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Socio-economic and other non-radiological impacts of the near surface disposal of radioactive waste

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FOREWORD

The International Atomic Energy Agency (IAEA) has, since its inception, recognized the importance of radioactive waste management. Low and intermediate level radioactive wastes are produced in almost all countries and their safe management is of great importance. Near surface disposal of the wastes is an option being currently practised or planned in many countries. There is a growing need in various countries for additional information and guidance in all aspects of this disposal system.

To address the needs of Member States, the IAEA has issued a series of technical reports and documents dealing with different aspects of the near surface disposal of radioactive waste, in particular the underlying scientific and technical issues that are important in repository development and radiological safety. However, it is now recognized that many non-radiological and non-technical factors and issues are also important in the repository development and implementation process from the initial planning stage. Thus, it was considered important and timely to prepare a report that covers the various non-radiological aspects of the near surface disposal of radioactive waste.

This report discusses the various socio-economic and other non-radiological impacts that could be associated with the near surface disposal of radioactive waste, and is intended to fill an existing gap in the IAEA's publications in the area of the management of low and intermediate level radioactive waste.

It is anticipated that the report will be particularly useful to managers and decision makers in Member States that are in the relatively early stages of a repository development programme.

The IAEA wishes to acknowledge the contributions made by the participants of the three consultants meetings convened during the period August 2000–March 2002. R. Dayal of the Division of Nuclear Fuel Cycle and Waste Technology was the responsible officer at the IAEA.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

Low and intermediate level wastes (LILW), derived from both nuclear power and nuclear applications, are currently in interim storage in many countries that have no operating disposal facilities. In many Member States, the preferred option for the long-term management of LILW is disposal in surface or near surface facilities with varying levels of engineering, including placement in mined or natural cavities some tens of metres below the surface. Many such facilities are now in operation, proposed for approval, or in the conceptual planning phase [1].

Recognizing the varying stages of repository development and implementation in the various countries and the needs of Member States that are in the conceptual planning stage of establishing disposal facilities, the International Atomic Energy Agency (IAEA) is developing a series of technical reports and documents dealing with specific technical and scientific issues relevant to repository development and repository safety assessment.

The importance of the underlying scientific and technical issues in support of repository development and radiological safety to the disposal of LILW has long been recognized. It is now also clear that many non-radiological factors and issues are also important in the repository development and implementation process from the initial planning stage. In a number of Member States, such considerations are addressed as part of the environmental impact assessment and approvals process for the repository.

Given this background, it was considered important and timely to prepare a technical report that addresses an existing gap in the IAEA’s activities in the LILW disposal area, namely the socio-economic and non-radiological environmental impacts of near surface disposal. For the purposes of this report, environmental impacts do not include radiological impacts on the natural and human environment or impacts from chemical or other toxic substances. These issues are addressed in separate IAEA documents (for example Refs [2–8]).

It is anticipated that this report will be particularly useful to managers and decision makers in Member States that are in the relatively early stages of a repository development programme. The report may also be of interest to government officials (national, regional and local), industry, trade and environmental organisations, indigenous people, other interest groups and members of the general public interested in the potential impacts associated with near surface disposal throughout the repository life cycle.

1.2. OBJECTIVE

The objective of this report is to introduce, in a generic sense, the elements that could comprise a socio-economic and non-radiological environmental impact assessment. The various social, economic and environmental impacts that could be associated with surface and near surface disposal are discussed through factors that could apply at the local, regional or national level. Impact management is also discussed. The report also introduces concepts to help Member States develop their own approaches to undertaking impact assessment and management.

The report is intended to complement IAEA documents on the technology and safety aspects of the near surface disposal of radioactive waste.

1.3. SCOPE

The scope of this report includes a discussion of a range of social, economic and non-radiological environmental impacts relevant to surface and near surface disposal and illustrations of some impact management measures, but does not include a description of specific assessment methods.

The discussion of socio-economic and other non-radiological impacts in this report is relevant to facilities ranging in size from small repositories taking medical or other institutional waste to large facilities intended primarily or solely for LILW from power plants. Although potential impacts may be significantly lower in magnitude for the former, impact assessment is still relevant to these facilities and needs to be addressed at an appropriate level of detail.

It is recognized that individual Member States will need to evaluate socio-economic and environmental considerations in repository development and operation in the context of their own situations. The report does not present specific "case study" experiences of Member States that have gone through a siting process.

Radiological impacts associated with near surface repository development and operation and specific methodologies for assessing individual impacts are not discussed in this report. Potential impacts associated with the disposal of high level waste and long lived low and intermediate level waste in geological repositories and remediation of contaminated sites are also outside the scope of this report.

1.4. STRUCTURE

Section 2 of the report describes the different phases of the repository life cycle. This discussion covers the period from initial planning, through siting, project review and approval, construction, operation, closure, and active post-closure institutional control. Section 3 discusses national policy, public involvement and cost considerations. Section 4 describes potential impacts on the natural and human environment at the local community, regional and national levels. Potential impacts that may occur during the various stages of the repository life cycle are also discussed. Section 5 describes illustrative examples of impact management measures. A process flow diagram for the impact assessment and management process is presented. The main conclusions of the report are presented in Section 6.

2. REPOSITORY LIFE CYCLE

2.1. INTRODUCTION

This section provides an overview of a generalized sequence of events that make up the life cycle for a surface or near surface disposal facility. Waste intended for disposal in near surface repositories will generally be predominantly short lived, i.e. the hazard will reduce to radiologically safe levels during the period of post-closure institutional control.

These wastes are derived primarily from the operation and decommissioning of nuclear power plants and/or research reactors and cyclotrons, and from various medical, industrial and research applications of radioactive materials. Waste may include lightly contaminated laboratory equipment and materials such as paper, plastics, protective garments and glassware, contaminated hand tools, ion exchange resins and other reactor coolant system filtration wastes, contaminated piping, biological wastes, smoke detectors, luminous watch dials, exit signs, lightning rods, well-logging devices and sealed sources from various industrial, medical or research applications of radioactive materials.

