6.0 GROUND-WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Ground-Water Quality Restoration

In conducting these evaluations, the reviewer should consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. The desired outcome is to identify any areas where duplicative NRC reviews may be reduced or eliminated. The NRC staff must make the necessary evaluations of compliance with applicable regulations for licensing the facility. However, the reviewer may, as appropriate, rely on the applicant's responses to inquiries made by a state or another federal agency to support the NRC evaluation of compliance. The reviewer should make every effort to coordinate the NRC technical review with the state or other federal agency with overlapping authority to avoid unnecessary duplication of effort.

Some of the review methods and acceptance criteria in the following sections are more rigorous than those previously used by the NRC staff. They provide increased confidence in the adequacy of ground-water restoration plans and the sureties associated with them.

Methods and models used in the technical assessment of the selected ground-water restoration methods, restoration time and pore volume displacements, and sureties may range from detailed, small-scale process models to large-scale, simplified models. Small-scale process models are generally used to evaluate potentially important complexities and mechanisms that govern the evolution of the contaminated areas, while large-scale, simplified models generally consider fewer complexities but may be suitable for evaluating average or effective processes for large areas. Model adequacy should be evaluated regardless of the level of complexity.

This review should be coordinated with the site hydrologic characteristics review conducted using Section 2.7 of this standard review plan.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.1.1 Areas of Review

The staff should review the following aspects of the ground-water quality restoration program:

(1) Aspects of any ground-water modeling that are important based on the extent to which the applicant relies on them to meet the objectives of the ground-water restoration. Particular attention will be paid to the estimation of restoration time and the extent of uncertainties in processes and data. Specifically, the modeling review should include:

   (a) Techniques used to collect data on the geology, hydrology, geochemistry, processes, plume geometry/extent, and physical phenomena of the site

   (b) Technical bases for the geology, hydrology, geochemistry, processes, and physical phenomena related to flow and transport pathways

(c) Consistency and adequacy of assumptions incorporated into modeling

(d) Technical bases for the concentrations of contaminants in models of the site

(e) Sufficiency of data and parameters used to support models and simplifications

(f) Technical bases for and uncertainty associated with model parameters

(g) Site numerical model results as compared to detailed model results or site data (i.e., model validation)

(2) Estimates of the concentrations, and lateral and vertical extent of those chemicals that may persist in leached-out well field production zones after termination of *in situ* leaching operations and before restoration activities.

(3) Descriptions of proposed methods and techniques to be used to achieve ground-water quality restoration, including identification of *in situ* chemical reactions that may hinder or enhance restoration. The staff should also review descriptions of fluids to be used during restoration and the hydraulic and geochemical properties of the receiving stratum.

(4) A schedule for sequential restoration of well fields.

(5) Descriptions of the expected post-reclamation conditions and quality of restored ground waters, compared with the pre-operational land and water quality characteristics, if there is prior experience in restoring ground water at the site.

(6) Assessments of the proposed water quality restoration operations with respect to their adverse effects on ground waters outside production zones.

(7) Procedures to be used for plugging, sealing, capping, and abandoning wells associated with the *in situ* leaching operations.

(8) Methods of effluent disposal, such as deep-well injection, discharge to surface water, and land application.

6.1.2 Review Procedures

The staff should review plans and schedules for ground-water quality restoration, and perform the following actions:

(1) If numerical ground-water flow or transport modeling is used to support or develop the ground-water restoration plans, examine the descriptions of features, physical phenomena, and the geological, hydrological, and geochemical aspects of the modeled aquifers. The staff should verify that the descriptions are adequate and that the

conditions and assumptions used in the modeling are realistic or reasonably conservative and supported by the body of data presented in the descriptions.

Evaluate the sufficiency of data used to support model parameter values. Data sources may include a combination of techniques such as laboratory experiments, aquifer hydraulic testing and water level measurements in wells, geochemical analyses, or other site-specific field measurements.

Evaluate the technical bases for parameter ranges, probability distributions, or bounding values. The reviewer should determine whether the parameter values are derived from either site-specific data, or an analysis to show assumed parameter values bound data uncertainty in a manner that is not overly optimistic.

Evaluate whether there are aspects of the model where additional data could provide new information that could invalidate the modeling results and significantly affect the ground-water restoration plan. For example, if constant head boundary conditions are used in a numerical ground-water flow model, could additional wells or sampling during a different season result in a significantly different interpretation of model boundary conditions? If so, is a different interpretation of boundary conditions likely to significantly alter model results used to develop or support the restoration plan?

Examine the initial conditions and boundary conditions used in any numerical modeling for consistency with available data. The staff should also consider the potential importance of temporal and spatial variations in boundary conditions and source terms used to support the ground-water restoration plan.

Evaluate the applicant's assessment of uncertainty and variability in model parameters. The reviewer should determine whether uncertainty in both temporal and spatial parameter variability is incorporated into or bounded by parameter values.

Examine the technical bases for the identification of post-extraction changes to ground-water quality. The staff should examine how the evolution of water quality has been incorporated into estimates of restoration time or the number of pore volumes required to attain restoration goals.

Examine the assumptions used to develop any model of reactive transport that accounts for site geochemical processes, such as sorption or any other geochemical reaction, that leads to reduction or retardation of contaminants. The modeling should consider available data about the native ground-water downgradient of the ore extraction areas, the geochemical environment, hydraulic and transport properties, and the spatial variations of properties of aquifers and ground-water volumetric fluxes along the flow paths.

Evaluate the estimated restoration time or required number of pore volume displacements for consistency with the output from any numerical model of ground-water restoration.

The reviewer should evaluate whether the applicant has appropriately reduced the dimensionality and complexity of models. The dimensionality of models, heterogeneity of aquifer parameters, and significant process couplings may be reduced if it is shown that the reduced and simplified dimension model bounds the prediction of the full dimension model. The staff should evaluate the acceptability of the sensitivity analyses used to support the model of the ground-water restoration and the estimation of restoration time and pore volume displacements.

Where appropriate, and when surety estimates are highly uncertain, the reviewer may use an alternative model to perform an independent technical assessment of ground-water restoration.

(2) Evaluate estimates of post-extraction ground-water quality by comparison to descriptions of lixiviant composition and host rock geochemistry. Ensure that methods for estimating the affected pore volume are consistent with the methods used at any research and development site or other sites upon which restoration estimates may be based.

(3) Compare descriptions of the proposed restoration methods with those methods that have been successfully applied at other *in situ* leaching facilities. Sources of information can include research and development and production sites that are located in similar hydrogeologic environments and have used similar restoration techniques. However, the applicant is not required to present operational experience from a research and development facility as part of an application. Ensure that the proposed restoration methods are appropriate for the host rock and lixiviant chemistry.

(4) Assess whether the applicant has provided a reasonable standard for the determination of restoration success and a realistic assessment of the expected post-restoration water quality by comparing standards with previous restoration work at the research and development site or other previously restored *in situ* leaching facilities.

(5) Evaluate the ability of the post-reclamation stability monitoring program to verify successful restoration.

(6) Consider whether the proposed restoration program adequately addresses water quality cleanup because of well field flare (undetected spread of extraction solutions between the well field and monitor wells of the production zone), and whether the quantity of water pumped during restoration will adversely affect off-site ground-water uses.

(7) Assess whether plans for plugging and abandoning wells before license termination are consistent with generally accepted techniques.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.1.3 Acceptance Criteria

The primary purpose of restoring the ground-water quality in a well field after the completion of uranium extraction operations is to assure the protection of public health and the environment. NRC shares the regulatory oversight of ground-water restoration with the EPA under its Underground Injection Control Program (40 CFR Part 144) and those underground injection control programs administered by EPA Authorized States. In addition to the NRC license, the EPA Authorized States issue underground injection control permits for *in situ* leaching operations, after the EPA grants an exemption from ground-water protection provisions for the portion of the aquifer undergoing uranium extraction (the exploited ore zone in an aquifer). The EPA aquifer exemption effectively removes that portion of the aquifer from any future consideration for ground-water protection; however, the ground-water protection provisions are still in effect for the aquifer adjacent to the exempted area. The EPA Authorized State typically imposes the ground-water restoration requirements, in accordance with the state's ability to implement requirements that are more stringent than the delegated federal program. The implementation of ground-water restoration requirements may vary from state to state. The reviewer is advised to closely coordinate the NRC licensing review activities with the underground injection control permitting programs of EPA Authorized States to avoid unnecessary duplication of effort. The following acceptance criteria should serve as the minimum requirements for demonstrating acceptability for the NRC licensing review.

The plans and schedules for ground-water quality restoration, surface reclamation, and plant decommissioning are acceptable if they meet the following criteria:

(1) The application includes estimates of the volume and quality of extraction solutions that need to be cleaned up during ground-water restoration. Generally, these estimates may be based on either experience with previous *in situ* leach operations or research and development investigations in similar host rock. Documentation of such prior experience should be included or referenced in the application. The applicant may also use numerical or analytical ground-water flow and transport modeling to support development of the ground-water restoration plan. When flow and transport modeling is used, the applicant must provide data and model justification to demonstrate that conclusions used to develop the restoration plan are reasonable. Data and model justification must meet the following criteria.

Important design features, physical phenomena, and consistent and appropriate assumptions are identified and described sufficiently for incorporation into the modeling that supports the ground-water restoration plan.

The applicant provides sufficient data to justify the models used to develop the ground-water restoration plan and to adequately define model parameters, initial and boundary conditions, and any simplifying assumptions.

Parameter values, assumed ranges, probability distributions, and/or bounding assumptions used in modeling ground-water restoration are technically defensible and

reasonably account for uncertainties and variabilities. The technical bases for each parameter value, ranges of values, or probability distributions used in the modeling ground-water restoration are provided.

In the case of sparse data and/or low confidence in the quality of available data or parameter estimates, the applicant demonstrates by sensitivity analyses or other methods that the proposed ground-water restoration is appropriate, and the contingency built into the surety is consistent with the uncertainties.

For reactive transport models, adequate site geochemical data are provided to support the ground-water restoration plans and models. Water chemistry data are needed to develop an understanding of geochemical evolution as ground water is restored in the subsurface. The important geochemical parameters that should be delineated include pH, Eh, dissolved oxygen, temperature, major cation and anion concentrations, concentrations of potential contaminants, and host-rock mineralogy.

Reactive transport models incorporate thermodynamic data on solid phases and aqueous species, allowing the mass action calculations that determine estimated aqueous concentrations and solid phase evolution. Thermodynamic parameters constitute a major source of uncertainty in geochemical modeling, with potentially large effects on predicted aqueous ion concentrations. Therefore, geochemical modeling supporting ground-water restorations should include sensitivity analyses that provide assurance that contaminant concentrations will not be underestimated. Likewise, any kinetic models employed are subjected to critical analysis because of the large influence of kinetic effects at low temperatures. Additionally, consideration of geochemical model limitations and their effects on uncertainty is an important component of the review by the NRC. Such limitations include: the assumption of local equilibrium, neglect of porosity changes caused by precipitation or dissolution of the solid phase, omitting colloidal transport; neglect of density effects due to varying total dissolved solids, simplifying the mineralogical suite, and neglecting surface reactions such as ion exchange.

The applicant documents how the model output is validated in relation to site characteristics.

(2) The applicant describes the method used for estimating well field *pore volume*[1] and the associated horizontal and vertical *flare.*[2]

A pore volume is an indirect measurement of a unit volume of aquifer water affected by *in situ* leach extraction. It represents the volume of water that fills the void space inside a certain volume of rock or sediment. Typically, a pore volume is calculated by multiplying the surficial area of a well field (the area covered by injection and recovery wells) by the thickness of the ore zone being exploited and the estimated or measured porosity of the aquifer material. The horizontal and vertical flares are usually expressed as additional percentages that are multiplied to the calculated pore volume. Specific flare factors approved in the past vary from 20 to 80 percent and are typically based on experience from research and development pilot demonstrations. The pore volume and flare factors provide a means of comparing the level of effort required to restore ground water regardless of the scale of the test. In general, the more pore volumes of water it takes to restore ground-water quality, the more effort it will cost to achieve restoration.

(3) The application includes well field restoration plans.

