatively low height starter wall was constructed, and additional volume is created by raising the walls with an outer layer of cover soils underlain by tailings. It is lined with a geo-membrane liner to minimise seepage losses, both for maximising water return and for minimising pollution potential. In order to facilitate return water from the dam an actively-managed decant pond is in place.

Swakop Uranium has a contract with a professional waste management organization, which provides on-site services, such as provision of the necessary waste management equipment, removal of all the general waste from the site, hazardous waste removal from the site to Walvis Bay, on-site recycling, on-site spillage clean-ups, management of the building rubble yard, on-site medical waste and fat trap management, on-site KleenBin services, and the provision of on-site health and safety and environmental staff.

I.2.2.13. Industrial involvement, including procurement

Swakop Uranium is a Class A Member of the Namibian Chamber of Mines, and a Founding Member of the Namibian Uranium Association. The company makes substantial contributions to the activities of these two bodies.

According to general practice in the Namibian mining industry, procurement is performed locally, as far as possible. In 2017, Swakop Uranium spent N$2.5 billion in local procurement, a figure that makes a very significant impact on the local economy.

I.2.3 Langer Heinrich mine

The Langer Heinrich mine (Fig. 7) is owned by Paladin Energy Ltd from Australia (51%) and China National Nuclear Corporation (49%). Langer Heinrich is a surficial calcrite type deposit, associated with sediments occurring within a tertiary paleodrainage system. Uranium mineralization occurs as carnitite containing uranium and vanadium. As of 1 January 2017, recoverable resources amounted to 37 623 tonnes of uranium at an average grade of 0.045% U\(^2\). Between 2007 and 2018, Langer Heinrich uranium mine operated a conventional open pit uranium mine located within the Namib-Naukluft National Park, some 90 km east of Walvis Bay. Uranium production for the period July 2017 to June 2018 comprised 1145 tonnes. Due to the ongoing low uranium price, a board decision was taken to prepare the mine for care and maintenance, which was put into effect in May 2018.

The key focus at Langer Heinrich uranium mine during care and maintenance is the safety of personnel and the security of the project assets. Care and maintenance activities include maintaining the processing plant and equipment in a state of readiness to facilitate a restart of
operations, complying with legal and social obligations, conducting environmental and radiological monitoring, and managing tailings facility water.

![Aerial view of Langer Heinrich mine](image)

**FIG. 7. Aerial view of Langer Heinrich mine (© Langer Heinrich Uranium).**

1.2.3.1. Stakeholder involvement

Langer Heinrich uranium mine considers stakeholder engagement to be the basis for building strong, constructive and responsive relationships that are essential for the successful management of the mine’s environmental and social impacts. Such engagement takes the form of stakeholder mapping, and subsequent meetings with interested and affected parties, there is a dedicated email address for queries and concerns, and a formal engagement plan is followed for the interaction with internal stakeholders by both, management and the mother company in Australia. Regular interaction with the relevant government ministries also takes place, and during the operational phase Langer Heinrich issued a newsletter.

1.2.3.2. Safety and radiation protection

Through its robust health, safety and radiation policies, Langer Heinrich uranium mine ensures that employees work in a safe environment and with the aim of zero harm. The mine operates within the relevant national and international legal, as well as voluntary internal requirements (e.g. not prescribed by law). The mine continuously assesses and reduces risks throughout the operation and raises health and safety awareness through specialized training and employee health awareness programmes. Langer Heinrich uranium mine’s occupational health and safety management system is based on the NOSA CMB253N Standard, which aligns with OHSAS 18001.
The radiation management system is implemented in accordance with Namibian national legislation, as well as the fundamental principles of the International Commission on Radiological Protection (ICRP) and related IAEA Standards, notably the BSS 2014, and is set out in its Safety, Health, Environment and Radiation Protection (SHER) Policy, Radiation Management Plan and Radiation Standards. It ensures that radiation protection principles are firmly established and that the radiation exposure of all employees and affected persons is lower than the legislated limits and as low as reasonably achievable, and that there are no adverse effects on the regional communities or their environment. The monitoring program which forms an integral part of the radiation management programme was revised to align with the care and maintenance activities. The 2019 calendar year monitoring program results have been used to derive the annual dose assessment for each worker. The total dose is the sum of the individual doses from the three exposure pathways namely:

- Inhalation of Long Lived Radioactive Dust (LLRD);
- Inhalation of Radon Decay Products (RDP);
- External gamma radiation.

**FIG. 8. Annual radiation doses for similar exposure groups for Langer Heinrich mine employees in 2019.**

Monitoring is performed on a statistical sampling plan across the Similar Exposure Groups (SEGs) on a risk prioritised basis. The routine doses received by each SEG for the 2019 calendar year from the identified exposure pathways are graphically presented in Fig. 8.

1.2.3.3. Environmental protection

Langer Heinrich uranium mine operates under the approved ML 140 and ML 172 Environmental Clearance Certificate conditions [90]. Environmental impact assessment processes were conducted during the project development phase in 2005. Further environmental impact assessments were subsequently undertaken at the mine for the stage 3 and stage 4 expansion projects in 2010 and 2012, respectively. All of the assessment processes involved extensive stakeholder consultation and the reports were made available for public review and comment.
Prior to project development and expansion projects, environmental baseline studies were conducted, potential impacts assessed, and environmental management plans and monitoring programmes established, to minimize impacts over the life of the mine.

Langer Heinrich uranium mine has an operational environmental management plan that has been submitted, as required, to the Namibian Government and relevant third parties. This environmental management plan consists of 15 management and mitigation plans developed and implemented in accordance with the International Organization for Standardization (ISO) 14001:2004 and the South African National Standard (SANS) 14001:2005 environmental management system requirements.