For the purposes of this report, 'surface' and 'near surface' disposal includes two main types of disposal systems: (a) shallow facilities consisting of disposal units located either above (mounds, etc.) or below (trenches, vaults, pits, etc.) the original ground surface; and (b) facilities where the waste is emplaced at greater depths in rock cavities. In the first case, the thickness of the cover over the waste is typically a few metres, whereas, in the second case, the layer of rock can be can be some tens of metres thick [9]. Examples of the former that are currently in operation include Centre de l'Aube in France, El Cabril in Spain, Drigg in the United Kingdom, Rokkasho in Japan, Richland and Barnwell in the USA, Dukovany in the Czech Republic, and Vaalputs in South Africa. Repositories developed in mined caverns include Forsmark in Sweden and Olkiluoto and Loviisa in Finland [1, 10].

The disposal facility will normally comprise areas for waste emplacement, buildings and services for waste receipt and (in some cases) for waste processing. The design and layout of the site will vary depending on the type, characteristics and quantities of waste for disposal, and on the site characteristics. The basic objective of a repository development process is to identify a suitable site for disposal, and to demonstrate that this site, together with the waste package requirements and the repository design, is capable of providing adequate isolation of radionuclides [10].

A description of a generalized repository life cycle, based on those currently being employed in certain Member States, is given below.

2.2. THE REPOSITORY LIFE CYCLE

For the purposes of this document, the repository life cycle is divided into a number of phases. These phases apply regardless of the nature and size of the planned repository. The phases include:

4 Planning and siting phase: Conceptual repository design, siting and process planning, public involvement, environmental impact studies and impact management planning;

4 Review and approval phase: The review of the repository design engineering, environmental impact assessment, safety analysis for the purposes of approval and licensing, and adoption of impact management plan;

4 Construction phase: Repository and related infrastructure construction and impact management implementation, including community liaison;

4 Operation phase: Waste acceptance and emplacement in the repository and impact management implementation, including community liaison;

4 Closure phase: Final repository sealing and removal of disposal support structures and impact management implementation, including community liaison; and

4 Post-closure institutional control phase: Environmental monitoring, surveillance and site maintenance with restricted access to the site.

2.2.1. Planning and siting phase

The planning phase includes a broad examination of a number of alternative disposal options and facility design concepts. This examination generally includes studies of waste form and packaging, waste emplacement methodology and possible retrievability options, transportation access options, closure, and institutional control and project financing arrangements. The repository design will typically be developed in sufficient detail to provide a framework for the siting process, while retaining flexibility to accommodate the specific characteristics of the site eventually selected for development.

Repository siting encompasses the process of identifying one or more candidate sites for repository development. During this phase, a broad range of criteria may be used to identity suitable sites potentially capable of meeting national policy objectives and specific project approval criteria and requirements, as well as scientific and technical requirements. The range of criteria employed generally include aspects of both the natural and human environment.

The conceptual design provides a basis for informing and involving interested parties in the repository project. Some Member States have initiated public involvement programmes during the siting phase and some have invited interested communities to volunteer for siting related activities. Others have sought input from local communities on the suitability of potential sites previously identified through the application of site screening criteria.

Familiarity with nuclear operations because of an existing nuclear facility in a local community or region may be an important factor in siting a new repository. Some Member States have adopted an approach that involves co-locating a new repository near an existing nuclear facility, such as a nuclear power plant. The co-location option may accelerate the repository development process, while minimising project costs and non-radiological impacts.

During the siting phase, the organisation responsible for proposing a repository may initiate the study of non-radiological impacts. This is the case in most Member States. Plans for addressing potential adverse impacts may also be developed during this phase. Design development, safety assessment and impact assessment will occur in parallel and be iterative throughout the siting process.

The time-frame for completion of the planning and siting phase depends on the process adopted by the Member State to identify a proposed site for review and approval. Experience indicates that this phase typically requires several years or more depending on the potential need to adapt the planning and siting process to new policy and planning developments and the approach to obtaining public acceptance.

Prior to the completion of the siting phase, the responsible organisation documents the detailed design of the facility, the safety analysis, and the socio-economic and environmental impact assessment for review.

2.2.2. Review and approval phase

During this phase, the reviewing agency or agencies evaluate the documentation detailing the design of the facility and the safety analysis, and the environmental impact assessment and considers it for approval and licensing. Reviewers could include relevant government regulatory bodies, such as planning authorities, radiological, health and safety, environmental regulatory agencies and others as specified in national legislation.

The reviewers may also prepare independent non-radiological impact studies in certain cases. The review process may include an opportunity for participation by interested individuals and groups in the local community and the general public through formal public hearings or other mechanisms intended to obtain public comment, e.g. by inviting written submissions. The overall aim of such processes is to receive and respond to public input and ultimately to achieve a final proposal that carries broad public acceptance.

Approvals may include certain conditions to repository development to manage adverse impacts. Experience indicates that the review and approval phase typically lasts several years or more based on the issues to be resolved, Member States' institutional frameworks, and the nature and extent of participation by interested parties.

2.2.3. Construction phase

During this phase, the approved repository is constructed at the selected site, subject to conditions arising from the review and approval process. The conditions may include requirements to address safety, socio-economic and environmental impacts. The organisation responsible for proposing a repository implements the impact management plan developed during the planning and siting phase.

The duration and types of activities and numbers of workers involved will depend on facility design. During the construction phase, public involvement activities generally continue, including community liaison. This phase typically involves greater schedule certainty than the planning, siting and project approval phases, and is the shortest in duration. While the specific time frame will be largely dependent on the repository engineering design and location, this phase may be completed in a year or less for some surface facilities.

Construction may also be accomplished in separate stages as initially constructed disposal units are filled with waste and new units are built as the need for additional disposal capacity arises. This approach may offer economic advantages by reducing the capital costs required to begin initial operations.

2.2.4. Operation phase

The operation phase comprises waste acceptance and emplacement in the repository. The skill types and numbers of workers employed during repository operation may be different than during the construction phase and will be dependent on facility design. Impact management activities continue. Activities associated with public involvement generally continue throughout this phase, including community liaison. The operation phase extends from the time construction is completed and approval is received to begin accepting wastes until waste emplacement operations cease and the repository is prepared for final closure. Typically, this phase can extend for tens of years.

