

Annex II: Work breakdown structure for activities for five major work elements of a geological disposal programme

1. Disposal Programme Management

| Phase Element | Initiation | Siting | | Disposal | | | Post-Closure |
|---|---|--|---|--|---|---|----------------------------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Strategy, planning, programme management | Establish programme core team | Maintain programme core team and ensure transmission of relevant knowledge | | Maintain programme core team and ensure transmission of relevant knowledge | | | |
| | Develop plans or strategies to implement disposal programme | Update plans or strategies to implement a disposal programme (siting, construction & operation, closure, monitoring, research, URFs, stakeholder involvement, etc) | | Update plans or strategies to implement the industrial disposal phase of the programme (construction & operation, closure, monitoring, RD&D, URF stakeholder involvement, regulatory compliance, H&S, etc) | | | |
| | Develop initial WBS and schedule | Update WBS and programme schedule | | Update WBS and programme schedule | | | |
| | Develop preliminary risk management plan | Update risk management plan – licence, feasibility, acceptance | | Update risk management plan – construction, operations, maintaining acceptance | | | |
| Programme requirements and control | Establish generic requirements | Establish requirements for safety, feasibility | Detail requirements for licence application | Detail requirements for commissioning | Detail requirements for license reviews | Detail requirements for post-closure phase | |
| | Start initial system for programme controls | Implement and update system for programme controls | | Implement and update system for programme controls | | | |
| | Develop systems engineering tools | Apply systems engineering analyses to define research and development needs | | Apply systems engineering analyses to assessment of research and development needs | | | |
| Licensing and permitting | | Submit licence application for site specific URF (option) | Submit licence application for construction | Submit licence application for operation | Submit licence application for closure | Prepare approach for termination of licence | |
| | | Submit EIA for site investigations | Submit EIA for construction | Submit EIA for operation | Submit EIA for closure | | |
| | | Obtain permits for site investigations | Obtain site permits for construction | Obtain permits for operations | Obtain required permits for closure | Obtain permits for post-closure activities | |
| | | Ensure compliance with all applicable regulations | | Ensure compliance with relevant occupational health and safety and environmental regulations | | | |
| Nuclear security and safeguards | | Review security and safeguard needs | Develop safeguards plan for construction | Develop detailed safeguards plan for operations | Implement safeguards measures | Develop safeguards plan for closure | Evaluate safeguards requirements |
| | | | Prepare cybersecurity programme | Implement and update cybersecurity and facilities protection programme | | | |
| Protection of health and safety and environment | Determine applicable regulatory requirements | Update assessment of health, safety and environment programme | | Update assessment of health, safety and environment as needed | | | |
| | Initiate health, safety and environment programme | Implement health, safety and environment programme | | Implement health, safety and environment programme | | | |
| | | Develop community safety and emergency response plan | | Update community safety and emergency response plan, as needed | | | |