Restoration plans contain descriptions of the process to be used for well field restoration and projected completion schedules based on well field ore depletion. This description should include restoration flow circuits, treatment methods, methods for disposal or treatment of wastes and effluents, monitoring schedules, a discussion of chemical additives used in the restoration process, anticipated effects of chemical additives, and alternate techniques that may be employed in the event that primary plans are not effective. Typically, restoration is divided into distinct sequential phases in which different techniques are employed. Ground-water sweep is used to pump water from the ore zone without reinjecting, to recall lixiviant from the aquifer and draw in surrounding uncontaminated water. Reverse osmosis/permeate injection circulates water from the well field through a reverse osmosis treatment process and reinjects the permeate into the well field, typically at rates similar to those used during production. Ground-water recirculation is used to evenly distribute water throughout the restored well field, to dilute any pockets of remaining contamination. An additional acceptable restoration method is the injection of chemical reductants (usually hydrogen sulfide, sodium sulfide, or sodium bisulfide) into the well field. These reductants are used to immobilize metals that may have been dissolved by the oxidizing lixiviant; however,

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[1]*Pore volume* is a term of convenience used by the *in situ* leach industry to describe the quantity of free water in the pores of a given volume of aquifer material. It provides a unit reference that an operator can use to describe the amount of lixiviant circulation needed to leach an ore body, or describe the unit number of treated water circulations needed to flow through a depleted ore body to achieve restoration. A pore volume provides a way for an operator to use relatively small-scale studies and scale the results to field-level pilot tests or to commercial well field scales.

[2]*Flare* is a proportionality factor designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the extraction phase. The flare is usually expressed as a horizontal and vertical component to account for differences between the horizontal and vertical hydraulic conductivity of an aquifer material.

some general water quality parameters, such as total dissolved solids, may be adversely affected by reductants.

NRC allows flexibility and innovation in approaches to restoration. Therefore, applicants are not limited to one restoration method for all well fields. Rather, they should describe the sequential phases of restoration that may be used and the most likely restoration scenario, based on research and development results and restoration experience. Other restoration approaches, such as in-place biological remediation techniques, have been discussed by some applicants. These techniques show promise, but have not been tested or evaluated at commercial scale *in situ* leach operations. The application of other restoration techniques may necessitate some form of pilot demonstration to evaluate the potential for unanticipated impacts, such as clogging of aquifer pore spaces or potential health impacts from introduced compounds and organisms, before the techniques are applied to full-scale operations.

Restoration plans should also include a list of monitored constituents, a monitoring interval, and the sampling density (wells/acre). An acceptable constituent list should be based on the chemistry of the production and restoration solutions used and on the host rock geochemistry. In the interest of minimizing expense, the applicant may propose a limited set of indicator constituents to monitor restoration progress and a sampling density that does not include all production and injection wells. The applicant may also propose monitoring composite samples from the restoration stream. However, all wells that were sampled for baseline conditions should be sampled for the full list of monitored constituents before a determination of restoration success is made.

The applicant should specify the criteria that will be used to determine restoration success. Generally, the acceptance criteria for restoration success are based on the ability to meet the predetermined numerical standards of the restoration program and the absence of a significant increasing trends of monitored constituent concentrations during the stability monitoring period.

For purposes of surety bonding, restoration plans must include estimates of the level of effort (typically in terms of pore volume displacements) necessary to achieve the primary restoration target concentrations. These estimations may be based on historical results obtained from the research and development site or experience in other well fields having similar hydrologic and geochemical characteristics.

(4) Restoration standards are established in the application for each of the monitored constituents.

The applicant has the option of determining numerical restoration limits for each constituent on a well-by-well basis, or as a statistical average applied over the entire well field. Restoration standards must be established for the ore zone and for any overlying or underlying aquifers that have the potential to be affected by *in situ* leach solutions.

(a) Primary Restoration Standards—The primary goal of a restoration program is to return the water quality within the exploited ore zone and any affected aquifers to pre-operational (baseline) water quality conditions. Recognizing that *in situ* leach operations fundamentally alter ground-water geochemistry, it is not reasonable to assume restoration activities can return ground-water quality to the exact water quality that existed at every location prior to *in situ* leach operations. Still, as a primary restoration goal, licensees are required to attempt to return the concentrations of the identified water quality parameters to within the baseline range of statistical variability for each parameter. This standard requires licensees to identify the type of statistical analysis and criteria that will be used to determine whether concentrations of water quality parameters in the affected aquifers fall within an acceptable range of baseline variability. Statistical approaches for determining whether contamination persists in affected aquifers are found in American Society for Testing and Materials Standard D 6312 (American Society for Testing and Materials, 2001).

(b) Secondary Restoration Standards—It is reasonable to expect that *in situ* leach operations may cause permanent changes in water quality within the exploited ore zone, because the *in situ* leach extraction process relies on changing the chemistry in the ore zone to remove the uranium. For this reason, it is acceptable for the applicant to propose returning the water quality within the exploited ore zone aquifer to its pre-operational class of use (e.g., drinking water, livestock, agricultural, or limited use), as a secondary restoration standard. Applications should state the principal goal of the restoration program and that secondary standards will not be applied so long as restoration continues to result in significant improvement in ground-water quality. The applicant must first attempt to return ground-water quality to primary goals before falling back on secondary standards. License conditions should be set up such that a license amendment is necessary before the applicant can revert to secondary goals. The applicant must demonstrate that a good faith effort was given to reach primary goals.

It is acceptable to establish secondary restoration standards on a constituent-by-constituent basis, with the numerical limits determined by applying the lower of the state or EPA primary or secondary drinking water standards. For radionuclides not included in the drinking water standards, it is acceptable to determine, on a constituent-by-constituent basis, secondary standards from the concentrations for unrestricted release to the public in water, from Table 2 of 10 CFR Part 20, Appendix B.

(c) If a constituent cannot technically or economically be restored to its secondary standard within the exploited ore zone, an applicant must demonstrate that leaving the constituent at the higher concentration would not be a threat to public health and safety or the environment or produce an unacceptable degradation to the water use of adjacent ground-water resources. This situation might arise with respect to general water quality parameters such as the total dissolved

solids, sulfate, chloride, iron, and others which do not typically present a health risk. However, not all the major constituents have a primary or secondary drinking water standard (e.g., bicarbonate, carbonate, calcium, magnesium, and potassium). Consequently, it is possible that ground-water restoration may achieve the secondary standard for total dissolved solids, but may not achieve a secondary standard for individual major ions that contribute to total dissolved solids. If such a situation occurred, the applicant must show that leaving the individual constituent at a concentration higher than secondary standard would not be a threat to public health and safety nor the environment or produce an unacceptable degradation to the water use of adjacent ground-water resources. Such proposed alternatives must be evaluated on a case-by-case basis as a license amendment request only after restoration to the primary or secondary standard is shown not to be technically or economically achievable. This approach is consistent with the as low as is reasonably achievable philosophy that is used broadly within NRC.

(5) The post-restoration stability monitoring program is described in the application.

The purpose of a stability monitoring program is to ensure that chemical species of concern do not increase in concentration subsequent to restoration. The applicant should specify the length of time that stability monitoring will be conducted, the number of wells to be monitored, the chemical indicators to be monitored, and the monitoring frequency. These requirements will vary based on site-specific post-extraction water quality and geohydrologic and geochemical characteristics. Before final well field decommissioning, all designated monitor wells must be sampled for all monitored constituents. Well fields may be decommissioned when all constituent concentrations meet approved standards and show no strong trends in ground-water quality deterioration as a result of *in situ* leach activities.

(6) The application includes a discussion of the likely external effects of ground-water restoration.

Ground-water restoration operations, and the expected post-reclamation ground-water quality, must not adversely affect ground-water use outside the exploited ore zone. Water users from nearby municipal or domestic wells that were in use before *in situ* leach operations should be provided reasonable assurance that their water quality will not be impacted. Impacts are not limited to chemical constituent concentrations, but also include changes in color, odor, hardness, and taste of the water. The water quality outside the exploited ore zone should not exceed EPA primary and secondary drinking water standards for ground water that can be used as an underground source of drinking water. Ground-water quality should not exceed the appropriate state water-use standards for aquifers that cannot support a drinking water use.

(7) Methods for abandoning wells are included in the application.

The basic purpose for sealing abandoned wells and bore holes is to restore the well field to pre-operational hydrogeologic conditions. Any well or bore hole to be permanently abandoned should be completely filled in such a manner that vertical movement of water along the borehole is prevented. *In situ* leach operators usually rely on a drilling contractor to perform well abandonment. The application should specify the methods and materials to be used to plug holes, and that records documenting the well abandonment will be maintained by the licensee. Abandonment procedures that: (i) conform to American Society for Testing and Materials Standard D 5299 (1992); (ii) are from the State Engineer's Office; or (iii) are codified in state regulations or rules are considered acceptable. An applicant may propose other generally accepted standards for abandoning wells and boreholes. References for these standards should be specified in the application, and copies should be kept on file by the applicant. Techniques that are not considered to be generally accepted abandonment practices should be described in detail and may require additional time for review.

(8) Descriptions of water consumption impacts.

During *in situ* leach operations, water quality impacts usually are more of a concern than water consumption impacts. This is because water consumption during *in situ* leach operations is relatively small. However, when restoration activities begin, water consumption will significantly increase. The amount of increase will depend on the restoration techniques applied. Techniques that clean up the aquifer by pumping water from the aquifer, cleaning the water, and reinjecting the clean water consume the least amount of water. Water consumption impacts will result in water loss from the aquifer and water level declines. The impacts of water consumption on local wells and water users should be evaluated. Water level declines can result in increased pumping costs or inability to obtain water from the aquifer in local wells. Water loss from the aquifer may mean that less water could be available to down gradient ground-water and surface-water users.

(9) The applicant may propose alternatives to restoring an exploited ore zone to primary or secondary ground-water restoration standards, in lieu of the above criteria. These alternatives must be evaluated on a case-by-case basis and must assure protection of human health and the environment, and assure no unacceptable degradation to the use of adjacent ground-water resources. As an example, if an applicant proposes no ground-water restoration activities within the exploited ore zone, the applicant would be required to show that adequate institutional control provisions are in place to assure the exploited ore zone would not be accessed for a use that would harm human health or the environment, and also show that the use of aquifers adjacent to the unrestored ore zone would not be degraded. If predictive computer modeling is used to support this alternative, the model must be validated by comparing the modeling results to ground-water monitoring for an appropriate period of time after *in situ* leach operations cease in a well field. The applicant must maintain a financial surety to cover potential restoration costs in the event the modeling results cannot be verified through monitoring, and ground-water restoration must be initiated.

6.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the plans and schedules for ground-water quality restoration, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans and schedules for ground-water quality restoration proposed for use at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the ground-water restoration program and schedules using the review procedures in standard review plan Section 6.1.2 and the acceptance criteria outlined in standard review plan Section 6.1.3.

The applicant has acceptably demonstrated that well field ground-water restoration standards will be representative of the pre-operational baseline ground-water conditions. As a secondary restoration goal, the applicant has identified and committed to use the federal primary and secondary drinking water standards.

The applicant's method for estimating well field pore volume is acceptable, taking into account the estimated effective porosity of the contaminated region and the lateral and vertical extent of contamination. With respect to the methodology for undertaking restoration, the applicant provided an acceptable mix of ground-water sweep, reverse osmosis, and ground-water recirculation. The well-field-specific mix of these approaches will be determined as part of the ground-water restoration plan for each individual well field. In addition, the applicant has demonstrated an acceptable method for determining the extent of well field flare and for ensuring acceptable restoration of the flare. The applicant has committed to an acceptable schedule for complete restoration for any well field after ore extraction ceases.

The applicant has presented an acceptable list of constituents to be monitored and has specified acceptable criteria to determine the success of restoration either on a well-by-well or well field average basis. The number of pore volume replacements necessary to achieve the primary restoration targets has been provided and is acceptable. The applicant has demonstrated that the primary restoration program will return the water quality of the ore zone and affected aquifers to pre-extraction (baseline) water quality, that any secondary restoration standards proposed by the applicant are acceptable, or that final water quality will protect public health and safety and the environment in compliance with as low as is reasonably achievable principles. The applicant post-restoration stability monitoring program is acceptable. Any likely adverse off-site effects of ground-water restoration are acceptable.

The methods proposed for abandoning wells and sealing them to restore the well field to pre-extraction hydrologic conditions are acceptable. The applicant has evaluated the consumptive water impacts of the *in situ* leach facility using acceptable methods.

Based on the information provided in the application and the detailed review conducted of the plans and schedules for ground-water quality restoration for the _____ *in situ* leach facility, the staff concludes that the proposed plans and schedules for ground-water quality

restoration are acceptable and are in compliance with 10 CFR 40.32(c), requiring the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), requiring that the issuance of the license will not be adverse to the common defense and security or to the health and safety of the public; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis. The related reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

6.1.5 References

American Society for Testing and Materials. "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs, Designation: D6312." West Conshohocken, Pennsylvania: American Society for Testing and Materials. 2001.