2.2.5. Closure phase

A disposal facility will normally cease waste emplacement operations when it has reached its maximum design capacity, in terms of waste volume or radionuclide inventory. In cases where the Member State institutional framework specifies an additional safety assessment, an additional review and approval process may be necessary prior to beginning shutdown and closure work. The closure phase includes the application of final cover materials and removal of disposal support structures. The amount of work and number of facility workers required to accomplish closure is dependent on the size and type of repository and the nature of the waste disposed. Impact management activities and community liaison generally continue. Informing and involving the public in the repository closure decision is an important consideration.

The duration of the closure phase is influenced by the extent of closure activities required, and the length of time needed to determine that the intended objectives have been accomplished. The closure process may last several years or longer.

2.2.6. Post-closure institutional control phase

The post-closure institutional control phase begins upon completion and regulatory body approval of closure work. Typically, Member State authorities specify institutional and financial arrangements to ensure that environmental monitoring, periodic surveillance and site maintenance activities are carried out. Access to the site is typically restricted during this phase. The length of the institutional control period and the extent of monitoring are based on the type and amount of waste disposed, and on the repository design. Community input may also be relevant to defining the post-closure programme. The period of institutional control may range from decades to several hundreds of years, depending on the nature of the disposed waste and on the type of facility.

3. NATIONAL POLICY, PUBLIC INVOLVEMENT AND COST CONSIDERATIONS

3.1. NATIONAL POLICY CONSIDERATIONS

National policy in the area of radioactive waste disposal stems from the Member State’s responsibility to isolate wastes from the human and natural environment in a safe and effective manner. The IAEA has established a framework of general principles to assist Member States in developing their respective legal frameworks for the establishment of radioactive waste repositories. An underlying principle is to avoid imposing undue burdens on future generations. Relevant IAEA safety guidelines and requirements are documented in Refs [2–8].

Guiding principles for radioactive waste disposal are included in the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* [11]. These principles cover the siting, design, safety assessment, construction, operation, closure and post-closure institutional control phases. The Joint Convention requires that safety and environmental assessments be conducted as appropriate, including making relevant safety information available to members of the public.

In many Member States, the process of policy development and siting involves identification and assessment of various options for waste management, culminating in selection of the preferred option. This may include choices between above ground storage facilities, and repositories developed on or near the ground or in existing or specially excavated caverns. Information on alternative management concepts and repository designs is given in Refs [12–16]. The approach adopted for public involvement and socio-economic and environmental impact assessment of the options is an individual Member State policy consideration, and in some Member States is addressed in national legislation.

3.2. PUBLIC INVOLVEMENT CONSIDERATIONS

The nature and extent of public involvement and participation varies among Member States, depending upon existing legal and political frameworks and cultural context. There are, however, a number of basic concepts that have general application (see for example Refs [17–21]).

Recent experience suggests that broad public acceptance will enhance the likelihood of project approval. An important element in creating public acceptance is the perceived trust and credibility of the responsible organisation and of the reviewing agency or agencies. Establishing trust can be enhanced when an inclusive approach to public involvement is adopted from the beginning of the planning process to help ensure that all those who wish to take part in the process have an opportunity to express their views, and have access to information on how public comments have been considered and addressed. Experience further suggests that trust is promoted by providing open access to accurate and understandable information about the development programme, conceptual design and the siting process at different levels of detail suitable for a broad range of interested parties. The transparency and traceability of the decision-making process is important. In addition to the perceived trust and credibility of the responsible organisation, other aspects of public acceptability can be location-specific, based on local requirements and cultural context.

The audiences for public involvement activities may include representatives from local communities, administrative units (e.g. national, regional and local), government officials, indigenous peoples where appropriate, regulatory agencies, community and public interest groups, environmental organisations, industry and trade groups, the scientific community and the news media. Different audiences may be involved through the various phases of the repository life cycle and be drawn from the local, regional or national levels, as appropriate. For example, during the development of national policy, the relevant audience may be the entire general public within the Member State.

As the process moves forward into more-focused siting activities, the issues may become more narrowly defined, as alternatives are considered and a specific site is proposed. At this time, interest may be focused on the communities located nearest to the proposed site as well as communities bordering that location. Communities along transport routes may also indicate interest. Significant levels of interest may exist at regional and national levels throughout the project development phase. Interest may also extend to neighbouring countries, as mandated under a number of international treaties and conventions, particularly if the proposed facility is located near an international border.

It may be useful to invite submission of questions and comments to the responsible organisation on a continuing basis as an element of a public involvement process. Maintaining a record of such submissions, including actions or responses, will help to document the process. This record should be accessible to regulatory agencies, other decision makers, interested parties and the general public.

As noted earlier in this report, formal public involvement mechanisms, such as public hearings or written submissions, may be part of the regulatory review and approval phase. To facilitate this information exchange and the public comment and response process, some Member States make independent information available to participating individuals and groups. In some cases, this has involved the participation of independent experts to review documents and data provided by the developer.

In some Member States, committees representing a range of local community interests (e.g. local government, schools, business and environmental groups, and interested citizens) have been formed to assist impact assessment and impact management planning activities. Experience suggests that these local committees may have continuing value during the repository construction and operation phases to help with the implementation of the impact management measures. Other potential functions include monitoring-related repository operations and serving as an independent information source to interested parties.

3.3. COST CONSIDERATIONS

For the purposes of this report, cost refers to direct expenditures during all repository life cycle phases. The costs of establishing a national policy framework and subsequently siting, developing, operating and closing a repository can be significant, regardless of repository size [22]. These include applicable costs for public involvement, non-radiological impact assessment and impact management.

An important aspect of national policy development is the identification of repository financing sources, and determining how funds will be provided during each repository life cycle phase. Different Member States have adopted varying approaches to repository financing, covering a spectrum from full government funding to full cost recovery from the waste producers utilising the repository [23]. These decisions will influence the ultimate cost to users of the repository. Financial constraints may influence the timing of repository development, and the possible need to rely on short- or long-term storage as an on-going management option. For planning purposes, it is important that all relevant costs be considered.