Langer Heinrich uranium mine applies a Water Use and Quality Standard to ensure efficient, safe and sustainable use of water and the protection of water resources and ecosystems around its sites. The mine undertakes its operations in a way that maximizes the recycling and reuse of water, it has a water management and mitigation plan in place and maintains a comprehensive site water balance to ensure that the company achieves its water usage, supply and resource protection objectives.

Air quality is managed through a formal air quality management and mitigation plan. Langer Heinrich uranium mine remains committed to avoiding, preventing and mitigating adverse impacts to air quality generated as a result of any activities. An air quality sampling and monitoring network provides the basis for the mine’s air quality management plan. During routine operations, various dust suppression and control measures are applied within the process plant and at work areas of high dust incidence. These procedures will be reactivated once the mine goes back into production.

Prior to the Langer Heinrich uranium mine’s project development and subsequent expansion projects, biodiversity baseline studies were conducted and potential impacts were assessed, from which a biodiversity management and mitigation plan was developed and implemented to address and manage potential impacts, for example in areas where animal and plant species were identified as needing protection. As the mine is located in the Namib-Naukluft National Park, extensive biodiversity studies have been conducted to establish and monitor biodiversity composition, structure and processes. Using the results from these studies, analyses were undertaken, and management measures developed, to avoid areas ranked as highly sensitive, and to minimize negative impacts on biodiversity in general. In the area of Langer Heinrich uranium mine, approximately 936 ha of land used for the mining and processing facilities is classified as ‘disturbed’. Approximately 39 ha of land has been rehabilitated to date (2019). The mine continues to maintain a biodiversity database with historical and current biodiversity data, including conservation status, preferred habitats and recorded sightings.

I.2.3.4. Protection/enhancement of cultural, tourism, farming, pastoral and similar interests

There are no permanent communities living in the direct vicinity of the mine, and therefore no local communities are likely to be directly affected by the mining operation. However, engagement continues with conservation and tourism stakeholders through a formal social performance management plan.

Langer Heinrich uranium mine supports the Gobabeb Training and Research Internship Programme, which targets young Namibian scientists interested in the fields of conservation and ecological restoration. Under the guidance of researchers from the Gobabeb Research and Training Centre, students design and implement independent research projects that contribute to Namibia’s ability to manage and restore degraded ecosystems.
1.2.3.5. Funding and financing

The mine is owned and financed by its shareholders. Under operational conditions it is funded from operational cash flow, while in care and maintenance funding is provided by its owners and operator.

1.2.3.6. Safeguards and security

Namibia is a signatory to all relevant international instruments for safeguards and the security of nuclear material, according to which the operations of Langer Heinrich uranium mine are managed and regulated. The company regards international best practice and product stewardship as a foundation of the way it conducts business. Regular reporting to the Ministry of Mines and Energy is carried out and National Radiation Protection Authority inspections take place on a regular basis.

Reporting to other relevant national regulatory authorities, such as, for example, the Ministry of Environment and Tourism, the Department of Water Affairs, the National Radiation Protection Authority, the Ministry of Health and Social Services, and the Ministry of Labour, Industrial Relations and Employment Creation, is done against agreed time frames and conditions.

1.2.3.7. Transportation/export route

During operation, the Langer Heinrich uranium mine adhered strictly to the terms of both the export and transport licences covering both the export of the product to various conversion facilities and the transport of metallurgical and geological samples to a range of various laboratories worldwide. In all circumstances, packaging, marking, labelling and documentation for the transportation were carried out in accordance with the IAEA Transport Regulations. The monitoring of the packages was conducted by competent personnel.

For shipment, the yellow cake product was packaged in 205 litre steel drums classified as industrial packaging category 1 (IP-1). Each drum was labelled with a category II label according to the regulations, describing its content as low specific activity category 1 (LSA-1) material. The drums were sealed with steel rings, stacked and strapped securely inside approved ISO freight containers. The packaging, labelling and documentation for each shipment fully complied with the requirements of the IAEA Transport Regulations.

Occasionally the Langer Heinrich uranium mine ships geological or metallurgical samples to independent laboratories for testing. As this material may contain radioactive material, each shipment is monitored to ensure full compliance with the IAEA Transport Regulations in terms of packaging (UN 2910 excepted packages), labelling and documentation.

1.2.3.8. Human resource development

Langer Heinrich uranium mine has routinely supported a range of education and skills development programmes. Through the mine’s study assistance programme, the company assisted employees in furthering their educational qualifications for both intermediate and long term development, aligned to the business needs. A Langer Heinrich uranium mine bursary programme provided financial support to a number of students to pursue formal qualifications in specific fields identified as scarce within Namibia and of direct importance to the operations. The graduate development programme focused on attracting graduates and trainees to develop a pool of future skilled individuals and potential leaders. The apprentice programme provided students from the Namibian Institute of Mining and Technology with opportunities to acquire hands on training in various vocational trades. An in-house processing training programme
provided internal competency based training to allow the recruitment of individuals with less experience. Lastly, an understudy development programme was in place, as all non-Namibian employees had an appointed understudy. Through the mathematics support and enrichment programme, Langer Heinrich uranium mine helped gifted learners to reach their full academic potential. The mine also supported the Annual National Mathematics Congress, which targets the development of mathematics, as well as the mathematics teaching skills of teachers across Namibia. Financially underprivileged, yet academically able learners were also supported via the Mondesa Youth Opportunities Trust.

I.2.3.9. Site and supporting facilities (infrastructure)

The mine is located about 90 km east of Walvis Bay on the foot of the Langer Heinrich Mountain in the Namib Desert and within the Namib-Naukluft National Park. The mine site encompasses two mining licences (ML 140 and ML 172) and accessory works areas of about 74 km², of which 4 km² has been used to date for mining, waste disposal and processing activities.