———. "Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, and Other Devices for Environmental Activities, Designation: D 5299." West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1992.

6.2 Plans And Schedules For Decommissioning Disturbed Lands and Affected Structures

6.2.1 Areas of Review

The staff should review all maps and data provided in the application showing the pre-reclamation operation conditions of affected lands and immediate surrounding areas. The staff should also review procedures for (i) reclaiming temporary diversion ditches and impoundments, (ii) reestablishing surface drainage patterns disrupted by the proposed activities, and (iii) returning the ground surface and structures for post-operational use, in accordance with the criteria in Section 5.2 of the standard review plan.

Staff should review the pre-remediation radiological survey program that will identify areas of the site that need to be cleaned up to comply with NRC concentration limits. The staff should evaluate measurement techniques and sampling procedures proposed for determining the radionuclide concentrations and the extent of contamination of structures, and soils. In addition, the review should confirm that the licensee will have an approved decommissioning radiation protection program in place before the start of reclamation and cleanup work and that an acceptable agreement is in place for off-site disposal of 11e.(2) byproduct material.

6.2.2 Review Procedures

The staff should determine whether the described procedures for reclaiming temporary diversion ditches and impoundments, reestablishing surface drainage patterns disrupted by the

proposed activities, and returning the ground surface and structures for post-operational use are consistent with regulatory guidance and are sufficient to verify that requirements of 10 CFR Part 40, Appendix A, Criterion 6(6), and 10 CFR 40.42 have been met. The staff should ensure that the licensee intends to restore topography and vegetation to a state that is similar to pre-operational conditions. The staff should review the pre-reclamation survey plan to ensure that it provides adequate coverage to designate contaminated areas for cleanup. Particular attention should be focused on sampling temporary diversion ditches and surface impoundments, well field surfaces, process and storage areas, transportation routes, and operational air monitoring locations. These areas are expected to have higher levels of contamination than surrounding areas. The staff should also ensure that plans exist for the disposal of contaminated soils at an existing licensed byproduct material disposal facility, consistent with 10 CFR Part 40, Appendix A, Criterion 2. The staff should confirm that the licensee has an approved radiological protection program to ensure worker safety during decommissioning, reclamation, and cleanup activities and should determine whether any changes have been proposed for this program. The program for radiation protection is addressed in Section 5.7 of the standard review plan but additional review is needed to ensure any hazards specific to decommissioning are addressed (e.g., yellowcake dryer demolition). The staff should review the compliance history for the radiation safety program to identify any deficient areas that may require special consideration before the start of work.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.2.3 Acceptance Criteria

The plans and schedules for reclaiming disturbed land and possibly affected structures are acceptable if they meet the following criteria:

(1) Appropriate cleanup criteria have been considered in developing the pre-reclamation surveys and planned cleanup activities. Acceptable cleanup criteria are discussed in standard review plan Sections 6.3 (for structures) and 6.4 (for soils).

(2) The pre-reclamation survey program for buildings and soils identifies instruments and techniques similar to the pre-operational survey program to determine baseline site conditions (e.g., background radioactivity) but also takes into account current technology (acceptable sensitivity), results from operational monitoring, and other information that provide insights to areas of expected contamination.

Survey areas should include diversion ditches, surface impoundments, well field surfaces and structures in process and storage areas, on-site transportation routes for contaminated material and equipment, and other areas likely to be contaminated. A sampling grid should be used and a statistical basis for sample size should be provided. Acceptable methods for sampling are provided in NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (NRC, 2000).

(3) The licensee provides the procedures for interpretation of the pre-reclamation survey results and describes how they will be used to identify candidate areas for cleanup operations. Acceptable survey methods are discussed in standard review plan Section 6.4, "Procedures for Conducting Post-Reclamation and Decommissioning Radiological Surveys."

(4) The post-reclamation (final status) survey procedure provides the survey methods and approach for complying with requirements in 10 CFR Part 40, Appendix A, Criterion 6(6).

(5) The discussion of surface restoration includes a pre-construction surface contour map, a description of any significant disruptions to surface features during facility construction and operation, and a description of planned activities for surface restoration that identifies any important features that cannot be restored to the pre-operations condition.

(6) Any changes to the existing NRC-approved radiation safety program that are needed for decommissioning and reclamation work are identified with appropriate justification to assure continued safety for workers and the public. Acceptable approaches for the radiation safety program are evaluated in accordance with Section 5.7 of this standard review plan, "Radiation Safety Controls and Monitoring."

(7) The applicant has an approved waste disposal agreement for 11e.(2) byproduct material disposal at an NRC or NRC Agreement State licensed disposal facility. This agreement is maintained on site. The applicant has committed to notify NRC in writing within 7 days if this agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination (failure to comply with this license condition will result in a prohibition from further lixivient injection).

(8) The applicant commits to providing final (detailed) decommissioning plans for land (soil) to the NRC for review and approval at least 12 months before the planned commencement of decommissioning of a well field or licensed area. The final decommissioning plan includes a description of the areas to be decommissioned, a description of planned decommissioning activities, a description of methods to be used to ensure protection of workers and the environment against radiation hazards, a description of the planned final radiation survey, and an updated detailed cost estimate. A license condition will be established to this effect.

(9) The decommissioning plan addresses the non-radiological hazardous constituents associated with the wastes according to 10 CFR Part 40, Appendix A, Criterion 6(7). Any unusual or extenuating circumstances related to such constituents should be discussed in the reclamation plan or decommissioning plan in relation to protection of public health and the environment and should be evaluated by staff.

(10) The quality assurance and quality control programs address all aspects of decommissioning. The plans should indicate a confidence interval or that one will be specified before collection of samples. The data to be used to demonstrate compliance

and the quality assurance procedures to confirm that compliance data are precise and accurate are identified. Management will ensure that approved procedures are followed.

6.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the plans and schedules for reclaiming disturbed lands and affected structures, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans and schedules for reclaiming disturbed lands and affected structures proposed for use at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the reclamation of disturbed lands program and schedules using the review procedures in standard review plan Section 6.2.2 and the acceptance criteria outlined in standard review plan Section 6.2.3.

The applicant has acceptable plans for a pre-reclamation radiation survey that use instrumentation and techniques similar to the pre-operational survey used to establish baseline site conditions if these are still acceptable methods. The applicant has acceptably considered results from operational monitoring and other information relative to areas of expected contamination in its reclamation plans. Areas to be evaluated include diversion ditches, surface impoundments, well field surfaces, and structures in process and storage areas, on-site transportation routes, and other areas likely to be contaminated. The applicant has proposed acceptable methodology to determine areas to be resampled or sampled with higher than normal densities. The applicant has defined appropriate procedures for the pre-reclamation survey and the means used to identify areas for cleanup using the acquired data. Methods proposed for decommissioning and an acceptable plan of activities for surface restoration, including identification of any irreversible changes, have been provided. The applicant has assured NRC that any required changes to the radiation safety program identified as a result of the decommissioning and reclamation work will be implemented before commencing the work.

Based on the information provided in the application and the detailed review conducted of the plans and schedules for reclaiming disturbed lands and affected structures for the _____ *in situ* leach facility, the staff concludes that the proposed plans and schedules are acceptable and are in compliance with 10 CFR 40.32(c), which requires applicant proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.42(g)(4), which provides requirements for final decommissioning plans; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate non-proliferation of waste disposal sites; 10 CFR Part 40, Appendix A, Criterion 6(6), which identifies cleanup criteria requirements; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis. The related reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and

schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations" and 7.0, "Environmental Effects" are addressed elsewhere in this technical evaluation report.

The decommissioning plan specifies the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and meets the criteria of 10 CFR 40.42(g)(4) and (5). The plan sufficiently demonstrates that the proposed decommissioning activities will result in compliance with 10 CFR 40.42(j)(2) requirements to conduct a radiation survey. The plan complies with the 10 CFR 40.42(k)(1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination. The plan demonstrates the proposed decommissioning activities will result in compliance with 10 CFR Part 40, Appendix A, Criterion 6(7) requirements to prevent threats to human health and the environment from non-radiological hazards. The decommissioning cost estimate meets the requirements of 10 CFR 40.42(g)(4)(v) and Appendix A, Criterion 9.

6.2.5 Reference

NRC. NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)." Revision 1. Washington, DC: NRC. 2000.

6.3 Procedures for Removing and Disposing of Structures, Waste Materials, and Equipment

6.3.1 Areas of Review

The staff should review procedures for removing and disposing of contaminated structures and equipment used during *in situ* leach operations, as well as procedures for managing toxic and radioactive waste materials. The reviewers should also evaluate procedures that identify radiological hazards before initiating dismantlement of structures and for detection and cleanup of removable contamination from structures and equipment. Procedures and plans for ensuring that all contaminated facilities and equipment are addressed and are either planned to be disposed of in a licensed facility, or will meet the contamination levels for unrestricted use, or are designated for re-use at another *in situ* leach facility, should be examined. The staff should also review provisions made for the removal and disposal of byproduct material to an existing uranium mill or licensed disposal site.

6.3.2 Review Procedures

The staff should determine whether the procedures for removing and disposing of structures used during *in situ* leach operations and all procedures for managing toxic and radioactive waste materials are consistent with regulatory guidance and sufficient to meet the applicable regulatory requirements in 10 CFR 40.42. Plans for structures and equipment to be released for unrestricted use should be reviewed using standard review plan Section 5.7.6, "Contamination Control Program." The staff should confirm that plans for dismantlement of structures and equipment include a preliminary assessment of anticipated hazards that should

be considered before dismantlement. This should include the use of appropriate survey methods to determine the extent of contamination of equipment and structures before starting decommissioning and reclamation work. Particular attention should be focused on those parts of the processing system that are likely to have accumulated contamination over long time periods such as pipes, ventilation equipment, effluent control systems, and facilities and equipment used in or near the yellowcake dryer area. The staff should also review provisions made for the removal and disposal of byproduct material to an existing uranium mill or licensed disposal site to ensure that they meet requirements of 10 CFR Part 40, Appendix A, Criterion 2.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.3.3 Acceptance Criteria

The procedures for removing and disposing of structures, waste materials, and equipment are acceptable if they meet the following criteria:

(1) A program is in place to control residual contamination on structures and equipment.

(2) Measurements of radioactivity on the interior surfaces of pipes, drain lines, and duct work will be determined by making measurements at all traps and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, and ductwork.

(3) Surfaces of premises, equipment, or scrap that are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement are presumed to be contaminated in excess of the limits.

(4) Before release of structures for unrestricted use, the licensee makes a comprehensive radiation survey to establish that contamination is within the limits specified in standard review plan Section 5.7.6, "Contamination Control Program" and obtain NRC approval.

(5) A contract between the licensee and a waste disposal operator exists to dispose of 11e.(2) byproduct material.

(6) The applicant commits to providing final (detailed) decommissioning plans for structures and equipment to the NRC for review and approval at lease 12 months before the planned commencement of decommissioning of such structures and equipment. The final decommissioning plan includes a description of structures and equipment to be decommissioned, a description of planned decommissioning activities, a description of methods to be used to ensure protection of workers and the environment against radiation hazards, a description of the planned final radiation survey, and an updated detailed cost estimate. A license condition will be established to this effect.

6.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the procedures for removing and disposing of structures, waste materials, and equipment, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the procedures for removing and disposing of structures and equipment used at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the procedures for removing and disposing of structures and equipment using the review procedures in standard review plan Section 6.3.2 and the acceptance criteria outlined in standard review plan Section 6.3.3.

The applicant has established an acceptable program for the elimination of residual contamination on structures and equipment. The applicant has made acceptable plans for measurements of radioactivity on the interior surfaces of pipes, drain lines, and ductwork by making appropriate measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination. All premises, equipment, or scrap likely to be contaminated but that cannot be measured, have been assumed by the applicant to be contaminated in excess of limits and will be treated accordingly. For all premises, equipment, or scrap contaminated in excess of specified limits, the applicant has provided detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination. The applicant has provided a detailed health and safety analysis that reflects that the contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public nor the environment. The applicant plans to conduct a comprehensive radiation survey to establish that any contamination is within limits specified before the release of the premises, equipment, or scrap. A contract exists between the licensee and a waste disposal operator to dispose 11e.(2) byproduct material.