Funding of closure and post-closure institutional control activities is another important cost consideration. In some Member States, the repository programme is required to set aside funds during operations to pay for repository post-operational expenses. These financial reserves may be collected as repository user fees and set aside in an interest-bearing account dedicated for this future use.

Funding requirements may be increased significantly if the repository development process is delayed during the siting and review and approval phases. Experience suggests that effective public involvement and impact assessment and management may help prevent the delay of repository development and reduce associated costs by facilitating acceptance of the disposal facility.

4. POTENTIAL IMPACTS DURING THE REPOSITORY LIFE CYCLE

4.1. INTRODUCTION

A broad range of socio-economic and other non-radiological impacts may arise during the repository life cycle. The type and magnitude of impacts relevant to a specific repository project will be influenced by the size and location of the repository, the types and amounts of waste to be accepted, the specific repository technology selected, the number of workers employed, specific community characteristics, proximity to populated areas and existing and future land uses, as well as other project and Member State specific requirements and circumstances. Impact assessment is, however, applicable to all facilities regardless of repository size.

The purpose of this section is to introduce the elements that could comprise an impact assessment and to discuss a range of social, economic and environmental impacts at the local, regional or national levels that could be associated with the life cycle of the near surface disposal of low and intermediate level waste.

4.2. ELEMENTS OF IMPACT ASSESSMENT

For the purpose of this report, the term ‘environment’ may be considered to include human, biota, abiota, physical surroundings and their interactions. This term may be defined within the framework of Member States’ national laws and is also addressed in international legal instruments [24]. Repository development (all life cycle phases) can result in changes, both positive and negative, both significant and not significant, to the natural and human environment. For the purpose of this report, impact assessment is considered to be a process used to identify and evaluate those potential changes in order to manage the impacts and to meet the requirements of relevant authorities. Impact assessment may also enhance repository acceptability to both the affected public and the regulatory authorities. In this report, socio-economic and environmental impacts are considered and are taken to mean impacts to the human and to the natural environment.

The scope of this report does not include the description of a specific method for the assessment of impacts. The reference section at the end of this report cites guidance documents on impact assessment methodologies developed by other organisations, as given in Refs [25–29]. For the purpose of this report, impact assessment is considered to comprise a systematic approach that includes characterising the nature of the project and profiling baseline conditions (the conditions existing prior to the repository development process) as a basis for the prediction and evaluation of potential impacts. The report presents a set of factors and indicators that are used to characterise baseline conditions and to discuss a range of potential socio-economic and environmental impacts. In some Member States, scoping of potential issues is initiated at the beginning of an impact assessment process to focus the work. This step is not described here.

The set of factors identified in this report are drawn from experience in Member States with large repository projects and well-developed nuclear power programmes. For smaller repository facilities, it is important to develop an approach to impact assessment in the context of local circumstances.

As mentioned above, a step in the systematic approach to assess impacts is describing the project characteristics because they can affect the local and regional community. Project characteristics usually include the number and skills of the required workforce, the duration and scope of the work required, the anticipated project spending, any infrastructure and off-site service requirements including land requirements and access routes, the physical attributes of the project including noise, dust, traffic levels and visual characteristics and the nature of the risk associated with the project. How the public understands the risk, especially regarding projects involving radioactive waste, may be a source of socio-economic impacts.

4.3. BASELINE SETTING

Accurate information, establishing the baseline setting, forms the basis for identifying and assessing potential repository life cycle impacts. For the purpose of this report, factors (e.g. built environment) and indicators (e.g. transportation network) are used to characterise the natural and human environment. These factors and indicators are addressed below and in Table 1.

4.3.1. Natural environment

For the factor ‘natural environment’, the indicators include land resources, ecologically sensitive areas, air quality, groundwater and surface water resources, the biota in the vicinity of the facility, visual landscape and historical or archaeological sites. Numerous methodologies exist for determining baseline conditions at a site, including baseline studies which could comprise site geology, hydrogeology and hydrology, plant and animal surveys, as well as review of land and water resources, including any existing contamination, in the potentially affected area. The impacts on the natural environment occur primarily at the local level.

4.3.2. Human environment

4.3.2.1. Social conditions

The factor ‘social conditions’ includes the indicators demographic, social structure, community character and community health. In some Member States, baseline conditions for these indicators would include specific consideration of potentially affected indigenous communities. A demographic study of population characteristics in the repository area and in the nearby region typically serves as a baseline for measuring future impacts. This study may include details of residential and transient populations, and projected population growth. Social structure can include the make up and organisation of the community. Community character can include culture, cohesion, and community stability. Changes to community health can result from project-related activities in the community. The perception of risk and stress-related or psycho-social health impacts may be considered in this context. Impacts associated with social conditions arise primarily at the local level.

4.3.2.2. Economic conditions

The factor ‘economic conditions’ comprises employment and labour supply and local economy. Employment and labour supply may include workforce participation rates, skill types, wage rates, trade union representation and unemployment levels. Local economic activities may include a description of local business activities including tourism, revenue and

TABLE 1. POTENTIAL IMPACTS AT LOCAL, STATE AND REGIONAL LEVELS

Impact factors	Level of potential impact		
	National	Regional	Local
Natural environment Land resources			x
Ecologically sensitive areas		x	x
Air quality			x
Groundwater resources			x
Surface water resources		x	x
Biotic resources			x
Visual landscape			x
Historical or archaeological sites			x
Social conditions Demographic			x
Social structure			x
Community character			x
Community health			x
Economic conditions Employment and labour supply		x	x
Local economic activity		x	x
Built environment Housing			x
Education			x
Transportation network		x	x
Community services			x
Utility availability			x
Land use Park and recreational lands			x
Development plans		x	x

sales and business development opportunities. In some Member States, baseline information for economic conditions are developed specifically for potentially affected indigenous communities. Impacts on economic conditions may occur at local and regional levels.