The site is connected to the Namibian road infrastructure through a 25 km long access road joining the C28, which passes the mine to the south-east. The C28 is an unsurfaced gravel road connecting Windhoek with Swakopmund via the Bosua Pass.

The site has existing water pipeline and power connections provided by the Namibian water and power utilities, respectively. The water pipeline and related infrastructure run alongside the C28 regional road for about 50 km and then branch off to follow the access road to site. The section of the water pipeline adjacent to the C28 is located above ground, whilst the section adjacent to the access road is underground. The power line infrastructure to the mine runs from the Kuiseb Substation in Walvis Bay to the access road, from there it runs parallel with the access road to the mine site. There is also an above ground water pipeline and associated gravel track between the Swakop River boreholes and the mining lease, running alongside the Langer Heinrich Mountain towards the operations area.

The mine is surrounded by the Namib-Naukluft National Park, and the nearest boundary of the Park to the north of the mine is about 15 km away. This boundary also indicates the location of the nearest commercial farm Modderfontein, i.e. the nearest neighbour. The northern parts of the Park include large tracts of land without any access by road. A small piece of land within the Park, close to one of the Swakop River abstraction boreholes, is privately owned. This land is referred to as Farm Riet and although it can never be developed, the owner has access to the land for camping and other non-intrusive activities.

I.2.3.10. Contingency planning

Under the structure of the Langer Heinrich uranium mine safety, health environment radiation management system, contingency plans and programmes are in place for all areas and processes requiring such response and or contingency planning.

I.2.3.11. Waste management and minimization

Waste generated during the different phases of the operations was categorized into the two key categories of mineralized waste and non-mineralized waste and dealt with in terms of a formal waste management and mitigation plan.

Mineralized waste constituted all mineralized material that cannot be processed further, either because of constraints related to current metallurgical technology and processes, or due to the current low uranium commodity price, or both. Mineralized waste is further categorized into mined mineralized waste rock and processed mineralized waste.
Non-mineralized waste included low level radioactive contaminated waste that was stored on-site at the designated waste location; general waste that was disposed of at the Swakopmund landfill site; hazardous waste that was taken to the Walvis Bay hazardous waste facility; recyclable material and recyclable metal sold to scrap metal dealers; and medical waste incinerated at the Swakopmund Cottage Medi-Clinic. Only non-mineralized waste with a radioactive surface contamination of less than 4 Bq cm\(^{-2}\) is cleared and authorized for removal from site.

I.2.3.12. Industrial involvement, including procurement

Langer Heinrich uranium mine is a member of the Namibian Chamber of Mines, and a Founding Member of the Namibian Uranium Association. This enables Langer Heinrich uranium mine to contribute to and participate in Namibian working groups to address key industry issues and understand the broader challenges of the uranium sector. According to general practice in the Namibian mining industry, procurement of goods and services is done locally within Namibia, as far as possible.

I.2.4. Trekkopje mine

The Trekkopje mine (Fig. 9) is 100% owned by Orano Mining Namibia, a subsidiary of the French Orano Group (previously AREVA). Orano Mining Namibia also owns the Erongo desalination plant, built to supply the Trekkopje mine with water for its operations. Trekkopje deposits (Klein Trekkopje and Trekkopje) are surficial deposits (80% of the mineralization is contained in the top 15 m) hosted in calcrete conglomerate of Cenozoic age. As of 1 January 2017, recoverable resources amounted to 18 720 tonnes of uranium at an average grade of 0.012% U\(^{[2]}\). The mine is situated 70 km north-east of Swakopmund and to the north of the Rössing mine in the Erongo Region. The mine site encompasses a licensed mining facility and accessory works areas of about 374 km\(^2\), of which only a small area is used for mining, waste disposal and processing.

Since 2005, the calcrete hosted uranium deposit has been developed in several phases. Mining was performed by blasting, loading and hauling from the open pit, before the uranium bearing rock was processed and subjected to an alkaline heap leach to produce sodium diuranate. In mid-2013, the almost completed processing plant and associated mining facilities were put on care and maintenance due to the unfavourable uranium spot price. A care and maintenance team currently protects the mine’s infrastructure so that it can be recommissioned when economic conditions become more favourable.
I.2.4.1. Stakeholder involvement

Orano Mining Namibia has engaged with all stakeholders, including the Namibian Government at the local, regional and national level in the areas of economic development, education, culture and sport in the Erongo Region. The company continues to support initiatives in these fields, although the mine is not generating income at present.

As the owners of the Erongo desalination plant, Orano Mining Namibia has a slightly different set of stakeholders from the other uranium mines in Namibia. The desalination plant currently supplies the Namibian water utility, NamWater, which in turn provides water to other mining operations and the coastal towns.

Orano Mining Namibia also has a stakeholder partnership with the Mineral Processing Department of the Namibian University of Science and Technology, where joint metallurgical research has been conducted. Orano Mining Namibia’s corporate communications officer interacts with all stakeholders to keep them informed about developments at both the mine and the desalination plant.

I.2.4.2. Safety and radiation protection

Orano has a shared safety culture that helps to reduce risks and prevent accidents. Under care and maintenance, Orano Mining Namibia uses its established safety management system to remind employees and contractors at every level of their responsibility for safety, to strengthen risk assessment and prevention, to standardize procedures and share best practices, and to carry out safety campaigns and monitor performance. On 3 October 2018, Orano Mining Namibia achieved a new safety milestone of six continuous years without lost time injury.