Based on the information provided in the application and the detailed review conducted of the procedures for removing and disposing of structures and equipment for the _____ *in situ* leach facility, the staff concludes that the procedures are acceptable and are in compliance with 10 CFR 40.32(c); 10 CFR 40.42(g)(4), which provides requirements for final decommissioning plans; which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; and 10 CFR Part 40, Appendix A, Criterion 2, which requires that the applicant provide objective evidence of an agreement for disposal of 11e.(2) byproduct materials either in a licensed waste disposal site or at a licensed mill tailings facility to demonstrate non-proliferation of waste disposal sites. The reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

6.3.5 References

None.

6.4 Procedures for Conducting Post-Reclamation and Decommissioning Radiological Surveys

6.4.1 Areas of Review

The staff should review procedures for conducting post-reclamation and decommissioning radiological surveys, including post-operational ground-water monitoring, and decontamination and removal of structures and equipment. The staff should review the radiological verification survey program that will serve as a basis for determining compliance with NRC concentration limits. The staff should evaluate the measurement techniques and sampling procedures proposed.

6.4.2 Review Procedures

The staff should determine whether the procedures for conducting post-reclamation and decommissioning radiological surveys are acceptable to verify that concentration limits of 10 CFR Part 40, Appendix A, Criterion 6(6) are met. The staff should ensure that sampling frequencies and locations are acceptable and representative of conditions at the site. The staff should consider the survey methods provided in NUREG–1575 (NRC, 2000) along with the applicable site conditions to determine the acceptability of the licensee proposed sampling program. The staff should confirm that the determination of background concentrations of radium-226 and other radionuclides is based upon sampling in uncontaminated areas near the site. Other radionuclides that should be sampled if suspected to be present include thorium-230, thorium-232, uranium; and lead-210.

The radium benchmark dose applies for cleanup of residual radionuclides other than radium in soil and for surface activity on structures. For such licensees, the reviewer should refer to Appendix F of this standard review plan for guidance on the benchmark approach.

For license renewals and amendment application, Appendix A to this standard review plan provide guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.4.3 Acceptance Criteria

The procedures for conducting post-reclamation and decommissioning radiological surveys are acceptable if they meet the following criteria:

(1) The cleanup criteria for radium in soils are met as provided in 10 CFR Part 40, Appendix A, Criterion 6(6).

This criterion states that the design requirements for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 m^2, which as a result of byproduct material, does not exceed the background level by more than

(i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 cm [5.9 in.] below the surface,

(ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm [5.9-in.] thick layers more than 15 cm [5.9 in.] below the surface

(2) Background radionuclide concentrations are determined using appropriate methods as described in Section 2.9, "Background Radiological Characteristics," of this standard review plan. If there are large variations in the background radionuclide concentrations within a given site, it is acceptable for a licensee to assign different background radionuclide concentrations to different areas of the site, provided that the licensee properly justifies the background concentrations selected for each area.

(3) Acceptable cleanup criteria for uranium in soil are as discussed in Appendix F of this standard review plan. This is the radium benchmark dose approach of 10 CFR Part 40, Appendix A, Criterion 6(6).

(4) For areas that already meet the radium cleanup criteria, but that still have elevated thorium levels, an acceptable cleanup criterion for thorium-230 is that concentration that, combined with the residual concentration of radium-226, would result in the radium concentration (residual and from thorium decay) that would be present in 1,000 years meeting the radium cleanup standard.

(5) The survey method for verification of soil cleanup is designed to provide 95-percent confidence that the survey units meet the cleanup guidelines. Appropriate statistical tests for analysis of survey data are described in NUREG–1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (NRC, 2000).

(6) Acceptable surface contamination levels for equipment and structures are provided in Table 5.7.6.3-1.

6.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the procedures for conducting post-reclamation and decommissioning radiological surveys, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the post-reclamation and decommissioning radiological surveys proposed for use at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used for the post-reclamation and decommissioning

radiological surveys using the review procedures in standard review plan Section 6.4.2 and the acceptance criteria outlined in standard review plan Section 6.4.3.

The applicant has developed an acceptable program for verification of cleanup (final status survey plan) that demonstrates that the radium concentration in the upper 15 cm [5.9 in.] of soil will not exceed 5 pCi/g and in subsequent 15 cm [5.9 in.] layers will not exceed 15 pCi/g. Also, the cleanup of other residual radionuclides in soil and residual surface activity on structures to remain onsite meet the criteria developed with the radium benchmark dose approach (Appendix F), including a demonstration of as low as is reasonably achievable and application of the unity test of 10 CFR Part 40, Appendix A, Criterion 6(6) where applicable. For cases in which the licensee has proposed an alternative to the requirements of Criterion 6(6) or the approved guidance, the staff determines that the resulting level of protection is equivalent to that required by this criterion.

Based on the information provided in the application and the detailed review conducted of the procedures for conducting post-reclamation and decommissioning radiological surveys for the _____ *in situ* leach facility, the staff concludes that the procedures are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security or to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the locations and purposes authorized in the license; 10 CFR Part 40, Appendix A, Criterion 6(6), which provides standards for cleanup of radium; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis. The reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

6.4.5 Reference

NRC. "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)." Revision 1. Washington, DC: NRC. 2000.

6.5 Financial Assessment for Ground-Water Restoration, Decommissioning, Reclamation, Waste Disposal, and Associated Monitoring

6.5.1 Areas of Review

The staff should review financial assessments (cost estimates) provided by the applicant for the costs of ground-water restoration (standard review plan Section 6.1); reclamation (standard review plan Section 6.2); and decommissioning, waste disposal, and monitoring (standard review plan Section 6.3). These assessments may be provided in the form of a narrative or as

an appendix. The staff should review provisions for a financial surety that is consistent with Criteria 9 and 10 of 10 CFR Part 40, Appendix A, and the guidance in Appendix D of this standard review plan.

6.5.2 Review Procedures

The staff should review the proposed surety amount provided by the applicant to verify that the activities incorporated in the cost estimate are consistent with the activities proposed in the application. In addition, the reviewer should verify that the activities proposed in the application are included in the financial assessments. Activities to be covered by the surety include reclamation, off-site disposal of 11e.(2) byproduct material, ground-water restoration, and closure. The purpose of the financial surety is to provide sufficient resources for completion of reclamation of the facility including building decommissioning and well field restoration and soil decommissioning, by a third party, if necessary.

The reviewer should determine whether the assumptions for the financial surety analysis are consistent with what is known about the site (standard review plan Section 2.0) and the design and operations of the facility and its effluent control system (standard review plan Sections 3.0, 4.0, and 5.0). To the extent possible, the applicant should base these assumptions on experience from generally accepted industry practices, from research and development activities at the site, or from previous operating experience in the case of a license renewal. The values used in the analysis should be based on current dollars (or adjusted for inflation) and reasonable values for the costs of various activities. The reviewer should also examine the type of financial instrument(s) proposed for the surety to ensure that it is consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9. Finally, the reviewer should verify that any expected long-term surveillance costs are provided for consistent with Criterion 10 of Appendix A to 10 CFR Part 40.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

6.5.3 Acceptance Criteria

The cost estimate for ground-water restoration, decommissioning, reclamation, waste disposal, and monitoring is acceptable if it meets the following criteria:

(1) The bases for establishing a financial surety are in 10 CFR Part 40, Appendix A, Criterion 9. The surety for well fields is usually established as they go into production. Once accepted, the surety will be reviewed annually by NRC to assure that sufficient funds would be available for completion of the reclamation plan by a third party. Detailed guidance on reviewing financial assessments for *in situ* leach operations is found in Appendix D of this standard review plan .

The reviewer shall examine licensee commitments and proposed schedules for surety updates in response to facility changes, annual updates, and changes in closure or decommissioning plans.

(2) All activities included in the cost estimate are activities that are included either in the reclamation plan or in the operations review completed using Sections 6.1 through 6.4 of this standard review plan.

(3) All activities included either in the reclamation plan or in Sections 6.1 through 6.4 of this standard review plan are included in the financial analysis.

(4) The assumptions used for the proposed surety are consistent with what is known about the site (standard review plan Section 2.0) and the design and operations of the facility and its effluent control system (standard review plan Sections 3.0, 4.0, and 5.0). To the extent possible, the applicant has based these assumptions on experience from generally accepted industry practices, research and development at the site, or previous operating experience in the case of a license renewal.

(5) Surety values are based on current dollars (or are adjusted for inflation), and reasonable costs for the required reclamation activities are defined.

(6) The applicant commits to funding the approved financial surety through one of the mechanisms described in 10 CFR Part 40, Appendix A, Criterion 9, including a (i) surety bond, (ii) cash deposit, (iii) certificate of deposit, (iv) deposit of a government security, (v) irrevocable letters or lines of credit, or (vi) combinations of the above that meet the total surety requirements.

(7) the applicant commits to updating the surety value annually, in response to changes in closure or decommissioning plans, and as necessitated by changes in the facility. The annual update will be submitted ninety (90) days prior to the anniversary date each year.

(8) The applicant commits to extending the surety for an additional year if NRC has not approved a proposed revision thirty (30) days prior to the surety expiration date.

(9) The applicant commits to revising the surety arrangement within three (3) months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing financial surety. This revised surety instrument will be in effect within thirty (30) days of NRC written approval of the surety documents.

(10) Surety documentation includes a breakdown of costs; the basis for cost estimates with adjustments for inflation; a minimum 15-percent contingency; and changes in engineering plans, activities performed, and any other conditions affecting estimated costs for site closure.

(11) The licensee commits to submitting for NRC approval an updated surety to cover any planned expansion or operational change not included in the annual surety update at least ninety (90) days prior to beginning associated construction.

(12) The licensee commits to providing NRC with copies of surety-related correspondence submitted to a state, a copy of the state's surety review, and the final approved surety arrangement. The licensee also commits that, where the surety is authorized to be held by the state, the NRC-related portion of the surety will be identified and will cover the above-ground decommissioning and decontamination, the cost of off-site disposal of 11e.(2) byproduct material, soil and water sample analyses, and ground-water restoration associated with the site.

(13) Reclamation/decommissioning plan cost estimates, and annual updates should follow the outline in Appendix D to this standard review plan.

(14) Any long-term surveillance costs are provided for consistent with Criterion 10 of 10 CFR Part 40, Appendix A.

6.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the cost estimate for ground-water restoration, decommissioning, reclamation, waste disposal, and monitoring, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the procedures for conducting cost estimates for ground-water restoration, decommissioning, reclamation, waste disposal, and monitoring proposed for use at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the procedures using the review procedures in standard review plan Section 6.5.2 and the acceptance criteria outlined in standard review plan Section 6.5.3.

The applicant has established an acceptable financial surety based on the requirements in 10 CFR Part 40, Appendix A, Criterion 9. The applicant has assured that sufficient funds would be available for completion of the reclamation plan by an independent contractor. The applicant has included in the financial analyses all the activities in the reclamation plan or in Sections 6.1–6.4 of the standard review plan. The applicant has based the assumptions for financial surety analysis on site conditions, including experiences with generally accepted industry practices, research and development at the site, and previous operating experience (in the case of a license renewal). The values used in the financial surety analysis are based on current dollars (or are adjusted for inflation) and reasonable costs for the required reclamation activities are defined. The financial instrument(s) proposed are acceptable to NRC and meet the total surety requirements (select appropriate description).

Based on the information provided in the application and the detailed review conducted of the procedures for conducting the financial assessment for ground-water restoration, decommissioning, reclamation, waste disposal, and associated monitoring for the _____ *in situ* leach facility, the staff concludes that the procedures are acceptable

and are consistent with 10 CFR Part 40, Appendix A, Criterion 9, which that requires financial surety arrangements be established by each operator; and 10 CFR Part 40, Appendix A, Criterion 10, which requires that the licensee provide funds sufficient for any long-term surveillance requirements. The reviews of the 10 CFR Part 51 environmental protection regulations for domestic licensing and related regulatory functions for plans and schedules for ground-water restoration in accordance with standard review plan Sections 5.0, "Operations" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

6.5.5 References

None.

7.0 ENVIRONMENTAL EFFECTS

7.1 Site Preparation and Construction

7.1.1 Areas of Review

The staff should review how construction activities may disturb the existing terrain and wildlife habitats, including the effects of such activities as building temporary or permanent roads, bridges, or service lines; disposing of trash; excavating; and land filling. The staff should also review information on how much land will be disturbed and for how long and whether there will be dust or smoke problems. The staff should review data indicating the proximity of human populations and identifying undesirable impacts on their environment arising from noise; disruption of stock grazing patterns; and inconvenience from the movement of men, material, or machines, including activities associated with any provision of housing, transportation, and educational facilities for workers and their families. Descriptions of any expected changes in accessibility to historic and archeological sites in the region should be assessed. Discussions of measures designed to mitigate or reverse undesirable effects such as erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats should be reviewed. The staff should also evaluate any discussion on the beneficial effects of site preparation construction activities.