4.3.2.3. Built environment

The factor 'built environment' includes the indicators of housing, education, transportation network, community services and utility availability. This factor comprises any man-made structures and features resulting from human activities in the vicinity of the disposal facility. These structures and features may include buildings, roads, dams and bridges, gas and electric transmission pipelines and cables and telephone lines. Housing includes availability and type of housing stock and market values. Education includes an inventory of locally-available schools and facilities.

The transportation network connecting waste producers, waste storage facilities or intermediate waste processors with the proposed disposal site is relevant at the local, regional and potentially national level. Where the repository is near or adjacent to a larger nuclear facility (e.g. a nuclear power plant or waste storage site), the necessary transportation network will already exist. Community services include social services, health and safety services and other community services and facilities. In some Member States, baseline information for the built environment may be included specifically for potentially affected indigenous communities. Impacts on the built environment may occur primarily at the local level, but may extend to the regional level in case of transportation.

4.3.2.4. Land use

The factor ‘land use’ includes the indicators park and recreational lands and development plans. The latter may include existing land uses and plans at various administrative levels concerning intentions about future uses of land. Ownership of land or mineral rights may be important baseline factors. In some Member States, the repository and surrounding land must, by law, be developed on government-owned land. In some Member States, indigenous peoples may be accorded ownership or other rights over certain lands by law. This may limit or eliminate the eligibility of potentially suitable areas for repository development. The factor ‘land use’ is primarily of local character, but may extend to the regional level.

4.4. POTENTIAL IMPACTS

4.4.1. Introduction

The degree and extent of potential impacts will vary depending on the phase of the repository life cycle. The greatest overall impacts generally occur during the construction, operation and closure phases. The following sections discuss a range of potential adverse and beneficial impacts occurring in the natural and human environments during the various repository life cycle phases. These potential impacts during the life cycle phases are summarized in Table 2. Illustrative measures to address impacts are discussed in the following section.

4.4.2. Natural environment

Land resources: A repository project may require excavation of soils or aggregate for disposal facility or road construction, or materials for cement batch plant operation if required by the design, waste cover material, disposal unit capping, and closure phase stabilisation. These materials may be obtained from on-site or off-site sources, resulting in some impact at these sources. This displacement of existing land resources may result in socio-economic impacts. Such impacts typically occur during the construction, operation, closure and post-closure phases.

Ecologically sensitive areas: Areas identified as ecologically sensitive, such as the habitat of rare or protected plant or endangered animal species or special wetlands, may be affected by repository development, including the potential for erosion of disturbed soils. These impacts may include loss of habitat, or disruption to species feeding or migration patterns. Ecosystems exhibiting special or unique biological diversity may also be considered sensitive. Such impacts typically occur during the construction and operation phases.

TABLE 2. POTENTIAL IMPACTS DURING REPOSITORY LIFE CYCLE PHASES

Impact factors	**Repository life cycle phases**					
	Siting	Review/ Approval	Con- struction	Opera- tion	Closure	Post- closure
Natural environment Land resources			x	x	x	x
Ecologically sensitive areas			x	x		
Air quality			x	x	x	
Groundwater resources			x	x	x	x
Surface water resources			x	x	x	
Biotic resources			x	x	x	x
Visual landscape			x	x	x	x
Historical or archaeological sites	x	x				
Social conditions Demographic			x	x	x	
Social structure			x	x	x	
Community character	x	x	x	x	x	
Community health	x	x	x	x		
Economic conditions Employment and labour supply			x	x	x	
Local economic activity			x	x	x	
Built environment Housing	x		x	x	x	
Education			x	x	x	
Transportation network			x	x	x	
Community services			x	x	x	
Utility availability			x	x	x	
Land use Park and recreational lands			x	x	x	
Development plans	x	x	x			x

Air quality: Generation and dispersion of dust from increased vehicle traffic, especially during repository construction, may reduce visibility, relative to baseline levels, and, together with combustion engine emissions, may affect ambient air quality. These impacts may affect the human environment and, typically, arise during the construction phase and, to a much lesser extent, during operation and closure phases.

Groundwater resources: Groundwater may be withdrawn to meet repository infrastructure water requirements, potentially including dust control, cement batch plant operation, waste container grouting, drinking water, or septic system or sewers. Groundwater withdrawals may affect well usage, springs or wetlands in the vicinity of the repository. The repository may also potentially adversely impact groundwater quality (in the event of contamination from the waste), affecting possible future uses. These impacts may also affect the human environment. Typically, these impacts arise during the construction and operation phases and, to a lesser extent, during closure and post-closure.

Surface water resources: Engineered stormwater control features may, depending on facility location and design, contribute effluent to surface water bodies or drainage systems and may cause erosion. Surface water resources may also be utilized for repository infrastructure requirements. The surface water requirements for the repository may also have an impact on the human environment. These impacts typically arise during the construction and operation phases and, to a lesser extent, during closure.

Biotic resources: A repository project involves removal of some land area from the baseline plant (flora) and animal (fauna) habitat. This may affect species present on or near the repository site and along transport routes to the repository. For wildlife, impacts extend to the home range of movement of the affected species, e.g. feeding and movement territories. Repository impacts on surface or groundwater resources, e.g. springs, may in turn affect flora and fauna. Light sources at the repository may affect wildlife behaviour. Truck traffic may also pose a threat to certain animal species. These impacts, typically, arise during the construction and operation phases, and diminish during the closure and post-closure institutional control phases.

Visual impacts: The aesthetic appearance of the natural landscape is likely to be changed by development of the repository and related infrastructure construction. For example, the repository design, and the extent, location, size and physical appearance of buildings may create visual impairments. New roads and electric transmission lines may also result in negative visual impacts. Depending on facility location, these changes may alter natural scenery or affect public enjoyment of the landscape. These impacts would typically occur during the construction and operation phases and, to a lesser degree, during the closure and post-closure phases.

Historic or archaeological sites: Repository development, affecting such sites, structures or artefacts, may alter or destroy historically or archaeologically significant resources, or impair their preservation for future use and enjoyment. Individual Member States may make specific policy provision and/or legislation to avoid such areas as potential sites for repository development. These impacts would typically arise during the siting and approval phases.