Occupational health monitoring includes regular medical examinations at the Chief Medical Officer’s practice and continuous radiation monitoring at the mine, which consists of personal and area monitoring. Radiation monitoring results have shown that there is no exposure higher than the background radiation on the mine site. Orano Mining Namibia has an approved radiation management plan that specifies the monitoring requirements and submits annual reports on radiation management to the National Radiation Protection Authority.
I.2.4.3. Environmental protection

The environmental performance of Orano Mining Namibia is monitored through internal tracking of environmental indicators, such as water, electricity and fuel consumption, greenhouse gas emissions and production of waste. To check compliance with the environmental management plan and legal requirements, an independent audit of the mine and the Erongo desalination plant is carried out every year. Biannual reports on the status of the environment and on water management are submitted to the Ministry of Environment and Tourism and the Ministry of Agriculture, Water and Forestry. In addition to these reports, the ministries carry out ad hoc inspections to assess the environmental situation at the site. Monitoring of fauna and flora and restoration trial areas continues during the care and maintenance phase.

I.2.4.4. Protection/enhancement of cultural, tourism, farming, pastoral and similar interests

While there are no farming interests in the desert environment of the Trekkopje mine, Orano Mining Namibia supports social projects in the areas of economic development, education, culture and sport in the neighbouring communities of Arandis, Swakopmund, Spitzkoppe and Usakos, and in the wider Erongo region. Micro loans to small and medium scale enterprises (SMEs), bursaries, the promotion of safety at schools and sports events are some of the tools used recently. Orano Mining Namibia also contributes to the protection of the Wlotzkasbaken lichen field in the Dorob National Park.

I.2.4.5. Funding and financing

The Trekkopje project is fully financed by the Orano Group of France.

I.2.4.6. Safeguards and security

Namibia is a signatory to all the relevant international instruments for safeguards and security of nuclear material, which also cover the operations of Orano Mining Namibia. Regular reporting to the Ministry of Mines and Energy is carried out and National Radiation Protection Authority inspections take place from time to time.

I.2.4.7. Transportation/export route

As there is no production during the care and maintenance phase, no transportation of any product takes place at present. In the event of future production, the final product will be transported by road to the harbour of Walvis Bay for onward shipping in accordance with Security and Safeguards requirements.

I.2.4.8. Human resource development

Orano Mining Namibia believes that promoting education and skills is indispensable for the development of the country as a whole. The availability of well educated and skilled people ensures the long term sustainability of the mining industry and other businesses. The care and maintenance phase has provided employees with more time to upgrade their skills or qualifications by attending training courses on and off the mine site. Identified talents are enrolled in professional or leadership development programmes that are preparing them for roles of increased responsibility.
1.2.4.9. Site and supporting facilities (infrastructure)

The mine is located 70 km north-east of Swakopmund and to the north of the Rössing mine in the Erongo Region. The mine site encompasses a mining licence and accessory works areas of about 374 km², of which only a small area has been used for mining, waste disposal and processing. At present, the existing infrastructure comprises a full recovery plant as well as some equipment intended to serve the heap leach pads. All infrastructure is protected and kept in working condition during the care and maintenance phase.

The site is connected to the Namibian road infrastructure through a 23 km access road, which links up with the B2 Trans Kalahari Highway some 70 km east of Swakopmund at Arandis. For potential future developments, a rail connection will be available there too. The mine is also connected to the existing power grid. An independent power producer has established a 5 MW PV plant on the Trekkopje site.

Orano Mining Namibia owns the largest reverse osmosis seawater desalination plant in southern Africa. It is located near Wlotzkasbaken, 30 km north of Swakopmund, and was inaugurated in 2010. The desalination plant can produce up to 20 million cubic metres of salt-free water per year, although its capacity is not fully used while the mine is under care and maintenance. Instead, the plant currently supplies up to 12 million cubic metres per annum to the national water utility, NamWater, which is utilized by the other mining operations and the coastal municipalities. The mine is linked to the desalination plant via a 40 km long purpose built pipeline. Orano Mining Namibia also has a town office in Swakopmund.

1.2.4.10. Contingency planning

Under the structure of Orano Mining Namibia’s HSE management system, contingency plans are in place for all areas and processes requiring emergency planning.

1.2.4.11. Waste management and minimization

Orano Mining Namibia produces limited amounts of waste during the current care and maintenance phase. Under the environmental management plan, this waste is classified into three categories, namely hazardous waste, non-hazardous waste and recyclable waste, and each category is managed accordingly. Once in operation, all spent ore will be returned to the pit, and approximately 30% of the waste and overburden can also be deposited in the pit. The heap leach method coupled with backfilling has provided a unique opportunity to design the entire operation to reduce the surface footprint of the mine and improve the prospects for post-mining rehabilitation.

1.2.4.12. Industrial involvement, including procurement

Orano Mining Namibia is a Class B Member of the Namibian Chamber of Mines, and a Founding Member of the Namibian Uranium Association. The company makes substantial contributions to the activities of these two bodies.

According to general practice in the Namibian mining industry, procurement is done locally, as far as possible. In 2018, Orano Mining Namibia made 99% of all purchases locally, spending N $206 million (including payments for utilities).
Appendix II

UNITED REPUBLIC OF TANZANIA CASE STUDY

II.1. BACKGROUND OF THE URANIUM INDUSTRY IN THE UNITED REPUBLIC OF TANZANIA

II.1.1. Overview of uranium geology and exploration activity

The geological setting of the United Republic of Tanzania (Tanzania) is favourable for the occurrence of most major metals, hydrocarbons, coal, uranium, phosphate, and metallic and many non-metallic minerals. The geological environment of the country covers the entire chrono-stratigraphic units from Archaean through Proterozoic to Quaternary [100, 101].

The occurrence of uranium in Tanzania was reported for the first time in 1953 in pegmatites of the Uluguru Mountains in the Morogoro region in the eastern part of the country from locally extracted uraninite. In 1978–83 the government of the United Republic of Tanzania sponsored airborne radiometric surveys of the entire country.