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|--|--|---|--|---|--------------------------------------|---|------------------------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Corporate services for a programme | Develop cost estimate tool and estimate cost | Review and update programme cost regularly | | Review and update programme cost regularly | | | |
| | Establish procurement and property management plans | Implement procurement and property management system | Develop detailed plan for procurement of construction and operations contracts | Implement procurement for construction | Implement procurement for operation | Implement procurement for closure | |
| | Identify staff skills and start recruitment plan | Update skills retention programme | | Update skills assessment and implement personnel recruitment, hiring and retention programme | | | |
| | Develop staff training programme | Implement staff training programme | | Implement staff training programme | | | |
| | Evaluate anticipated legal needs | Provide legal services (corporate operations, contracting, licensing) | | Provide legal services for the industrial disposal phase of the programme (corporate operations, contracting, licensing) | | | |
| Management system, quality assurance and control | Develop high level management system | Update management system for site activities and construction | | Update management system for operations | Update management system for closure | Update management system for post closure | |
| | Develop and implement training and oversight programme for management system | | | Implement training and oversight programme for management system | | | |
| | Establish auditing system for the management system | Implement auditing system for the management system | | Implement auditing system for the management system | | | |
| Knowledge management | Establish archive system and database | Maintain programme archives and database | | Maintain programme archives and database | | | Archive and maintain records |
| | Develop database for disposal system design controls and geoinformation | Maintain and update database for disposal system design controls and geoinformation; preserve knowledge underlying major programme decisions (e.g. siting, licensing) | | Maintain and update database for disposal system design controls and geoinformation; preserve and transfer knowledge underlying major programme decisions (e.g. operations, licensing, closure) | | | |
| | | Establish and maintain system for knowledge access for stakeholders | | Update and maintain system for knowledge access for stakeholders | | | |
| International cooperation | Develop strategic partnerships, including with other WMOs | Collaborate in relevant research and development work in geological disposal | | Continue collaboration in relevant research and development work in geological disposal | | | |
| | Establish connections with international URF programmes | Collaborate on specific studies in existing URFs in other nations | | Continue collaborative research and development work in other URFs | | | |
| | | Foster and support international participation in generic or site specific URF(s) if constructed | | Support and foster international participation in the site specific URF | | | |

2. Stakeholder Involvement

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|-------------------------------|--|---|--|--|--|--------------------------------|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| National government | Establish liaisons with relevant national agencies | Conduct and continue periodic policy and technical exchange with national government agencies | | Conduct and continue periodic policy and technical exchange with national government agencies | | | |
| | Determine potential issues of concern to national agencies | Refine and update list of potential issues of concern to national agencies | | Refine and update list of potential issues of concern to national agencies | Communicate closure activities | | |
| Local/regional government | | Conduct policy and technical exchange, including community benefits | Continue policy and technical exchange, including community benefits | Continue periodic policy and technical exchange with local/regional government agencies | | | |
| | | List potential issues of concern from local/regional govt | Update list of potential issues from local/regional govt | Update list of potential issues of concern to local/regional government authorities and officials | | Communicate closure activities | |
| | | | Make an agreement for site investigations if needed | Update and maintain agreements for each phase, provide community benefits | | | |
| Regulatory bodies | Establish liaisons with regulatory bodies | Conduct and continue periodic policy and technical exchange with regulatory bodies | | Conduct and continue periodic policy and technical exchange with regulatory bodies | | | |
| | List potential issues of concern from regulators | Refine and update list of potential issues of concern to regulatory bodies | | Refine and update list of potential issues of concern to regulatory bodies for the disposal phase of the programme | | Communicate closure activities | |
| | | | Contribute to the licence application for construction | Contribute to the licence application for operation | Contribute to the licence application for closure | | |
| Advisory /consultative bodies | Establish liaisons | Conduct and continue policy and technical exchange with advisory/ consultative bodies | | Conduct and continue periodic policy and technical exchange with advisory/ consultative bodies | | | |
| | List potential issues of concern | Refine and update list of potential issues of concern to advisory/consultative bodies | | Refine and update list of potential issues of concern to advisory/ consultative bodies | | Communicate closure activities | |
| Waste producer | Establish liaisons with waste producers | Conduct and continue periodic policy and technical exchange with waste producers | | Conduct and continue periodic policy and technical exchange with waste producers | | | |
| | List potential issues of concern to waste producers | Refine and update list of potential issues of concern to waste producers | | Refine and update list of potential issues of concern to waste producers | | Communicate closure activities | |
| | | Establish preliminary WAC in consultation with waste producers | Establish detailed WAC in consultation with waste producers | Finalize WAC in consultation with waste producers | | | |
| | | Establish preliminary waste delivery schedule, logistics | Establish detailed waste delivery schedule, logistics | Update waste delivery schedule, logistics | Update waste delivery schedule, logistics, as needed | | |