4.4.3. Human environment

4.4.3.1. Social conditions

Demographic: Depending on the size and nature of the repository, increases in population may occur in the local community due to incoming workers and family members, especially if the initial size of the host community is relatively small. These changes can affect housing, community social services and infrastructure demands and community character. These impacts are likely to be greatest during construction and operation, diminish during closure, and be minimal during post-closure.

Social structure: Changes could result if the income levels and educational background of the incoming workers varies significantly from the existing social structure in the local community. The significance of these impacts will depend on proximity to larger communities. These impacts are likely to be greatest during the construction phase and diminish over time.

Community character: During siting, impacts in the local community and adjacent areas may occur based on varying opinions about the proposed repository. The involvement of interested parties from outside the local community may increase these impacts. Community views may range from perceptions of an undesirable image and related social tensions to support for economic development and job creation benefits. If the proposed repository is located near communities characterised by low income levels, or near an indigenous community or a local racial minority group, environmental justice issues may arise during the repository planning and siting and review and approval phases. During the construction phase, impacts can arise in community character from tensions between incoming workers and their families and the established community. These impacts are likely to be greatest during the siting, review/approval and construction phases, and generally diminish over time.

Elevated noise levels, increased vehicle traffic levels and new light sources can affect people's enjoyment of property, local lifestyles, and other aspects of community character. These potential nuisance effects occur mainly during the construction, operation and closure phases.

Community health: The nature of the facility to be built may cause anxieties and fears in some individuals and groups that may result in potential human health impacts, especially during the early phases of the repository development process.

4.4.3.2. Economic conditions

Employment and labour supply: Repository development is generally accompanied by local job creation. The total number and the skill levels required, will vary depending on repository size, nature of wastes accepted, and the technology utilised. New workers may be drawn from the local or surrounding community, or the outlying region if the repository is in an area remote from populated areas. Employment opportunities may be seen as a local benefit. However, the extent of the opportunity depends on the required skill sets. Trade union provisions may also apply. Other local employers may experience a decrease in available skilled workers and perhaps upward pressure on wage levels. Employment needs may fluctuate considerably during different repository life cycle phases. For example, different skills and work force numbers are typically involved in the construction and operation phases. Employment needs diminish considerably during closure.

Local economic activity: A repository project is accompanied by direct purchase of materials, supplies, buildings, vehicles, equipment, fuel, lodging, restaurant meals, professional and trade services. This purchasing may represent an opportunity for local and regional suppliers and also could result indirectly in new business development. Depending on the level of direct repository-related spending, these expenditures may have a significant multiplier effect on local and possibly regional economic development. Business development may include complementary nuclear- and engineering-related industries, such as a waste treatment facility, batch cementation plant, or a container fabrication plant. Like employment, this impact may occur primarily during the construction, operation and closure phases.

Repository development may temporarily or permanently remove lands from agricultural use. This impact will vary depending on the size of the repository and can potentially affect local agricultural business, decreasing crop revenues and numbers of farm workers employed. The concern regarding the radioactive waste in the repository could affect local image, in turn potentially affecting the sale of certain agricultural products. This may be offset by visitors interested in viewing repository operations, as has been experienced in some Member States.

Other business activity in the local and regional area, such as tourism, may experience adverse impacts resulting from public concerns associated with radioactive waste.

4.4.3.3. Built environment

Housing: The influx of new employees and their families may place demands on available housing stock, both for rental and ownership, possibly resulting in higher housing costs, increased property values, a shortage of housing, and a potential need to provide additional temporary and permanent housing, depending on the size of the repository. The closure of the facility could result in a surplus of housing stock, affecting housing market activity. Alternatively, the concern regarding the radioactive waste in the repository could adversely affect housing market activity and depress property values. The extent of these impacts may differ considerably during the different repository phases, but are likely to be greatest during the construction, operation and closure phases.

Education: Depending on the size of the repository, incoming workers and their families may also put pressure on local educational facilities if there are not sufficient numbers of teachers and classrooms to accommodate new students. Where education provision is the responsibility of the local administrative body, that body may not have the resources to respond to the demand for new facilities. During the closure of the repository the demand on the educational system will be reduced, possibly resulting in surplus facilities and staff.

Transportation network: If the shipment of waste to the repository is by road, this transport will increase traffic levels and possibly road maintenance needs. Construction of new access roads or the improvement of existing roads or the provision of new rail access may be required. Where the local road network is the responsibility of the local administrative body, that body may not have the resources to respond to the potential need for road upgrades or maintenance needs. These impacts typically occur during the construction and operation phases, diminish during closure, and are minimal at post-closure. Repository safety assessment would normally address the potential for increased road accidents on transportation routes. Radiological safety aspects of transportation are addressed in Ref. [30].

Community services: Depending on the size and nature of the facility, repository development may produce direct and indirect demands on local community services and facilities, especially if the initial size of the host community is relatively small. These services may include the provision of police and fire protection, hospitals and other health care facilities, social services, emergency response services, and public transportation. Funding for these services may come from a variety of sources. Where community services is the responsibility of the local administrative body, that body may not have the resources to respond to increasing demands for some of these services. These impacts may arise during the construction, operation and closure phases.

Utility availability: A repository project requires electric power, potentially involving transmission line extension or electricity substation development. Water use and wastewater discharge may require connection to off-site infrastructure, or provision of an on-site water supply well or septic system. Where utility services are the responsibility of the local administrative body, that body may not have the resources to respond to increasing demands. These impacts typically occur during the construction and operation phases, diminish during closure, and are minimal at post-closure, e.g. some provision may be needed for ongoing storm water drainage.

4.4.3.4. Land use

Park and recreational lands: Lands set aside for parks, hunting, hiking, fishing or other recreational uses may be affected if repository development would restrict or prevent future use, or impair the quality of recreational activities. Where park and recreational lands are the responsibility of the local administrative body, that body may not have the resources to respond to increasing demands. These impacts may arise during the construction, operation and, to a lesser degree, closure phases.