Uranium occurs in seven geological types: four sedimentary rock types and three alkaline volcanic rock types. The first uranium concentration in time is connected to the Upper Proterozoic stratiform copper mineralization of the Zambian Copperbelt type at Chimala in the southern part of Tanzania close to the Zambian border. The sandstone type lies on the fluvial Karoo Supergroup, which extends from the great Karoo system from South Africa. High uranium concentration occurs in the Upper Tertiary to Quaternary periods in the surficial (‘calcrete’) type in Bahi and Manyoni in Central Tanzania and the lacustrine phosphate deposit of Minjingu. Uranium is also hosted in rift related alkaline volcanic formations with uraniferous carbonatites, such as Galapo (northern part) and Panda Hill (southern Tanzania). The uranium occurrence blocks are shown in Fig. 10.

FIG. 10. Uranium occurrences in Tanzania (Source: Geological Survey of Tanzania 2013) [100]. Block A — Karoo sandstone, vein-like (unconformity); Block B — Dodoma calcrete; Block C — sandstone; Block D — Minjingu and Galappo sedimentary (phosphate), intra-intrusive (carbonatite); Block E — Monduli–Tarosero volcanics; Block F — Mbeya–Njombe sedimentary (black shales), intra-intrusive (carbonatite), vein-like (unconformity); Block Q — Bukoba vein-like (unconformity), intra-intrusive (granite), sandstone.
Airborne geophysical surveying and ground follow-up of numerous radiometric anomalies were completed by the German based company, Uranerzbergbau GmbH (UEB) [101] from 1978 to 1982. Regional airborne survey and ground follow-up work indicated that blocks A and B from Fig. 10 were the most promising areas for uranium exploration. Uranium mineralization associated with Karoo sandstones was discovered in block A and calcrite related secondary mineralization associated with Mbuga was detected in block B. The unconformity between the Karagwe– Ankolean and Bukoban systems of blocks C and Q appeared to be less prospective for a potential vein-like type uranium deposit than the Ubendian/Bukoban unconformity. Block Q and part of block C were classified as uneconomic, whilst the remaining part of block C was assumed to be potentially economic. Uranium in phosphate was proven in block D, but the erratic grades and low tonnage did not justify further exploration. Exploration for uranium in acid volcanics and carbonatites (blocks D, E and F) and uranium in Upper Proterozoic shales (block F) was discontinued due to low uranium levels in the trachytic basalts of Monduli juu, carbonatites of Galappo and Panda and copper bearing shales of Chimala.

Blocks A and B showed significant uranium mineralization, in keeping with the sandstone type in the Karoo system, which extends from southern Africa to Tanzania. In addition, these blocks contain calcrite type uranium mineralization. Block A, a Karoo basin located in the southern eastern part of the country, contained in excess of 3000 m of sediments, which were preserved in several NNE–NE striking half grabens or other structural basin conditions [102, 103]. They are all intracratonic basins, most of which filled with terrestrial sediments. Sedimentation commenced with glacigene deposits. These are of Late Carboniferous to Early Permian age and may be equated with other glacial successions in Africa and elsewhere in Gondwana. The glacigene beds are overlain by fluvial–deltaic coal bearing deposits succeeded by arkoses and continental red beds. In 1982, uranium exploration was stopped because of low uranium prices in the world market.

Interest in uranium exploration was rekindled after the rise of uranium prices in 2007, when the government granted over 70 uranium prospecting licences. The second exploration wave was centred in Manyoni and Bahi in central Tanzania and Mkuju River in southern Tanzania. Uranex NL and TanzOz Uranium Ltd performed extensive exploration in the Bahi and Manyoni uranium exploration sites, while Mantra Resources Ltd concentrated on the Mkuju River basin in the Karoo system in southern Tanzania.

The exploration and feasibility studies in the Bahi, Manyoni and Mkuju river uranium exploration projects identified several areas with potential low grade uranium deposits. Pre-feasibility studies of the Bahi and Manyoni deposits found that low surficial uranium processing was not economic. This finding pushed Uranex to move to the Mkuju river sandstone hosted uranium deposit for further exploration. Mantra Resources Tanzania Ltd concentrated on the Mkuju River project, located in the Selous Game Reserve, a classified United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site in the south of the country.

II.2. OVERVIEW OF THE MILESTONES ASSOCIATED WITH TANZANIAN URANIUM PROJECT

The uranium project at Mkuju River conforms to Milestone 2 of the Milestones Approach in the uranium production cycle (a country proposing to initiate or reinvigorate uranium mining, with known exploitable reserves). Mantra/Uranium One completed a definitive feasibility study at the end of 2013 and were granted a Special Mining Licence (SML) to commerce uranium mining. Historically, a SML is granted for large scale mining operations whose capital investment is more than US $100 million. The designed production as approved by the SML was 2300 tU per year.
II.2.1. Mkuju River project viability

The project was declared economically viable in early 2011 after the completion of a definitive feasibility study (DFS).

II.2.2. Stakeholder involvement

Mantra/Uranium One won strong support from the government because of the commitment of the operator to co-operate on social responsibility during uranium exploration. The operator also benefits from local support from the nearby village of Likuyu Sekamagananga and other villages surrounding the proposed mine area. The support is attributable to the well-developed corporate social responsibility (CSR) programme that is sensitive to local needs and is addressing various stakeholder groups with targeted activities and support. The operator has supported schools, healthcare, poaching prevention and small and medium scale enterprise (SME) development. During exploration, the operator used local suppliers for procurement, for example for poultry and other food produce. The operator employed over 90% of the semi-skilled labour from the region. A list of stakeholders for the uranium industry in Tanzania was carefully considered and a detailed stakeholder map was created (Fig. 11) that highlights both direct and indirect stakeholders associated with the industry.