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|---|---|--|--|--|-----------|--------------------------------|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Public (including local community) | | Conduct and continue periodic policy and technical exchange with members of the public and local community | | Conduct and continue periodic policy and technical exchange with members of the public and local community for the disposal phase of the programme | | | |
| | List potential issues of concern to the impacted public | Refine and update list of potential issues of concern to local communities and the public | | Refine and update list of potential issues of concern to the local communities and the public | | Communicate closure activities | |
| | | | Provide tours of repository construction | Provide tours of repository operations | | | |
| Indigenous Peoples (if applicable) | Establish liaisons with Indigenous Peoples | Conduct and continue periodic policy and technical exchange with Indigenous Peoples | | Conduct and continue periodic policy and technical exchange with Indigenous Peoples for the disposal phase of the programme | | | |
| | List potential issues of concern to Indigenous Peoples | Refine and update list of potential issues of concern for Indigenous Peoples | | Refine and update list of potential issues of concern for Indigenous Peoples | | Communicate closure activities | |
| | | Consult with Indigenous Peoples regarding site investigation activities | | Consult with Indigenous Peoples for each phase of the programme | | | |
| Other stakeholders (media, scientific and academic community, etc.) | Establish liaisons with other concerned stakeholders | Conduct and continue periodic policy and technical exchange with other stakeholders | | Conduct and continue periodic policy and technical exchange with other stakeholders | | | |
| | List potential issues of concern to other stakeholders | Refine and update list of potential issues of concern to other stakeholders | | Refine and update list of potential issues of concern to other stakeholders | | Communicate closure activities | |
| | | | Provide tours of repository construction | Provide tours of repository operations | | | |