Development plans: Depending on the size and nature of the facility, repository development may affect existing land uses and future plans. Concerns regarding the radioactive nature of the waste could adversely affect future development opportunities. The waste facility itself may not be compatible with current development plans. The ability of the local planning authority to accommodate repository siting and operation may depend on local and regional community size, and on previous experience and attitude towards similar industrial development. After the closure of the repository, the local planning authority may have alternative plans for the future use of the site. These impacts typically occur during the siting, construction and post-closure phases.

4.4.4. Other considerations

4.4.4.1. Indigenous people

For those Member States who have indigenous populations, siting, constructing and operating a radioactive waste repository can affect indigenous people. In some instances, unique treaty or other rights need to be considered in the impact assessment process. Impacts can arise if repository development restricts, prevents or otherwise impairs the traditional use or ownership of certain lands by indigenous people for cultural, religious or economic purposes. Impacts can also arise if indigenous people are not consulted in a culturally appropriate and timely fashion.

4.4.4.2. Cumulative impacts

Cumulative impacts can be understood as changes to the environment that are caused by an action in combination with other past, present and future actions (for example, Ref. [29]). In some Member States, cumulative impact assessment is considered an important component of impact assessment.

To illustrate, if a repository siting were in a community currently experiencing other industrial activity, the impacts that may arise as a result of the new facility may, together with the impacts arising from the other activities, result in significant adverse impact on the local community. For example, if the repository project includes the removal of some land area, and the other industrial activities also include the removal of land, the combined loss of plant and animal habitat can result in a significant overall deterioration in the local ecosystem. Individually, for each project, the loss may not have been significant. However, the combined loss is a significant impact. The environmental assessment of the repository development in some jurisdictions takes into account these cumulative impacts.

TABLE 3. EXAMPLES OF POTENTIAL IMPACTS AND IMPACT MANAGEMENT MEASURES

Impact factor	Potential impact	Potential measure
Natural environment		
Land resources	Disturbance of soil through excavation	Control erosion and re-vegetate distributed landscape
Historical or archaeological sites	Disturbance of historical or archaeological artefacts	Document and remove artefacts and place in museum subject to community agreement and legislation, or select another site
Air quality	Increase in dust at site	Apply water to minimise dust
Groundwater resources	Reduction in water availability in neighbouring water wells	Obtain water from deeper well or off-site source
Surface water resources	Increase in storm water run-off to drainage systems	Divert storm water to on-site use, or implement flood control measures
Biotic resources	Removal of vegetation	Offset with new vegetation renewal project
Visual impacts	Repository visible to local residents	Plant trees to screen view
Ecologically sensitive areas	Harm to rare or endangered animal species	Hire biologists to plan and implement protection plan, or create new habitats
Social conditions		
Demographic	Increase in local population from incoming workers and families	Construct work camps and institute travel allowances (during construction)
Social structure	Pressure on existing community due to discrepancy in economic circumstances of incoming workers	Work with local community representatives to help integrate newcomers
Community character	Decrease in people’s enjoyment of property due to nuisance effects	Implement truck routing to avoid residential areas
Community health	Stress caused by repository development	Involve residents or local community organisations in impact management, especially in monitoring programmes
Economic conditions		
Employment and labour supply	Increase in locally available job opportunities	Hire and train local residents as much as possible
Local economic activity	Increase in local business activity if can supply project goods and services	Early information to local contractors regarding project requirements
Built environment		
Housing	Potential difficulty in selling homes	Provide property value protection programme to purchase homes for later sale
Education	Increase in student population overcrowding school facilities	Advance planning with school authorities and support for temporary classroom facilities
Transportation network	Increase in traffic congestion	Schedule truck deliveries to avoid peak times
Community services	Increased demand for emergency service response	Work with local emergency response agencies and support training and facility development
Utility availability	Demand for water service from local supply system exceeds system capability	Work with local authority and support system capability expansion if needed
Land use		
Park and recreational lands	Restricted access to popular park	Work with community to either establish new park or improve other existing park
Development plans	Repository proposal not compatible with approved development plan	Work with local authority to find compatible location within existing plan framework

5. IMPACT MANAGEMENT MEASURES

5.1. INTRODUCTION

While the previous section presented a discussion of a range of potential impacts on the natural and human environment during the repository life cycle, this section provides a description of illustrative examples of impact management measures. A process flow diagram for the impact assessment and management process is presented.

For the purposes of this report, ‘impact management’ means the co-ordinated application of measures designed to mitigate, enhance, compensate, plan for contingencies, monitor and to ensure continuing liaison. ‘Mitigate’ here is taken to mean to avoid or reduce an impact.

5.2. IMPACT MANAGEMENT

Impact management planning generally begins during the impact assessment process. Once potential changes in the natural environment are identified, impact management planning may be focused on meeting the requirements of existing standards, legislation, or other regulatory requirements. In the human environment, once potential socio-economic changes are identified, one of the initial considerations is amenability to impact management measures. Impacts that cannot be avoided or reduced through changes in the design of the facility may be addressed through comprehensive impact management measures. These may be developed in negotiation with potentially affected communities. In this way, the most effective measures can be planned.

For the purpose of this report, a number of illustrative impact management measures have been developed for each of the factors and indicators discussed in Section 4. Table 3 presents a selection of potential impacts and corresponding impact management measures.

Certain impacts may occur at different stages of the repository life cycle, but impact management measures designed to avoid impacts may be implemented before the impact occurs while other impact management measures may be implemented more appropriately as the impact occurs. For example, measures designed to address potential impacts in the housing market due to incoming workers could be put in place prior to their arrival. Community liaison measures are implemented while community change is occurring to ensure that impacts are addressed.

Figure 1 presents a flow diagram that illustrates the various steps involved in the impact assessment and management process. The project review and approval process may require refinement of the initially proposed impact management measures. Following project approval, compliance monitoring by relevant authorities may be appropriate to ensure successful implementation.