![Stakeholder Map](image)

**FIG. 11.** The United Republic of Tanzania Uranium Project Stakeholder Map, with Project Task Force Membership (stakeholder meeting, Dar es Salaam, 29 May 2013).
Mantra/Uranium One has established a plan for infrastructure development in Likuyu-Sekamaganga and surrounding areas. The planned upgrades to address the infrastructure needs in a collaboration between the operator, the community and the district authorities are as follows:

— Development of a 10-year town master plan for Namtumbo district, which sets out new areas for residential expansion, transport hubs, industrial developments and community facilities, as well as services such as the new district hospital and the expansion of the police station;
— The government has upgraded the main road from Songea, Namtumbo to Mtwara and plans are in place to upgrade the road between Namtumbo, Likuyu-Sekamaganga and the site (with support from Mantra);
— Put in place water supply improvement projects to service a forecasted population of 50,000 (from current base of about 20,000):
— Intensify HIV awareness campaigns, macro and micro loan institutions;
— Development of agricultural projects to supply the mine with fresh food;
— Establish a new vocational education centre in Namtumbo;
— Allocate 150 ha in Likuyu-Sekamaganga for the mine village and associated infrastructure;
— Allocate land for a new police station;
— Develop supporting infrastructures, such as:
  (i) Water supply infrastructure;
  (ii) A new hospital and laboratory;
  (iii) Possible future electricity supply;
— Undertake other initiatives relating to community development, including:
  (i) Game scout patrols in the wildlife management area;
  (ii) 500 desks for secondary schools and 360 desks for primary schools in the area;
  (iii) Bursary support for 287 pupils to attend secondary school;
  (iv) Support for micro projects such as sewing of overalls, rearing of chickens, egg production and vegetable gardening.

II.2.3. Safety and radiation protection

Mkuju River Project (MRP) has established a system of safety and radiation protection for workers and visitors in accordance with established regulatory requirements, as stipulated in the Tanzanian national regulatory framework. The proponent has established radiation safety and protection in accordance with international guidelines, standards and recommendations to ensure thorough control practices and measures. Personnel, workers and members of the public visiting the site will not, as a result of the uranium mining and processing of uranium, surface storage of mined and processed at the site at Mkuju, be exposed to effective doses exceeding limits recommended by national laws and the International Commission on Radiological Protection (ICRP) [104].

II.2.4. Environmental and social impact assessment (ESIA)

According to the Environmental Management Act 2015, an environmental and social impact assessment (ESIA) is mandatory for large mining projects. An ESIA is an important document for building confidence regarding the project’s environment and social impact and is also a process that is required by the Ministry of Minerals to issue a mining licence. Normally, the proponent appoints a company registered by the National Environmental Management Council (NEMC) to perform the ESIA in areas covered by the proponent’s prospecting licence.
The process of conducting an assessment of the possible environmental and social impacts of the project consists of several stages, such as screening, scoping and preparation of terms of reference (ToR), conducting the environmental impact assessment, preparation of the environmental impact statement (EIS), preparation of the environmental management plan (EMP), stakeholder consultations and review. The stages lead to the ESIA report, which is audited by the appointed committee according to the Environmental Management (Impact Assessment and Audit) Regulations 2005. The audit committee report is submitted to NEMC. The audit report is normally used by NEMC for comment to the Minister of Environment in order to grant environment clearance.

For the Mkuju River project, the ESIA [105] was performed in full to ensure that the mining, production and associated activities are carried out in a manner that complies with the locally and internationally accepted best practices in environmental, health, safety and socioeconomic parameters. The objective of the ESIA for the proposed uranium mining was to identify the potential impacts and propose mitigation measures to ensure that the project is implemented within international environmentally acceptable standards.

II.2.5. Project timeline

The Mkuju River project is the most advanced uranium project in the United Republic of Tanzania. It was declared economically viable in early 2011 after a DFS [106]. The overall high level history of the resource progression is outlined in Table 6.
In 2012, Uranium One acquired a minority share in the Mkuju River uranium project and became the operator of Mantra Resources Tanzania Ltd. Mantra/Uranium One acquired a SML from the Ministry of Minerals in 2013. The construction was planned to commence in early
2014 and operation in 2015. However, a drop in the uranium spot price within the market forced the company to postpone the plan because the project became uneconomical.

Since 2013, the company has been maintaining the mine by continuing a reduced level of exploration activity (Fig. 12) and retrenching staff. In 2016 the company applied for a permit for care and maintenance from the Ministry of Minerals. The mine has followed the same trend as a number of uranium development projects across Africa, which were frozen and postponed, including activities in Namibia, Niger and Malawi (e.g. Trekkopje, Langer Heinrich (Namibia), Imouraren (Niger), Sonnia (Niger) and Kayelekera (Malawi)).

II.2.6. Anticipated economic impact of uranium project

In common with most global uranium producers, the United Republic of Tanzania does not have production facilities to support the complete nuclear fuel cycle (e.g. mining to conversion) and does not intend to have this processing capability. The domestically produced uranium ore concentrate will be solely for export to its current owner or to the world market in conformity with national and international laws and safeguards. The uranium is expected to generate benefits through payment of government taxes, royalties, increase of the employment rate and stimulation of the local economy, in particular within the Namtumbo District. Skills development will be a benefit both in the exploitation of uranium (the first mine of its kind in the country) and through fully transferable skills, such as natural resource project planning, management and regulation, stakeholder engagement, environmental and social impact assessments and strategic planning for sustainable development. In due course, Mkuju River will be the first uranium mine in the United Republic of Tanzania and will rank among the top 10 uranium deposits in the world. It is estimated that it will employ more than 700 workers when the operations start. Mantra/Uranium One has already invested over US $211 million for project development. An additional US $700 million is required for further development.
II.2.7. Government policy in the United Republic of Tanzania for uranium mining