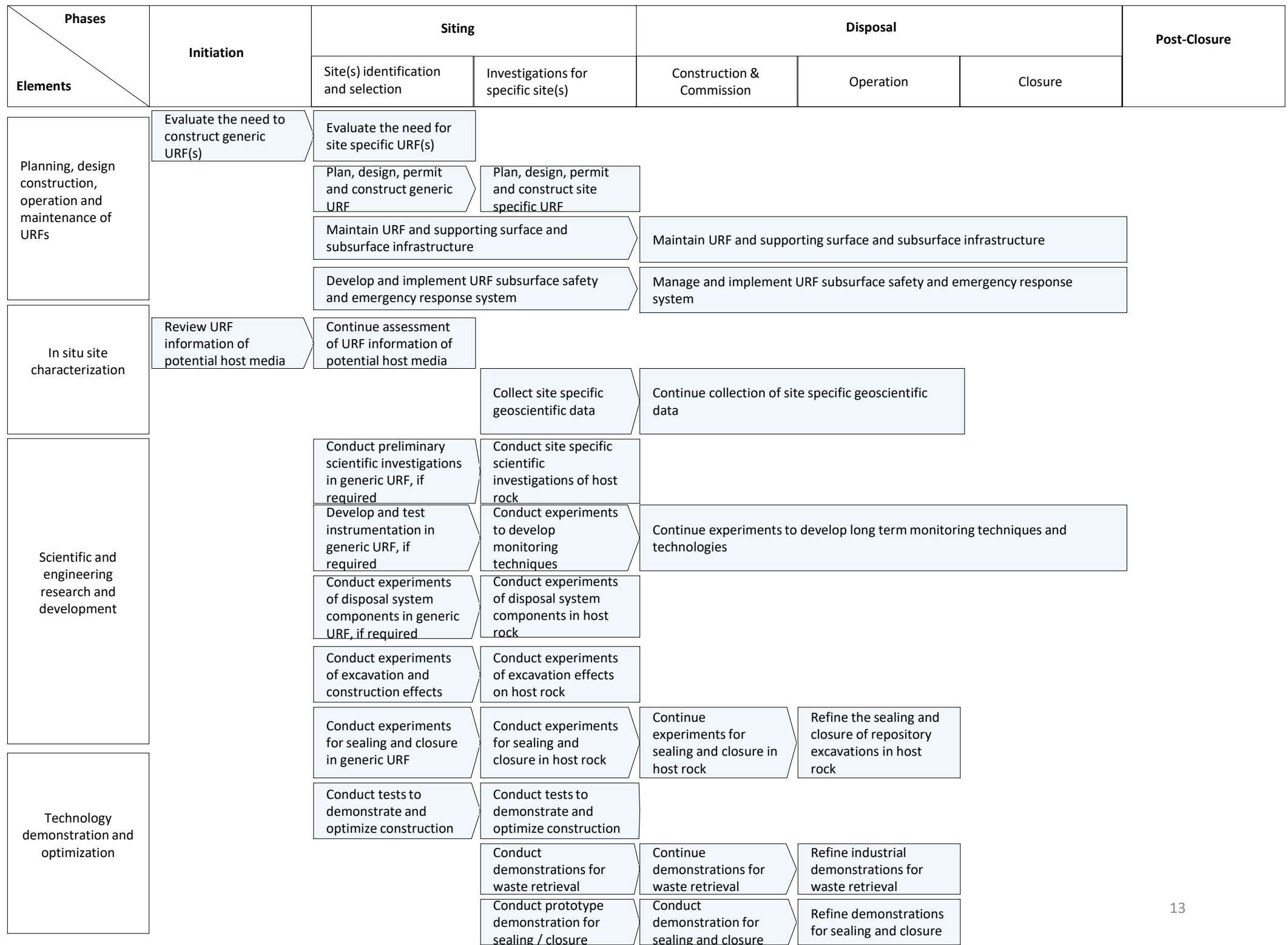
3. Disposal System Development

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|---|--|---|--|--|--|--|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Safety strategy | Develop generic safety strategy (containment and isolation, robustness, etc.) | Detail the generic safety strategy | Detail the safety strategy for licence application for construction | Detail the safety strategy for licence application for operations | Detail the safety strategy for licence application for licence application for closure | | |
| Waste inventory and characterization | Conduct initial waste inventory analysis, including projections | Update initial waste inventory analysis, including projections | Update waste inventory analysis for construction licence | Update waste inventory analysis for operations licence | Update record of waste inventory (disposed of) for closure licence | | |
| | Develop initial waste characterization plan | Conduct preliminary waste characterization | Conduct waste characterization for construction licence | Conduct waste characterization for operations licence | Ensure full record of waste characterization results for closure | | |
| | Develop generic waste acceptance criteria | Develop preliminary waste acceptance criteria | Detail waste acceptance criteria | Detail waste acceptance criteria | Verify waste inventory as emplaced for licence application for closure | | |
| Site investigations and characterization | Collect information on national geology and geodynamics for understanding geological options | Conduct site investigations to address key gaps in regional geological information | Conduct site characterization to acquire site specific geological information for construction licence | Conduct site characterization for operation licence | Conduct site characterization for closure licence | Continue site characterization for licence termination | |
| | Survey and update site investigations and characterization methods and tools | | | Survey and update site investigations and characterization methods and tools | | | |
| | Develop preliminary conceptual models | Update conceptual models in potential host regions | Update conceptual models at selected site(s) | Update conceptual models as needed | | | |
| | | Develop preliminary conceptual models for biosphere release mechanisms and exposure pathways | Update conceptual models for biosphere release mechanisms and exposure pathways | Update models for biosphere release mechanisms and exposure pathways | | | |
| Supporting research and development (R&D) | Develop preliminary conceptual models for engineered systems and coupled processes | Update conceptual models for engineered systems and coupled processes in potential host regions | Update conceptual models for engineered systems and coupled processes at selected site(s) | Update models for engineered systems and coupled processes, as needed | | | |
| | Conduct literature survey of disposal concepts for potential geological media from international community | Conduct preliminary R&D of disposal system components, such as waste package, buffer and backfill | Conduct detailed R&D of disposal system components and construction equipment | Conduct additional R&D of disposal system components and operational equipment | | | |