The staff should review the impact of site preparation and construction activities on area water sources and the effects of these activities on fish and wildlife resources, water quality, water supply, aesthetics, as applicable. Reviewers should evaluate measures such as pollution control and other procedures for habitat improvement to mitigate undesirable effects. Staff should consult NUREG–1748 (NRC, 2001) for general procedures for environmental reviews and the environmental assessment process.

The staff should review the resources and ecosystem components cumulatively affected by the proposed action and other past, present, and reasonably foreseeable future actions. The reviewer should examine cumulative impacts by considering whether:

(1) A given resource is especially vulnerable to incremental effects

(2) The proposed action is one of several similar actions in the same geographic area

(3) Other activities in the area have similar effects on the resource

(4) Effects have been historically significant for this resource

(5) Other analyses in the area have identified a cumulative effects concern

7.1.2 Review Procedures

The staff should determine if the application adequately addresses how site preparation and construction activities may disturb the existing terrain, wildlife habitats, and area water sources in compliance with National Environmental Policy Act Requirements in 10 CFR 51.45 and 51.60. The consequences of these activities to both human and wildlife populations should be

considered. The descriptions should be adequately supported by site-specific data, well-documented calculations, and accepted modeling studies. The discussion should include those impacts that are unavoidable as well as those that are irreversible. The staff should ensure that the applicant provides information pertaining to how much land will be disturbed and for how long. The staff should confirm that the effects of the following activities and circumstances, where applicable, are addressed: the building of temporary or permanent roads, bridges, or service lines; disposing of trash; excavating and land filling; and the likelihood of dust and smoke problems. The proximity of site activities to nearby human populations should be addressed, as well as anticipated impacts on their environment including noise; disruption of grazing patterns; inconvenience from movement of material and machines; effects arising from additional housing, transportation, and educational facilities for workers and families; and any disruption in access to historic or archeological sites. The staff should ensure that mitigation measures that are adequate to alleviate or significantly reduce environmental impacts are discussed. Examples of mitigation measures include erosion control, dust stabilization, landscape restoration, control of truck traffic, and restoration of affected habitats.

The staff should consider the adequacy of the cumulative impact analysis with respect to past, present, and reasonably foreseeable actions. The staff should determine if the cumulative analysis adequately considered whether and to what extent the environment has been degraded, whether ongoing activities in the area are causing impacts, and trends for activities and impacts in the area. The Council on Environmental Quality has developed guidance (Council on Environmental Quality, 1997) on considering cumulative impacts in the context of National Environmental Policy Act requirements.

The staff should also evaluate any discussion of likely beneficial effects from site preparation and construction to the extent that such might counteract detrimental effects.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.1.3 Acceptance Criteria

The environmental impacts of site preparation and construction are acceptable if they meet the following criteria:

(1) All environmental impacts from construction activities are adequately described and supported with site-specific data and, where applicable, modeling studies and calculations.

A thorough discussion of all construction activities is provided with associated impacts including the generation and control of wastes; dusts; smoke; noise; traffic congestion; disruption of local public services, routines, and property; and aesthetic impacts.

(2) The applicant adequately describes all unavoidable and irreversible impacts to both the natural environment and nearby human populations.

(3) The applicant adequately describes the amount of land to be disturbed and the length of time it will be disturbed.

(4) The applicant has provided an adequate evaluation of the environmental resources that are vulnerable to the incremented effects from the cumulative impacts of the proposed action and other past, present, and reasonably foreseeable action.

(5) The applicant recommends reasonable mitigation measures for all significant impacts.

(6) The applicant demonstrates that land can be restored to original characteristics.

7.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the site preparation and construction plans, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the plans for site preparation and construction proposed for use at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to conduct the site preparation and construction using the review procedures in standard review plan Section 7.1.2 and the acceptance criteria outlined in standard review plan Section 7.1.3.

The applicant has acceptably identified all environmental impacts from construction activities including waste generation; dusts; smoke; noise; traffic congestion; disruption of public services, routines, and property; and aesthetic impacts. Applicant plans are supported with site-specific data and modeling studies or calculations, where applicable. The effects of all unavoidable and irreversible impacts on the natural environment and humans are acceptable. Disturbance of land and the length and nature of the disturbance are acceptably described. The applicant has recommended appropriate mitigation measures for all significant impacts. The applicant has determined that the land can be returned to its original use after cessation of *in situ* leach operations.

Based on the information provided in the application and the detailed review conducted of the site preparation and construction plans for the _____ *in situ* leach facility, the staff concludes that the proposed site preparation and construction are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property; 10 CFR 40.32(d), which requires that the issuance of the license will not be inimical to the common defense and security nor to the health and safety of the public; 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis.

7.1.5 References

Council on Environmental Quality. "Considering Cumulative Effects Under the National Environmental Policy Act." Washington, DC: Council on Environmental Quality, Executive Office of the President. 1997.

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.2 Effects of Operations

7.2.1 Areas of Review

The staff should review discussions in the application that address the impact of facility operations on the environment, including surface-water bodies, ground water, air, land, land use, ecological systems, and important plants and animals, as discussed in Section 2.0 of this standard review plan. Staff should consult NUREG–1748 (NRC, 2001) for general procedures for environmental reviews and the environmental assessment process.

7.2.2 Review Procedures

The staff should determine whether the application addresses the environmental impact of facility operations on the environment, including surface-water bodies, ground water, air, land, land use, ecological systems, and important plants and animals. The staff should determine whether the supporting evidence is based on and supported by theoretical, laboratory, onsite, or field studies undertaken for this or for previous operations.

The staff should determine whether the proposed facility provides for the protection of ground water from the environmental effects of operations. In conducting the review, the staff should focus on (i) characteristics of the hydrological system, (ii) effluent control systems, (iii) spill detection and containment systems in the processing facilities and storage areas, (iv) ground-water monitoring and surface-water monitoring programs, and (v) the ground-water restoration program provided in the application. This information should provide a strong basis for determining the likely overall effects of any impacts to the ground-water system, such as lixiviant excursions, infiltration from spills, or ruptures of wells.

The staff should ensure that, if surface water exists onsite or is connected to off-site surface-water systems, the likely consequences of impacts of operations on surface water are assessed, and mitigation measures are provided. Likely consequences of impacts might include siltation from disruption of surface ground cover or changes to surface drainage patterns. The staff should also determine whether the applicant has assessed the likelihood for decreased air quality resulting from dust loading from truck traffic on dirt roads and exposure of disturbed surface soils to wind. Radiological impacts to air from operations are assessed in other sections of this standard review plan.

In conducting the review, the staff should consider the applicant's ecological information as reviewed in Section 2.8 of this standard review plan to determine if any endangered or sensitive species of plants and animals exist on site. The level of concern for ecological impacts of operations will be affected by the presence of any such sensitive or endangered species. For most facilities, the ecological impacts are expected to be minimal during this period because of the lack of surface disruption during operations. The staff review should ensure that measures have been taken to restrict terrestrial animals from entering facility grounds by use of fencing and other means. In areas used by migrating waterfowl, additional measures may need to be taken to ensure that any surface impoundments are not used by waterfowl. Local ecological conditions may be such that the facility grounds provide favorable habitat for local wildlife, and efforts to minimize contact between wildlife and contaminated areas should be considered. These efforts will serve to mitigate immediate impacts on local species, but will also serve to limit introduction of contamination into the food chain.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.2.3 Acceptance Criteria

The environmental impacts from operations are acceptable if they meet the following criteria:

(1) All anticipated significant environmental impacts from facility operations are identified and the applicant provides (i) mitigation measures for these impacts, (ii) justification for why impacts cannot be mitigated, or (iii) justification for why it is not necessary to mitigate these impacts to protect the local environment.

(2) At a minimum, the applicant demonstrates that the anticipated impacts on terrestrial and aquatic ecology, air quality, surface- and ground-water systems, land, and land use are environmentally acceptable.

7.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effects of operations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the effects of operations proposed at the _____ *in situ* leach facility. This review included an evaluation of the effects of operations using the review procedures in standard review plan Section 7.2.2 and the acceptance criteria outlined in standard review plan Section 7.2.3.

The applicant has acceptably described all anticipated significant environmental impacts from facility operations. The applicant has provided acceptable (i) mitigation of such impacts, (ii) justification of why impacts cannot be mitigated, or (iii) justification of why it is not necessary to mitigate the impacts to protect the local environment. The applicant has demonstrated that

anticipated impacts to terrestrial ecology, air quality, surface- and ground-water systems, and land use are environmentally acceptable.

Based on the information provided in the application and the detailed review conducted of the effects of operations on the _____ *in situ* leach facility, the staff concludes that the anticipated effects of operations are acceptable and are in compliance with 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR 51.45(c), which requires the applicant to provide sufficient data for the Commission to conduct an independent analysis.

7.2.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.3 Radiological Effects

7.3.1 Exposure Pathways

The staff should review information on the radiological effects of operations on humans, including estimates of the radiological impacts from all exposure pathways. The staff should evaluate descriptions of the plant operations with special attention to the likely pathways for radiation exposure of humans. The staff should review information on accumulation of radioactive material in specific compartments and should ensure that both internal and external doses are included in the analysis. This information can be tabulated using the outline provided in Appendix A of the Standard Format and Content Guide (NRC, 1982).

7.3.1.1 Exposures from Water Pathways

7.3.1.1.1 Areas of Review

The staff should review the estimates of annual average concentrations of radioactive nuclides in receiving water at the site boundary and at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains. The review should include the data presented in support of these estimates, including details of models and assumptions used in supporting calculations of total annual whole body and organ doses to individuals in the off-site population from all receiving water exposure pathways as well as any dilution factors used in these calculations. Additionally, the staff should review estimates of radionuclide concentration in aquatic and terrestrial food chains and associated bioaccumulation factors. The staff should evaluate calculations of internal and external doses. If there are no waterborne effluents from the facility, then these analyses are not needed. Details of models and assumptions used in calculations may be provided in an appendix to the application.

7.3.1.1.2 Review Procedures

The staff should determine whether the concentration estimates at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) which specifies limits for annual average concentrations of radionuclides in liquid effluents. The staff should also check to ensure that calculations of concentrations have been done for receiving water at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains, to meet public dose limits in 10 CFR 20.1301. If the liquid effluent dose is calculated separately from the air pathway dose, it is important that the staff ensures that the results can be summed with the air pathway dose for the total dose comparison to the limit in 10 CFR 20.1301. The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. The staff should review the parameter selections including the justifications provided for important parameters used in the dose calculation. The staff should check the input data for modeling results, to ensure the parameters discussed in the application are the same as those used in the modeling. Code outputs should be spot-checked to ensure that the results are correctly reported in the application. For simple hand calculations, spot calculations can be used to verify that they were done correctly.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.1.3 Acceptance Criteria

The exposures from water pathways are acceptable if they meet the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i), which specifies limits for annual average concentrations of radioactive nuclides in liquid effluents, or the dose limit in 10 CFR 20.1301.

(2) Calculations of concentrations of radionuclides in receiving water at locations where water is consumed or is otherwise used by humans or where it is inhabited by biota of significance to human food chains are included in the compliance demonstration for public dose limits in 10 CFR 20.1301.

(3) For facilities that generate liquid effluents, the relevant exposure pathways are included in a pathway diagram provided by the applicant.

(4) The conceptual model (scenarios and exposure pathways) is similar to and consistent with the methodology for liquid effluent exposure pathways in Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50," Appendix I (NRC, 1977).

(5) The conceptual model used for calculating the source term and individual exposures (and/or concentrations of radionuclides) from liquid effluents at the facility boundary is

representative of conditions described at the site, as reviewed in Section 2.0 of this standard review plan.

(6) The parameters used to estimate the source term, environmental concentrations, and exposures are applicable to conditions at the site, as reviewed in Section 2.0 of this standard review plan.

7.3.1.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the exposures from water pathways, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from water pathways at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.1.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.1.3.