The mining industry in the United Republic of Tanzania is governed by the minerals policy of 2009. The policy is anchored on the role of minerals to achieve the goal of a sustainable, integrated economy in the country in the coming 25 years. The aim of this policy is to continue to attract private companies to take the lead in exploration, mining, mineral beneficiation and marketing, with the purpose of increasing the mineral sector’s contribution to the national GDP and reducing poverty by integrating the mining industry into the national economy. Other objectives declared in the policy are as follows:

— To improve the economic environment in order to attract and sustain local and international private investment in the mineral sector;
— To promote economic integration between the mineral sector and other sectors of the economy;
— To strengthen the legal and regulatory framework for the mineral sector and enhance the capacity for monitoring and enforcement;
— To strengthen the institutional capacity for effective administration and monitoring of the mineral sector;
— To participate strategically in viable mining projects and establish an enabling environment for Tanzanians to participate in ownership of medium and large scale mines;
— To support and promote the development of small scale mining so as to increase its contribution to the economy;
— To establish transparent and adequate land compensation, relocation and resettlement schemes in mining operations;
— To strengthen the involvement and participation of local communities in mining projects and encourage mining companies to increase their corporate social responsibility commitments;
— To promote and facilitate value addition activities within the country to increase income and employment opportunities;
— To promote the research, development and training required in the mineral sector and encourage their utilization;
— To improve communication concerning the mineral sector with respect to the public through education and provision of accurate and timely information.

In early July 2017, the Government of the United Republic of Tanzania revised the mining laws to foster mine development in the country to allow the country to benefit more readily from its rich mineral wealth. Mineral royalty rates have been separated into two categories. For gemstones and diamonds the royalty rate increased from 5% to 6%. For metallic minerals such as gold, silver and copper the royalty rate also increased from 4% to 6%. In the Mining Act No. 14 of 2010 [107] uranium falls under energy minerals such as coal, for which the royalty rate is similar to metallic minerals at 6%.

The new regulations empower the government to renegotiate existing agreements as well as strike more advantageous new ones. The income legislation supersedes all other laws, such as the Mining Act, which provides for fiscal stability clauses. The revised laws are flexible to allow the government to convert tax expenditures resulting from stability agreements into equity holdings in a mining operation. The laws possess robust measures for the training of local staff. It also defines local stakeholders, requirements for insurance coverage, strict liability for environmental damage and provision for co-operative social responsibility expenditure.
II.2.8. National position on the milestones

The United Republic of Tanzania’s mining project at Mkuju River falls under Milestone 2 of the Milestones Approach in the uranium production cycle (the country is proposing to initiate or reinvigorate uranium mining, with known exploitable reserves). Mantra/Uranium One completed a definitive feasibility study at the end of 2013 and were granted a Special Mining Licence (SML) to commence uranium mining. Historically, a SML is granted for large scale mining operations whose capital investment is more than US $100 million. The intended production as approved by the SML is 2300 tU per year.

II.2.9. Uranium mining regulatory framework

II.2.9.1. Mining legislation and regulatory framework

According to the Mining Act No. 14 of 2010 [107] and the Atomic Energy Act No. 7 of 2003 [108], the Ministry of Minerals (MoM) was placed at the centre as the main regulator for all mining and related activities. The Act set up the legal framework governing mineral exploration and exploitation in the United Republic of Tanzania, advocating the general principles, authorization requirements, administrative measures, royalties, fees and other charges applicable to mining activities, the reporting requirements and other related provisions. However, the Mining Act also regulates radioactive minerals, including uranium, which are classified as ‘energy minerals’, defined in section 4(1) as “a group of minerals comprising of coal, peat, uranium, thorium and other radioactive minerals”. Radioactive minerals are defined in section 108(4).

The MoM regulated uranium mining by issuing the prospecting licence (PL) and later a SML that allows the operator to start uranium mining and processing. Further, on behalf of the Government, it negotiates and agrees with the operator on how the Government will be compensated based on royalties and taxes. This is well defined in the Mining Development Agreement (MDA).

II.2.9.2. Environmental legislation and regulatory framework

Environmental regulatory control for the uranium mining industry is governed by the Environmental Management Act, 2004 (EMA). The law establishes the legal and institutional framework for sustainable management of the environment, giving the principles for environmental management, and the requirements for impact assessment, prevention and control of pollution, waste management, environmental quality standards, public participation, compliance and enforcement. The objective of the EMA is to provide for and promote the enhancement, protection, conservation and management of the environment.

The National Environmental Management Council (NEMC) issues environmental clearance if the project qualifies after an environmental and social impact assessment (ESIA) has been performed and audited. NEMC also performs routine environmental inspections to ensure that the mines conform to environment requirements and standards.

II.2.9.3. Nuclear legislation and regulatory framework

The Atomic Energy Act established the Tanzania Atomic Energy Commission (TAEC) as the nuclear regulatory body, prescribing its functions in relation to the control of ionizing radiation in order to protect the people and the environment from the harmful effects of ionizing radiation. The Act was revised in 2017 to incorporate the updated international safety standards and the IAEA recommendations following the 2013 Uranium Production Site Appraisal Team (UPSAT) mission and the 2015 Integrated Regulatory Review Service (IRRS) mission.
recommendations [79]. The revision of the Act has been conducted in line with the national policies on nuclear law. The Atomic Energy (Radiation Safety in the Mining and Processing of Radioactive Ores) Regulations, 2011 provide the regulatory framework for radiation safety in the uranium mining industry. The Regulations include provisions for radioactive waste management, including guidelines for the development of a radioactive waste management plan by the operation licence holders, the observance of the Radioactive Waste Management for the Protection of Human Health and Environment Regulations, and the storage of radioactive waste and tailings from processing facilities designed and constructed to offer maximum containment. Other regulations that are under revision for the control of the uranium mining life cycle include the following:

— The Atomic Energy (Radioactive Waste Management) Regulations, 2019;
— The Atomic Energy (Protection from Ionizing Radiation) Regulations, 2019;
— The Atomic Energy (Packaging and Transport of Radioactive Material) Regulations, 2019;
— The Atomic Energy (Security of Radioactive Sources) Regulations, 2019;
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[72] AUSTRALIA SECURITIES EXCHANGE, Listing Requirements.