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|--|---|--|---|---|---|--|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Disposal system design and engineering | Develop generic design of disposal system | Develop conceptual design of disposal system | Develop design of disposal system for construction license | Develop and optimize the detailed design of disposal system for operations | Refine and optimize the detailed design of disposal system | Refine and optimize the design of barriers and seals for closure | |
| | | Develop design of surface and subsurface facilities | Detail the design of surface and subsurface facilities | Refine the design of surface and subsurface facilities | | | |
| | | | Develop the design for waste handling and emplacement equipment | Develop the design for waste handling and emplacement equipment | Refine design for waste handling and emplacement equipment | | |
| | | | Develop operational procedures | Refine and optimize operational procedures | | | |
| Conceptualization, models, simulation | Develop generic conceptual model of long term evolution of the site | Develop preliminary conceptual model of long term evolution of the site | Develop conceptual model of long term evolution of the site for safety case | Detail model of long term evolution of the site for safety case | Detail model of long term evolution of the site for the safety case | | |
| | Develop generic conceptual model of long term evolution of the engineered system | Develop preliminary conceptual model of long term evolution of the engineered system | Develop conceptual model of long term evolution of the engineered system for the safety case for construction | Detail model of long term evolution of the engineered system for the safety case for operations | Detail model of long term evolution of the engineered system for the safety case for closure | | |
| | | Develop generic mathematical model for disposal system | Continue development of mathematical model for disposal system | Continue refining mathematical model for disposal system, incorporating collected data | | | |
| Post-closure safety assessment | Review FEPs scenario for generic reference cases | Analyse FEPs scenario for generic reference cases | Detail FEPs scenario for construction licence | Detail FEPs scenario for operation licence | Detail FEPs scenario for closure licence | Detail FEPs scenario for licence termination | |
| | Establish database and input parameters for the generic post-closure safety analysis models | Update database and input parameters for the generic post-closure safety analysis models | Update database and input parameters to support post-closure safety analysis for construction | Update database and input parameters to support post-closure safety analysis for operations | Update database and input parameters to support post-closure safety analysis for closure | Update database and input parameters to support post-closure safety analysis for licence termination | |
| | Conduct generic radionuclide screening analysis | Update radionuclide screening analysis | Update radionuclide screening analysis | Update radionuclide screening analysis | | | |
| | Conduct generic post-closure safety analysis in support of generic safety case | Update generic post-closure safety analysis in support of generic safety case | Conduct site specific computational safety analysis to support post-closure safety | Conduct site and design specific computational safety analysis to support post-closure safety | Conduct site and design specific computational safety analysis to support post-closure safety | Conduct site and design specific computational safety analysis to support post-closure safety | |
| | Develop post-closure safety analysis models | Update post-closure safety analysis models | | Update post-closure safety analysis models | | | |

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|---------------------------------------|--|--|--|---|---|--|---|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Operational safety assessment | | Conduct risk analysis and scenario development | Detail risk analysis (e.g. anticipated occurrences) | Update detailed risk analysis and scenarios, record and incorporate operating experience | | | |
| | | Develop generic models for operational safety | Detail accident management procedures | Update and detail accident management procedures | | | |
| | | Conduct safety calculation of the generic models | Conduct safety calculation of the generic models for construction | Conduct safety calculation of the generic models for operation | | | |
| | | | Ensure operation of the facility is consistent with the safety case | Operational decisions relevant to safety should be investigated in an update of the safety case prior to their implementation | | | |
| Monitoring and surveillance | | | Implement environmental baseline monitoring programme at selected site(s) | Implement environmental monitoring programme for construction, operations and closure phases | | | Implement post-closure monitoring and surveillance programme, if required |
| | | | | Implement disposal system monitoring programme | | | |
| Safety case development | Define contents and structure of generic safety case | Update the safety case based on site(s) information | Update the safety case for licence application for construction | Update the safety case for licence application for operations | Update the safety case for licence application for closure | Update the safety case for licence termination | |
| | Identify and evaluate uncertainties for generic safety case through gap analysis | Identify and reduce uncertainties for generic safety case through gap analysis | Identify and reduce uncertainties for the safety case for licence application for construction | Identify and reduce uncertainties for the safety case for licence application for operation | Identify and reduce uncertainties for the safety case for licence application for closure | Identify and reduce uncertainties for the safety case for licence termination | |
| Environmental Impact Assessment (EIA) | Conduct supplementary studies for environmental impact assessment | Evaluate the preliminary environmental impact assessment | Complete and document the environmental impact assessment for repository construction | Complete and document the environmental impact assessment for repository operation | Complete and document the environmental impact assessment for closure | Complete and document the environmental impact assessment for termination of the nuclear license | |