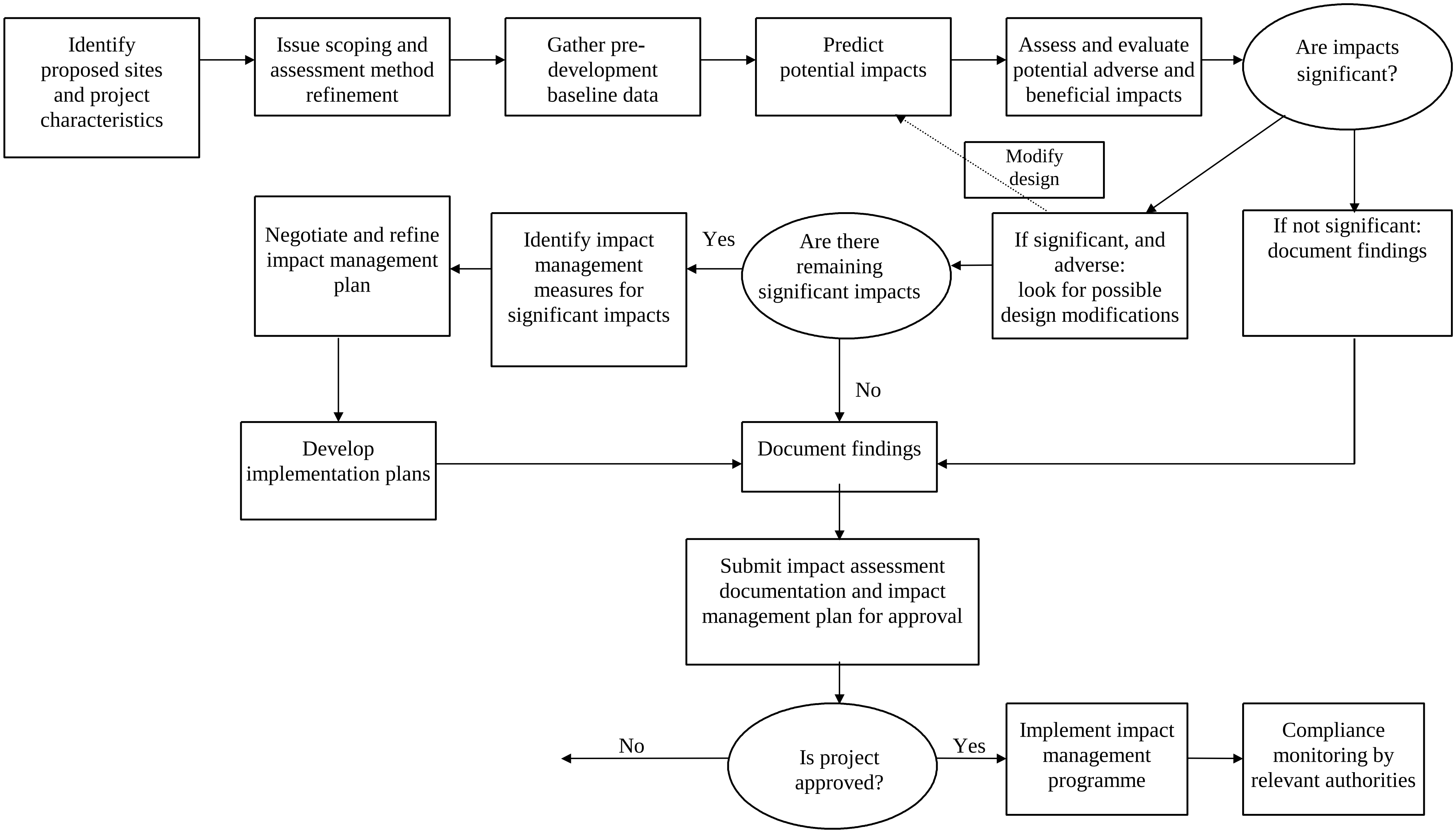

FIG. 1. Impact assessment and management process.

6. CONCLUSIONS

This report provides a discussion of various social, economic and environmental impacts that could be associated with the surface and near surface disposal of low and intermediate level waste. Environmental impacts, discussed in this report, do not include radiological impacts or impacts from chemical or toxic substances. Factors and indicators are used to indicate impacts that could apply at the local, regional or national level, and during the various phases of the repository life cycle. The report also presents illustrative examples of impact management measures. Finally, a process flow diagram for the impact assessment and management process is presented.

The set of factors and indicators identified are largely drawn from experience in Member States with nuclear power programmes and with operational repositories. Potential impacts associated with small disposal facilities are likely to be lesser in magnitude and may have a correspondingly reduced impact at the local, regional or national level.

The main conclusions of the report are as follows:

4 Potential socio-economic and other non-radiological impacts are important considerations during the life cycle of a near surface disposal facility, covering the period from the initial planning phase through siting, construction, operation, and closure to the post-closure institutional control phase.

4 A broad range of socio-economic and environmental impacts may occur during the repository life cycle. Potential factors that have been identified include those relating to the natural environment, social conditions, economic conditions, built environment and land use. Most impacts are likely to occur at the local level and, to a lesser degree, at the regional level.

4 The nature and magnitude of the potential impacts associated with a specific repository project will depend on the size, design and location of the repository, the types and inventories of waste accepted for disposal, the type of technology selected, the number of workers employed, specific community characteristics and other project- and country-specific requirements and circumstances.

4 Both short- and long-term impacts can be expected during the repository life cycle. The greatest overall impacts generally occur during the construction, operation and closure phases.

4 Impact management measures can be applied in different ways to eliminate or reduce actual and potential adverse impacts during the repository life cycle. Measures may also be employed to enhance beneficial impacts of repository development and operation.

4 Cost considerations are an important national policy matter with regard to repository development, construction, operation and closure. Repository funding issues have a direct impact on the selection and timing of implementation of the preferred options. Funding requirements may be significantly higher if the repository pre-construction process is delayed.

4 Public involvement in impact assessment and impact management planning is an important Member State consideration. Such involvement and input, through appropriate mechanisms such as local committees, is particularly important in the project development and operational phases of the repository.

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