Applicant estimates of individual exposure to radionuclides from water pathways at the site boundary are acceptable since they are less than the requirements in 10 CFR 20.1302 (b)(2)(i) with regard to annual average concentrations in liquid effluents, or they are less than the dose limit in 10 CFR 20.1301. The applicant has demonstrated that the concentrations of radionuclides in receiving water where it is consumed or otherwise used by humans, or where it is inhabited by biota significant to the human food chain are in compliance with the public dose limits in 10 CFR 20.1301. The applicant has included the relevant pathway diagrams in the application. The applicant has used an acceptable representation of the conditions at the site in the determination of the source term for the model calculations. The applicant has acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures, and the parameters are representative of the _____ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from water pathways for the _____ *in situ* leach facility, the staff concludes that the exposures from water pathways are acceptable and are in compliance with 10 CFR 20.1302(b)(2)(i), which specifies limits for annual average concentrations of radionuclides in liquid effluents and 10 CFR 20.1301, which specifies dose limits for individual members of the public.

7.3.1.1.5 References

NRC. Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining." Washington, DC: NRC, Office of Standards Development. 1982.

———. Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50, Appendix I." Washington, DC: NRC, Office of Standards Development. 1977.

7.3.1.2 Exposures from Air Pathways

7.3.1.2.1 Areas of Review

The staff should review estimated release rates of airborne radioactivity considering applicable meteorological data as reviewed in Section 2.0 of this standard review plan. The staff should then review the estimates of annual total body and organ doses to individuals including (i) at the point of maximum ground level concentration offsite, (ii) at the site boundary in the direction of the prevailing wind, (iii) at the site boundary nearest the emission source, and (iv) at the nearest residence in the direction of the prevailing wind. The applicant can choose to show compliance with a concentration limit or with individual dose limits. Therefore, the staff should initially determine the method of compliance chosen by the applicant and focus the review accordingly. Regardless of which compliance method is chosen, the reviewer should also evaluate an individual dose to the public to verify compliance with the requirements in 10 CFR 20.1301. The staff should review data, models, calculations, and assumptions used in support of these estimates. The review should consider both the source term and exposure pathway components of the calculation and should include deposition of radioactive material on food crops and pasture grass.

7.3.1.2.2 Review Procedures

The staff should determine whether the estimates of annual total body and organ doses to individuals at the point of maximum ground level concentrations offsite; individuals exposed at the site boundary in the direction of prevailing wind; individuals exposed at the site boundary nearest to the sources of emissions; and individuals exposed at the nearest residence in the direction of the prevailing wind, meet the regulatory requirements in 10 CFR 20.1301. The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions.

An acceptable computer code that calculates off-site doses to individuals from airborne emissions from *in situ* leach facilities is MILDOS-AREA (Yuan, et al., 1989). This code does not calculate the source term. Therefore, the applicant must provide documentation of the source term calculation that is used as input to MILDOS-AREA (Yuan, et al., 1989), if this code is used. The staff should review the source term equation to ensure that it is an accurate estimation of all significant airborne releases from the facility including, where applicable, yellowcake dust from the dryer stack and radon emissions from processing tank venting and well field releases. If a closed processing loop is used, then radon release from processing is expected to be negligible. If a vacuum dryer is used for yellowcake, then dust emissions from drying may also be assumed to be negligible. The staff should focus attention on the values used for the production flow and the fraction of this flow that is expected to be released during operations. A reasonable estimate of well field radon release is about 25 percent. The staff should also ensure that the source term calculation accounts for all material released during startup, production, and restoration activities.

The review of the MILDOS-AREA (Yuan, et al., 1989) calculation should focus on the code input provided by the applicant. The applicant should have provided a list of the relevant parameter information that was used. The information from this list should be compared with

the input from the code run to ensure that the correct values have been used. Dose results from the code output should be checked against the tabulated results in the application to ensure that the values have been correctly reported. The staff should also evaluate warning messages that the code provides in the output to identify anomalies in the input data or problems with the run. If reported results appear anomalous, the staff may conduct confirmatory analyses using MILDOS-AREA (Yuan, et al., 1989).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.2.3 Acceptance Criteria

The exposures from air pathways are acceptable if they meet the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) with regard to annual average concentrations of radionuclides in airborne effluents or the dose limit in 10 CFR 20.1301. The estimates of individual exposure to radionuclides (not including radon) indicate that the as low as is reasonably achievable constraint on air emissions in 10 CFR 20.1101(d) will be met.

(2) Calculations of concentrations of radionuclides in air at locations downwind where residents live or where biota of significance to human food chains exist are included in the compliance demonstration for public dose limits in 10 CFR 20.1301. The estimates of individual exposures to radionuclides (not including radon) indicate that the as low as is reasonably achievable constraint on air emissions, in 10 CFR 20.1101(d), will be met.

(3) Relevant airborne exposure pathways are included in the pathway diagram provided by the applicant.

(4) The conceptual model used for calculating the source term and individual exposures (and/or concentrations of radionuclides) from airborne effluents at the facility boundary is representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan. The conceptual model is consistent with the methodologies described in Regulatory Guide 3.51, Sections 1–3, "Calculational Models for Estimating Radiation Doses to Man From Airborne Radioactive Materials Resulting From Uranium Mill Operations" (NRC, 1982). The conceptual model for the MILDOS-AREA code (Yuan, et al., 1989) is one acceptable method for performing these exposure calculations. Other methods are acceptable if the applicant is able to satisfactorily demonstrate that the model includes the criteria discussed above.

(5) The parameters used to estimate the source term, environmental concentrations, and exposures are applicable to conditions at the site as reviewed in Section 2.0 of this standard review plan. Guidance on source term calculations is available in Regulatory Guide 3.59, Sections 1–3, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (NRC, 1987). Additionally, an example

source term calculation specifically applicable to *in situ* leach facilities is described in Appendix E.

7.3.1.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from air pathways, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from air pathways at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.2.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.2.3.

Applicant demonstrations of individual exposure to radionuclides from air pathways are acceptable since they are less than the limits in 10 CFR 20.1302 (b)(2)(i) with regard to annual average concentrations in airborne effluents or they are less than the dose limit in 10 CFR 20.1301. The applicant has acceptably demonstrated that the concentrations of radionuclides in air at locations where residents live or where biota of significance to human food chains exist are in compliance with the public dose limits in 10 CFR 20.1301 and the as low as is reasonably achievable constraint on air emissions in 10 CFR 20.1101(d). The applicant has included the relevant airborne exposure pathway diagrams in the application. The applicant has used an acceptable representation of the atmospheric conditions at the site in the determination of the source term and individual exposures for model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the _____ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from air pathways for the _____ *in situ* leach facility, the staff concludes that the exposures from air pathways are acceptable and are in compliance with 10 CFR 20.1302(b)(2)(i), which specifies limits for annual average concentrations of radionuclides in airborne effluents; 10 CFR 20.1301, which specifies dose limits for individual members of the public; and the as low as is reasonably achievable constraint on airborne emissions in 10 CFR 20.1101(d).

7.3.1.2.5 References

NRC. Regulatory Guide 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations." Washington, DC: NRC, Office of Standards Development. 1987.

———. Regulatory Guide 3.51, "Calculational Models for Estimating Radiation Doses to Man From Airborne Radioactive Materials Resulting From Uranium Milling Operations." Washington, DC: NRC, Office of Standards Development. 1982.

Environmental Effects

Yuan, Y.C., J.H.C. Wang,, and A. Zielen. "MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources." Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.3.1.3 Exposures from External Radiation

7.3.1.3.1 Areas of Review

The staff should review estimates of maximum annual external dose that would be received by an individual from direct radiation at the nearest site boundary and in off-site populations. The staff should also review data, models, calculations, and assumptions used in support of these estimates.

7.3.1.3.2 Review Procedures

The staff should determine whether the estimates of maximum annual external dose that would be received by an individual from direct radiation at the nearest site boundary meet the limits specified in 10 CFR 20.1301(a)(2). The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. Staff should confirm that the input parameters used for the external dose calculation are consistent with the information provided in the application. The staff should also confirm that the selected parameter values are representative of conditions at the site as reviewed in Section 2.0 of this standard review plan. Staff should check the source term conceptual model and selected parameter values to ensure that they are appropriate for the site conditions described in the application.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.3.3 Acceptance Criteria

The exposures from external radiation are acceptable if they meet the following criteria:

(1) The estimates of external radiation exposure at the site boundary meet the regulatory limits in 10 CFR 20.1301(a)(2), in accordance with 10 CFR 20.1302(b).

(2) The applicant provides an exposure pathway diagram that includes the relevant external exposure pathways.

(3) The model(s) used for calculating the source term, environmental concentrations, and external exposures at the facility boundary are representative of site conditions reviewed in Section 2.0 of this standard review plan.

(4) The parameters used to estimate the source term, environmental concentrations, and external exposure are applicable to site conditions as reviewed in Section 2.0 of this standard review plan.

7.3.1.3.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects of exposures from external radiation, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposure from external radiation at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.3.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.3.3.

Applicant demonstration of individual exposure to radionuclides from external radiation is acceptable and meets the limits in 10 CFR 20.1301(a)(2) in accordance with the requirements of 10 CFR 20.1302 (b). The applicant has provided an acceptable exposure pathway diagram that includes all relevant external pathways. The applicant has used an acceptable representation of the external exposures at the site in the determination of the source term, environmental concentrations, and individual exposures for the model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the _____ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of exposures from external radiation for the _____ *in situ* leach facility, the staff concludes that the exposures from external radiation are acceptable and are in compliance with 10 CFR 20.1301(a)(2), which specifies limits for radiation doses in unrestricted areas from external sources in accordance with the methods contained in 10 CFR 20.1302(b).

7.3.1.3.5 References

None.

7.3.1.4 Total Human Exposures

7.3.1.4.1 Areas of Review

The staff should review estimates of the maximum annual dose that could be received via all pathways described above by an individual at the site boundary and at the nearest residence. For commercial-scale operations, the staff should also review estimates of radiation dose from all pathways to the regional population within 80 km [50 mi] of the facility including the total annual 100-year environmental dose commitment to the population from all pathways. The staff should also review data, models, calculations, and assumptions used in support of these estimates. Much of this review will already have been completed for the pathway-specific calculations, and the total dose will be the sum of these results.

Environmental Effects

7.3.1.4.2 Review Procedures

The staff should determine whether estimates of the maximum annual dose that could be received via all pathways described above by an individual at the site boundary and at the nearest residence meet regulatory requirements in 10 CFR 20.1301. For commercial-scale operations, the staff should also review estimates of radiation dose from all pathways to the regional population within 80 km [50 mi] of the facility. These calculations can be effectively executed by the MILDOS-AREA code (Yuan, et al., 1989). The staff should also determine whether these estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. After the pathway-specific calculations have been reviewed, staff should check to ensure that the doses have been correctly summed to determine the total dose. Also, staff should ensure the population dose is compared with a meaningful reference dose, such as that which is expected for the exposure to the same population from background radiation sources.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.4.3 Acceptance Criteria

The total human exposure is acceptable if it meets the following criteria:

(1) The estimates of individual exposure to radionuclides at the site boundary meet the regulatory requirements in 10 CFR 20.1302(b)(2)(i) with regard to annual average concentrations of radioactive nuclides in airborne and liquid effluents or the dose limit in 10 CFR 20.1301.

(2) Calculations of the maximum individual whole body and organ doses at the site boundary and for the nearest downwind resident and where biota of significance to human food chains exist are included in the compliance demonstration for public dose limits in 10 CFR 20.1301.

(3) The exposure pathway diagram provided by the applicant includes pathways relevant to all effluents expected from facility operations.

(4) The models used for calculating the source terms and individual exposures (and/or concentrations of radionuclides) from all effluents at the facility boundary are representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan. The conceptual models are acceptable as described in Sections 7.3.1.1, 7.3.1.2, and 7.3.1.3 of this standard review plan.

(5) The parameters used to estimate source terms, concentrations, and exposures are representative of conditions described at the site as reviewed in Section 2.0 of this standard review plan.

7.3.1.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from total human exposures, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of total human exposures at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.4.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.4.3.

Applicant determination of total human exposure to radionuclides at the site boundary is acceptable since it meets the requirements in 10 CFR 20.1301. The applicant has provided an exposure pathway diagram that includes all relevant external pathways. The applicant has used an acceptable representation of the external exposures at the site in the determination of the source term, environmental concentrations, and individual exposures for the model calculations. The applicant has used acceptable values for parameters used to estimate the source term, environmental concentrations, and exposures; and the parameters are representative of the _____ *in situ* leach site.

Based on the information provided in the application and the detailed review conducted of total human exposures for the _____ *in situ* leach facility, the staff concludes that the total human exposures are acceptable and are in compliance with 10 CFR 20.1301 which specifies dose limits for individual members of the public.