4. Underground Research Facility (URF) Activities



| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|---------------------------------------|------------|---|---|---|---|---------|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Training and professional development | | Develop methods, training programme and equipment needed for staff training | Construct training and demonstration exercise for construction and operations | Continue training and demonstration exercise for construction and operations | | | |
| | | Train staff to augment scientific and technical understanding for a geological disposal programme and gain experience on field experiments and activities | Train programme personnel for construction and operations | Train programme personnel for construction and operations for the industrial disposal phase of the programme | | | |
| | | Provide a training programme for relevant stakeholders | Continue training programme for relevant stakeholders | Continue a training programme for academia and other relevant stakeholders for the industrial disposal phase of the programme | | | |
| Stakeholder outreach | | Engage stakeholders and interested communities, using URFs for information exchange, demonstration of expertise, and confidence building | Engage stakeholders and local communities and use URFs as a vehicle for information exchange, demonstration of expertise, and confidence building | | | | |
| | | Initiate stakeholder outreach and develop a public information programme | Continue stakeholder outreach and implement a public information programme | Continue stakeholder outreach and implementation of a public information programme for the industrial disposal phase of the programme | | | |
| | | | Provide tours and site specific subsurface information to stakeholders | Provide tours and demonstration of disposal operations to stakeholders | Provide tours and demonstrations of disposal operations to stakeholders | | |

5. Disposal Implementation

| Phases Elements | Initiation | Siting | | Disposal | | | Post-Closure |
|---------------------------------------|------------|--------------------------------------|--|---|---|---------|--------------|
| | | Site(s) identification and selection | Investigations for specific site(s) | Construction & Commission | Operation | Closure | |
| Construction of surface facilities | | | Conduct planning for construction of surface facilities | Contract, construct, and install site infrastructure | | | |
| | | | | Contract, construct, and install surface facilities | | | |
| | | | | Implement mine safety and emergency response plan | | | |
| Construction of subsurface facilities | | | Conduct planning for construction of subsurface facilities | Contract, excavate and install subsurface facilities | Expand subsurface facilities, if necessary | | |
| | | | | Implement mine safety and emergency response plan | | | |
| Commissioning of disposal facility | | | | Develop detailed plan for commissioning | Update commissioning verification and testing for any changes | | |
| | | | | Conduct verification of 'as built' facilities | | | |
| | | | | Implement testing of facilities and equipment | | | |
| Surface operations | | | | Develop detailed procedures for surface operations | Implement procedures for surface operations | | |
| | | | | Develop plan for waste inventory tracking | Implement waste inventory tracking system | | |
| Subsurface operations | | | | Develop detailed procedures for waste emplacement | Implement detailed procedures for waste emplacement | | |
| | | | | | Implement detailed procedures for backfilling and sealing | | |
| | | | | | Implement waste inventory tracking and system | | |
| Closure of subsurface facilities | | | | Develop detailed closure plan for subsurface facilities | Implement closure plan for subsurface facilities | | |
| | | | | | Implement procedures for backfill and sealing | | |
| | | | | | Prepare documentation for licence termination | | |
| Closure of surface facilities | | | | Develop detailed closure plan for surface facilities | Implement closure plan for surface facilities | | |
| | | | | | Prepare documentation for the termination of licence | | |