[105] MANTRA RESOURCES TANZANIA LTD, Environmental and Socio-Economic Impact Assessment, Mantra, Dar Es Salaam (2010).
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AEB</td>
<td>Atomic Energy Board of Namibia</td>
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<tr>
<td>ALARA</td>
<td>as low as reasonably achievable</td>
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<td>CIM</td>
<td>Canadian Institute of Mining</td>
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<td>COMINAK</td>
<td>Compagnie Minière d’Akouta</td>
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<td>CRIRSCO</td>
<td>Combined Reserves International Reporting Standards Committee</td>
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<td>CSA</td>
<td>comprehensive safeguards agreement</td>
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<td>CSR</td>
<td>corporate social responsibility</td>
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<td>DFS</td>
<td>definitive (or detailed) feasibility study</td>
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<td>EIS</td>
<td>environmental impact study</td>
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<td>EMA</td>
<td>environmental management act</td>
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<td>EMP</td>
<td>environment management plan</td>
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<td>EQO</td>
<td>environmental quality objective</td>
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<td>ESIA</td>
<td>environmental and social impact assessment</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>GNG</td>
<td>greenhouse gas</td>
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<td>HSE</td>
<td>health, safety and environment</td>
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<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<td>ICMM</td>
<td>International Council on Mining and Metals</td>
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<td>IFRS</td>
<td>international financial reporting standards</td>
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<td>INFCIRC</td>
<td>International Atomic Energy Agency Information Circular</td>
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<td>IRRS</td>
<td>Integrated Regulatory Review Service</td>
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<td>ISO</td>
<td>International Standards Organization</td>
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<td>IUREP</td>
<td>International Uranium Resources Evaluation Project</td>
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<td>JORC</td>
<td>Joint Ore Reserves Committee</td>
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<td>LHUM</td>
<td>Langer Heinrich uranium mine</td>
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<td>LSA</td>
<td>low specific activity</td>
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<td>MDA</td>
<td>Mining Development Agreement</td>
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<td>MEM</td>
<td>Ministry of Energy and Minerals (Tanzania)</td>
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<td>MLEYD</td>
<td>Ministry of Labour, Employment and Youth Development (United Republic of Tanzania)</td>
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<td>MoWI</td>
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<td>ML</td>
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<td>MoU</td>
<td>Memorandum of Understanding</td>
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<td>Acronym</td>
<td>Definition</td>
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<td>MRP</td>
<td>Mkuju River Project</td>
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<td>NAOT</td>
<td>National Audit Office of Tanzania</td>
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<td>NEA</td>
<td>Nuclear Energy Agency</td>
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<td>NEMC</td>
<td>National Environmental Management Council</td>
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<td>National Occupational Safety Association</td>
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<td>NPT</td>
<td>Treaty on the Non-Proliferation of Nuclear Weapons</td>
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<td>NRPA</td>
<td>National Radiation Protection Authority</td>
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<td>OSHAS</td>
<td>Occupational Health and Safety Assessment Series</td>
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<td>SAMREC</td>
<td>South African Mineral Resource Committee</td>
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<td>South African National Standard</td>
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<td>SDG</td>
<td>sustainable development goal</td>
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<td>SEA</td>
<td>strategic environmental assessment</td>
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<td>SEMP</td>
<td>strategic environmental management plan</td>
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<td>SLO</td>
<td>social licence to operate</td>
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<td>SME</td>
<td>small and medium sized enterprises</td>
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<td>SOE</td>
<td>state owned enterprise</td>
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<td>SOMAIR</td>
<td>Société des Mines de l’Air</td>
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<td>SOMINA</td>
<td>Société des Mines d’Azelik</td>
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<tr>
<td>SSAC</td>
<td>State System of Accounting for and Control of Nuclear Material</td>
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<td>Surface and Marine Transport Regulatory Authority (United Republic of Tanzania)</td>
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<td>UDEPO</td>
<td>World Distribution of Uranium Deposits</td>
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<td>United Nations Framework Classification</td>
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<td>UOCs</td>
<td>uranium ore concentrates</td>
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<td>UPSAT</td>
<td>Uranium Production Site Appraisal Team</td>
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<td>WNA</td>
<td>World Nuclear Association</td>
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CONTRIBUTORS TO DRAFTING AND REVIEW

Abbes, N.  Groupe Chimique Tunisien, Tunisia
Blaise, J.R.  International Atomic Energy Agency
Brown, G.  Boswell Capital Corporation, Canada
Dunn, G.  Hydromet Pty Ltd, South Africa
Edson, K.  Consultant, United States of America
Hama Siddo, A.  Ministry of Mines and Energy, Niger
Hanly, A.  International Atomic Energy Agency
Hilton, J.  Aleff Group, United Kingdom of Great Britain and Northern Ireland
Itamba, H.  Ministry of Mines and Energy, Namibia
Lazykina, A  International Atomic Energy Agency
Lopez, L.  National Atomic Energy Commission (CNEA), Argentina
Moldovan, B.  International Atomic Energy Agency
Mwalongo, D.  Tanzania Atomic Energy Commission, United Republic of Tanzania
Roberts, M.  International Atomic Energy Agency
Schneider G.  Namibian Uranium Institute, Namibia
Scissions K.  KHS Solutions, Canada
Woods, P.  International Atomic Energy Agency

Consultants Meetings

Vienna, Austria: 12–14 December 2016; 4–7 September 2017