7.3.1.4.5 Reference

Yuan, Y.C., J.H.C. Wang, and A. Zielen. "MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources." Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.3.1.5 Exposures to Flora and Fauna

7.3.1.5.1 Areas of Review

The staff should review estimates of maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna. The staff should also review data, bioaccumulation factors, models, calculations, and assumptions used in support of these estimates.

7.3.1.5.2 Review Procedures

The staff should determine whether estimates of maximum radionuclide concentrations that may be present in important local flora and local and migratory fauna are calculated such that environmental impacts from facility operations can be assessed to address the requirements of 10 CFR Part 51. The staff should also determine whether these estimates are supported by

properly interpreted data, reasonable bioaccumulation factors, approved calculations, and model results using reasonable assumptions. Detailed biosphere modeling is not necessary for these calculations. Output from MILDOS-AREA (Yuan, et al., 1989) provides ground level concentrations of radionuclides that can then be converted to plant and animal concentrations by use of simple conversion equations that include deposition, uptake factors, plant interception fractions, and animal consumption rates obtained from the literature. The staff should spot-check parameter values against known sources to ensure that they are within expected ranges. The tabulation of bioaccumulation factors and their sources can be presented in an appendix to the application. Provided these concentrations are protective of human health, they would not be expected to adversely affect native plants and animals (Barnthouse, 1995).

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.3.1.5.3 Acceptance Criteria

The exposures to flora and fauna are acceptable if they meet the following criterion:

(1) The model and parameter values used for calculation of concentrations of radionuclides in important local flora and fauna are consistent with generally accepted health physics practice and are applicable to the species identified at the site, as reviewed in Section 2.0 of this standard review plan.

7.3.1.5.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radiological effects from exposures to flora and fauna, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the radiological effects of exposures to flora and fauna at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate radiological effects using the review procedures in standard review plan Section 7.3.1.5.2 and the acceptance criteria outlined in standard review plan Section 7.3.1.5.3.

The applicant has demonstrated that the off-site impacts of operation would be minimal. Flora and fauna in the areas surrounding the project site are similar to those onsite and are common in the region. Since calculated human exposures are protective of human health, they would not be expected to adversely affect the native plants and animals, and as such, are acceptable.

Based on the information provided in the application and the detailed review conducted of exposures to flora and fauna for the _____ *in situ* leach facility, the staff concludes that the exposures to flora and fauna are acceptable and are in compliance with 10 CFR Part 51 which requires that environmental impacts from facility operations be assessed.

7.3.1.5.5 References

Barnthouse, L.W. "Effects of Ionizing Radiation on Terrestrial Plants and Animals, A Workshop Report." ORNL/TN–13141. Oak Ridge, Tennessee: Oak Ridge National Laboratory. 1995.

Yuan, Y.C., J.H.C. Wang, and A. Zielen. "MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources." Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989.

7.4 Non-Radiological Effects

7.4.1 Areas of Review

The staff should review estimates of concentrations of nonradioactive wastes in effluents at the points of discharge as compared with natural ambient concentrations without the discharge and with applicable standards. The review should include the projected effects of the effluents for both acute and chronic exposure of the biota (including any long-term buildup in soils and sediments and in the biota). The staff should evaluate discussions of dilution and mixing of discharge into the receiving environs, and estimates of concentrations at various distances from the point of discharge. The effects on terrestrial and aquatic environments from chemical wastes that contaminate ground water should also be examined.

The staff should also review discussions of any likely consequences of the proposed operation that do not clearly fall under any specific topic previously addressed. These may include changes in land and water use at the project site; sanitary and other recovery plant waste systems; interaction of the facility with other existing or projected neighboring facilities; effects of ground-water withdrawal on ground-water resources in the vicinity of the well field(s) and recovery plant(s); effects of construction and operation of roads, transmission corridors, railroads, et cetera; effects of changes in surface-water availability on biotic populations; and disposal of other solid and liquid wastes.

7.4.2 Review Procedures

The staff should determine whether the specific estimated concentrations of nonradioactive wastes in effluents at the point of discharge and the projected effects for both acute and chronic exposure of the biota are adequately quantified in accordance with the National Environmental Policy Act requirements in 10 CFR 51.45 and 51.60. Where applicable, the staff should determine whether these estimates are supported by properly interpreted data, reasonable bioaccumulation factors, calculations, and model results using reasonable assumptions.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.4.3 Acceptance Criteria

The non-radiological effects are acceptable if they meet the following criteria:

(1) The estimated concentrations of nonradioactive wastes in effluents at the point of discharge and the projected effects for both acute and chronic exposure of the biota are adequately quantified in accordance with the National Environmental Policy Act of 1969 requirements in 10 CFR 51.45 and 51.60.

7.4.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the nonradiological effects, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the nonradiological effects at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate nonradiological effects using the review procedures in standard review plan Section 7.4.2 and the acceptance criteria outlined in standard review plan Section 7.4.3.

The applicant has acceptably described anticipated significant nonradiological environmental impacts from facility operations. The estimated effects of nonradioactive wastes in effluents at the point of discharge and the projected effects for both acute and chronic exposure of biota are acceptable.

Based on the information provided in the application and the detailed review conducted of nonradiological effects for the _____ *in situ* leach facility, the staff concludes that the nonradiological effects are acceptable and are in compliance with 10 CFR Part 51.45 which specifies the content of environmental reports.

7.4.5 References

None.

7.5 Effects of Accidents

7.5.1 Areas of Review

The NRC has evaluated the effects of accidents at *in situ* leach facilities [NUREG–0706 (NRC, 1980); Center for Nuclear Waste Regulatory Analyses, 2001]. These analyses demonstrate that, for most potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. Specific areas where NRC analyses (NRC, 1980; Center for Nuclear Waste Regulatory Analyses, 2001) indicated that consequences could be significant are (i) radon releases from process streams, (ii) yellowcake dryer explosions, (iii) lixiviant leaks in buried piping between the well fields and the processing facility, and (iv) chemical accidents.

Applicants whose facilities are consistent with the operating assumptions, site features, and designs examined in these NRC analyses need not conduct independent accident analyses. For these applicants, the staff review should focus on accidents procedures and personnel training in their use. Personnel training is evaluated using Section 5.5 of this standard review plan. If an applicant's operating assumptions, site features, and designs are not consistent with these analyses, the applicant must conduct independent accident analyses. In that case, the staff review should evaluate the adequacy of these independent analyses. The scope of this review includes radiological, nonradiological, and transportation accidents. This review should verify that the accident analyses address a spectrum of accidents ranging in severity from trivial to significant, including a characterization of the occurrence rate or probability and likely consequences.

For all applicants, the reviewers should examine standard operating and accident procedures and the training programs for ensuring that personnel can execute them properly. *In situ* leach facility training programs are reviewed using Section 5.5 of this standard review plan.

7.5.2 Review Procedures

For applications that contain independent accident analyses, the staff should determine whether accident scenarios described in the application are reasonable based on descriptions of the facility and operations reviewed in Sections 3.0, 4.0, and 5.0 of this standard review plan and are sufficiently complete to determine environmental impacts of operations pursuant to National Environmental Policy Act requirements. The staff should determine whether these scenarios and estimates are supported by properly interpreted data, calculations, and model results using reasonable assumptions. If consequences cannot be quantified, a qualitative description of the impacts should be reviewed for adequacy. The staff should confirm that uranium extraction industry experience is used to support any accident analyses, including consideration of plant design and specific components that are prone to failure or are known to have failed at other facilities.

For independent analyses of transportation accidents, the staff need not review all operational aspects of transportation activities, as these will be addressed through inspections relevant to the general transportation license requirements.

The staff should ensure the applicant has procedures in place to detect and respond to postulated accident conditions and to mitigate consequences. The reviewers should pay particular attention to procedures related to monitoring, identification, and response to accidents related to (i) radon release, (ii) yellowcake dryer operations, (iii) leaks in buried lixiviant piping, and (iv) chemical releases as they might affect radiological accidents.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.5.3 Acceptance Criteria

The independent analyses of consequences of accidents are acceptable if they meet the following criteria:

(1) The applicant has provided analyses of probable accident consequences that are consistent with the facility design and planned operations and are sufficient to identify likely environmental impacts from operations.

(2) Analyses of accident consequences include mitigation measures, as appropriate.

(3) Analyses of accidents include results from operating experience at similar facilities.

(4) For radiological accidents, the applicant's response program provides for notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

Adequate procedures to respond to and mitigate or remediate the likely consequences of accidents are identified or referenced in the application.

7.5.4 Evaluation Findings

If the staff's review, as described in this section, results in acceptance of the effects of accidents, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the effects of accidents for the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate the effects of accidents using the review procedures in standard review plan Section 7.5.2 and the acceptance criteria outlined in standard review plan Section 7.5.3.

The applicant has acceptably described all likely significant effects of accidents from facility operations. The applicant has provided an acceptable analysis of probable accidents and their consequences, if necessary, consistent with facility design, site features, and planned operations. If appropriate, the applicant has confirmed that facility design, site features, and planned operations are consistent with previous NRC accident analyses. The applicant has identified likely environmental impacts from such accidents and has included mitigation measures. Any accident analyses have considered past operating experience from similar facilities. Adequate response and remediation procedures have been identified or referenced, and the facility personnel will be qualified to implement them. The applicant's response program for radiological accidents will comply with the notification requirements of 10 CFR 20.2202 and 20.2203.

Based on the information provided in the application and the detailed review conducted of the effects of accidents for the _____ *in situ* leach facility, the staff concludes that the effects of accidents are acceptable and are in compliance with 10 CFR Part 51.45, which specifies the content of environmental reports; 10 CFR 40.32(c), which requires that the applicant's proposed equipment, facilities, and procedures be adequate to protect health and

minimize danger to life or property; and 10 CFR 20.2202 and 20.2203, which define response program requirements for radiological accidents.

7.5.5 References

Center for Nuclear Waste Regulatory Analyses. "Final Report on a Baseline Rick-Informed, Performance-Based Approach for *In Situ* Leach Uranium Extraction Licenses." San Antonio, Texas: Center for Nuclear Waste Regulatory Analyses. 2001.

NRC. NUREG–0706, "Final Generic Environmental Impact Statement on Uranium Milling—Project M–25." Washington, DC: NRC. September 1980.

7.6 Economic and Social Effects of Construction and Operation

The staff should review descriptions in the application related to the likely economic and social effects of construction and operation of the proposed facility. These impacts should be discussed in separate sections covering benefits, costs, and resources committed.

7.6.1 Benefits

7.6.1.1 Areas of Review

The staff should review social and economic benefits from the proposed *in situ* leach operations that affect various political jurisdictions or public and private interests. Some of these reflect transfer payments or other values that may partially, if not fully, compensate for certain services as well as external or environmental costs, and this fact should be reflected in the designation of the benefit. Some examples of benefits to be reviewed include

(1) Tax revenues to be received by local, state, and federal governments

(2) Temporary and permanent new jobs created and the associated payroll (value-added concept)

(3) Incremental increases in regional productivity of goods and services

(4) Enhancement of recreational values

(5) Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats

(6) Creation and improvement of local roads, waterways, or other transportation facilities

(7) Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with plant operation and technological improvements from applicant research programs

Environmental Effects

The staff should also review discussions of significant benefits that may be realized from construction and operation of the proposed facility, including expressions in monetary terms, discounted to present worth, of who is likely to be affected and for how long. In the case of aesthetic impacts that are difficult to quantify, the staff should review photographs or pictorial drawings of structures or environmental modifications visible to the public.

7.6.1.2 Review Procedures

The staff should determine whether sufficient detail is presented to evaluate significant economic and social benefits that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility. The staff should determine whether the likely benefits are reasonable and supported by properly interpreted data, calculations, and model results, using reasonable assumptions. The staff should determine to what extent likely benefits can serve to offset adverse effects and costs of construction and operation of the facility. The Standard Format and Contents of License Applications, Including Environmental Reports (NRC, 1982) provides a list of the types of benefits to be included in the application. The NRC has also provided guidance in NUREG–1748 (NRC, 2001) for compliance with requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.6.1.3 Acceptance Criteria

The economic and social effects of construction and operation are acceptable if they meet the following criteria:

(1) The applicant's analyses of economic and social benefits that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility are supported by properly interpreted data, calculations, and model results.

(2) For each benefit identified, the applicant identifies who is affected and the duration of the impact.

(3) For special case environmental assessments (e.g., those that have substantial public interest, decommissioning costs involving on-site disposal, decommissioning/ decontamination cases that allow radioactivity in excess of release criteria, or cases where environmental justice issues have been previously raised) the applicant has provided sufficient data to assess environmental justice issues in accordance with NUREG–1748 (NRC, 2001).

7.6.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effects of the economic and social benefits of construction and operation, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the economic and social benefits of construction and operation proposed at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate effects of economic and social benefits of construction and operation using the review procedures in standard review plan Section 7.6.1.2 and the acceptance criteria outlined in standard review plan Section 7.6.1.3.

The applicant has acceptably described anticipated economic and social benefits of construction and operation of the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of the standard review plan. The applicant has provided an acceptable analysis of probable benefits consistent with the facility design and industrywide experience. The applicant has included analyses of (i) tax revenues, (ii) creation of temporary and permanent jobs and accrued payroll, (iii) incremental increases in regional productivity of goods and services, (iv) enhancement of recreational values, (v) environmental enhancement and increased knowledge of the environment through ecological research and environmental monitoring programs, and (vi) creation and improvement of infrastructure (e.g., roads, waterways, water and power supply, and other transportation facilities). The applicant has acceptably identified for each benefit who is affected and the expected duration of the beneficial effect. Overall, the applicant has demonstrated that the analysis of the economic and social benefits from the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility are supported by properly interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of economic and social benefits of construction and operation for the _____ *in situ* leach facility, the staff concludes that the economic and social benefits of construction and operation are acceptable and are in compliance with 10 CFR Part 51.45(c) which requires an analysis that balances the impacts of proposed actions.

7.6.1.5 References

NRC. Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for *In Situ* Uranium Solution Mining." Washington, DC: NRC, Office of Standards Development. 1982.

———. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

7.6.2 Socioeconomic Costs

7.6.2.1 Areas of Review

The staff should review information presented concerning the primary corporate internal costs including (i) the capital costs of land acquisition and improvement; (ii) the capital costs of facility construction; (iii) other operating and maintenance costs, including license fees and taxes; (iv) ground-water quality restoration, surface reclamation, and plant decommissioning costs; and (v) research and development costs, including postoperational monitoring requirements. The applicant should discount these costs to present worth. Resource commitments are addressed in Section 7.6.3 of this standard review plan.

The staff should also review information on external costs, including the probable number and location of the population group is adversely affected, the estimated economic and social impact, and any special measures taken to alleviate the impact. Environmental justice considerations are presented in NUREG–1748 (NRC, 2001).

Temporary external costs should also be evaluated including housing shortages; inflationary rentals or prices; congestion of local streets and highways; noise and temporary aesthetic disturbances; overloading of utilities, water supply, and sewage treatment facilities; crowding of local schools, hospitals, or other public facilities; overtaxing of community services; and disruption of people's lives or of the local community caused by acquisition of land for the proposed site.

Finally, the staff should review information regarding long-term external costs including: (i) impairment of recreational values (e.g., reduced availability of desired species of wildlife and sport animals, or restrictions on access to land or water areas preferred for recreational use); (ii) deterioration of aesthetic and scenic values; (iii) restrictions on access to areas of scenic, historic, or cultural interest; (iv) degradation of areas having historic, cultural, natural, or archeological value; (v) removal of land from present or contemplated alternative uses; (vi) reduction in quantities of regional products because of displacement of persons from the land proposed for the site; (vii) lost income from recreation or tourism that may be impaired by environmental disturbances; (viii) lost income attributable to environmental degradation; (ix) decrease in real estate values in areas adjacent to the proposed facility; and (x) increased costs to local governments for the services required by the permanently employed workers and their families. In discussing these costs, the applicant should indicate, to the extent practical, who is likely to be affected, to what degree, and for how long.

7.6.2.2 Review Procedures

The staff should determine whether sufficient detail is presented to evaluate significant economic and social internal and external costs that may be incurred during construction, operation, restoration, reclamation, and decommissioning of the proposed facility. The assessment of costs should be reviewed in the context of the information provided in other chapters of the application as reviewed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan to ensure consistency and completeness. The staff should review any data,

models, calculations, and assumptions used in support of these projections. The staff should ensure the applicant has identified who it is that will bear the cost, the number of such people, the duration of the impacts, and what measures will be taken to mitigate the impacts. Costs should be discounted to present worth. The NRC has provided guidance in NUREG–1748 (NRC, 2001) for compliance with the socioeconomic requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

7.6.2.3 Acceptance Criteria

The costs of the *in situ* leach operations are acceptable if they meet the following criteria:

(1) The analyses of economic and social costs that may be realized from construction, operation, restoration, reclamation, and decommissioning of the proposed facility are supported by properly interpreted data, calculations, and model results.

(2) For each cost identified, the applicant identifies who is affected, the duration of impacts, and any mitigation measures necessary to alleviate or reduce impacts.

(3) Costs are discounted to present worth.

7.6.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the effects of the economic and social costs of construction and operation, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the effects of economic and social costs of construction, operation, restoration, reclamation, and decommissioning operations proposed at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to evaluate effects of economic and social costs of construction and operation using the review procedures in standard review plan Section 7.6.2.2 and the acceptance criteria outlined in standard review plan Section 7.6.2.3.

The applicant has acceptably described all anticipated economic and social costs of construction and operation of the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan. The applicant has provided an acceptable analysis of probable costs consistent with the facility design and industrywide experience. The applicant has included analyses of (i) impairment of recreational values; (ii) restriction on access to water or land for recreational use; (iii) restriction on access to areas of scenic, historic, or cultural interest; (iv) deterioration of aesthetic and scenic values; (v) degradation of areas having historic, cultural, natural, or archeological values; (vi) removal of land from present or contemplated alternative uses; (vii) reductions in quantities

of regional products; (viii) lost income from recreation or tourism that may be impaired by environmental disturbances; (ix) lost income attributable to environmental degradation; (x) decrease in real estate values adjacent to the proposed facility; and (xi) increased costs to local governments for increased services and infrastructure. The applicant has identified for each cost who is affected, to what extent, and the expected duration of the effect. Overall, the applicant has demonstrated that the analysis of the economic and social costs from the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility is supported by acceptably interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of economic and social costs of construction and operation for the _____ *in situ* leach facility, the staff concludes that the economic and social costs of construction and operation are acceptable and are in compliance with 10 CFR Part 51.45(c) which requires an analysis that balances the impacts of proposed actions.

7.6.2.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

8.0 ALTERNATIVES TO PROPOSED ACTION

8.1 Areas of Review

The staff will review comparative reconnaissance level evaluations of available alternatives to the licensing action proposed in the *in situ* leach facility application in accordance with the requirements of National Environmental Policy Act of 1969 including realistic alternatives for the various processing stages. As part of this review, the staff should consider to no-action alternative. Alternative designs do not have to be described in as great detail as the proposed action. The purpose of these evaluations is to determine that alternatives that provide a significant reduction in impacts to human health and the environment have not been overlooked. The reviews should include descriptions of the ground-water quality restoration programs to be applied for each alternative other than the no-action alternative. The staff should evaluate alternatives that may reduce or avoid significant adverse environmental, social, and economic effects expected to result from construction and operation of the proposed facility. The staff should also review the bases and rationales for the choices in regard to number, availability, suitability, and factors limiting the range of alternatives that might avoid some or all of the environmental effects identified in Section 7.0 of this standard review plan. For commercial-scale operations, the review should include the comparative evaluation of available alternatives using results obtained from research and development operations, if applicable.

The staff should also review waste management alternatives considering siting, design, and operational performance objectives developed by NRC staff, in addition to the plans for final disposal discussed in Section 6.0 of this standard review plan.

The review should include discussions regarding locating the liquid impoundment areas at sites where disruption and dispersion by natural forces are eliminated or reduced to acceptable levels, and designing the impoundment areas so that seepage of materials into the ground-water system would be eliminated or reduced to acceptable levels.

8.2 Review Procedures

The staff should determine that the applicant has justified the choice of particular recovery processes for the ore body by considering and choosing among techniques and processes that affect the environment in minimal ways. The justification should include a comparative evaluation of the available practicable alternatives. Strengths and weaknesses associated with the likely effects of the use of each technique or process, including the ground-water quality restoration program, should be presented. The staff should determine whether the applicant has considered and chosen those alternatives that may reduce or avoid significant adverse environmental, social, and economic effects expected to result from the construction and operation of the proposed facility. The staff should evaluate the bases and rationales the applicant used for the consideration and rating of the alternatives. The staff should determine that, for commercial-scale operations, the comparative evaluation of available alternatives includes results from research and development operations or similar production-scale sites, if appropriate. The staff shall evaluate whether the proposed action would meet the requirements of 10 CFR Part 40, Appendix A.

Alternatives to Proposed Action

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

8.3 Acceptance Criteria

The evaluation of alternatives to the proposed action is acceptable if it meets the following criteria:

(1) The applicant considers process alternatives to the proposed action. The applicant identifies alternatives to the operation of the proposed facility in the manner reviewed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan that may mitigate adverse environmental, social, and economic effects reviewed in Section 7.0 of this standard review plan. These alternatives may include, but are not limited to

(a) The no-action alternative (must be included)

(b) Alternative ore extraction processes such as traditional open-pit and underground mining

(c) Alternative lixiviant chemistry

(d) Alternative ground-water restoration and long-term monitoring techniques

(e) Alternative monitoring and waste management practices

(f) Uranium recovery process alternatives

(g) Construction of a central processing facility versus use of satellite facilities

(2) The alternatives are compared with the proposed actions considering the site characteristics as reviewed in Section 2.0 of this standard review plan and consistent with existing uranium extraction standards and practices.

The rationale for selecting the proposed method should be provided, and the proposed action should be shown to be at least as effective as the considered alternatives in meeting all regulatory requirements. If the application is for a new commercial-scale license, the consideration should be based on the results of the research and development site, if applicable.

(3) The applicant considers the environmental, social, and economic effects of a no-action alternative. Presumably, the applicant will provide information to demonstrate that the proposed action will provide social and economic benefits that outweigh the environmental impact of operating the facility.

(4) The applicant clearly identifies the preferred alternative and demonstrates that it would meet the requirements of 10 CFR Part 40, Appendix A.

8.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the alternatives to the proposed action, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the alternatives to the proposed action at the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to develop the alternatives to the proposed action using the review procedures in standard review plan Section 8.2 and the acceptance criteria outlined in standard review plan Section 8.3.

The applicant has considered other alternatives to its proposed *in situ* leach facility such as open-pit or underground mining. Alternatives to the proposed facility operations that might mitigate environmental, social, and economic effects identified in standard review plan Section 7.0 are presented in a form similar to that required in Sections 2.0, 3.0, 4.0, 5.0, and 6.0, of this standard review plan. Alternatives were acceptably considered for lixiviant chemistry, ground-water restoration techniques, waste management practices, and uranium recovery processes. The applicant has demonstrated that the choice of alternative is effective in meeting the applicable requirements of 10 CFR Part 40, Appendix A. Data from past operations or considerations based on results of an research and development site were included in the evaluation of the alternatives, as appropriate. The applicant has considered a no-licensing alternative and has demonstrated that the social and economic benefits of the proposed _____ *in situ* leach facility outweigh any adverse environmental impact of the facility.

Based on the information provided in the application and the detailed review conducted of alternatives to the proposed action for the _____ *in situ* leach facility, the staff concludes that the assessment of alternatives to the proposed action is acceptable and is in compliance with 10 CFR Part 51.45(b)(3) which requires that alternatives to the proposed action be analyzed and applicable portions of 10 CFR Part 40, Appendix A, which provides the requirements for extracting source material from ores and for disposal of the associated wastes.

8.5 References

None.

9.0 BENEFIT-COST ANALYSIS

9.1 Areas of Review

The benefit-cost analysis proposed in this section is intended to be a summary of the benefits and costs of the proposed facility. The staff should review the discussion provided and any accompanying illustrations and tables that explain the important benefits and costs of the proposed facility and operations to determine that the issuance of a license is justified. It is important that both quantitative and qualitative justifications be supported with acceptable data and appropriate rationale.

The review should include criteria for assessing and comparing benefits and costs where these are expressed in nonmonetary or qualitative terms and rationales for the selection of process alternatives as well as subsystem alternatives. The staff should also evaluate descriptions of any likely cumulative effects, and the rationale for omitting apparent benefits or costs.

The staff should review irreversible and irretrievable commitments of resources caused by the construction, operation, restoration, reclamation, and decommissioning of the proposed facility. This review should include both relative impacts and long-term net effects. Such resources should include permanent land withdrawal, irreversible or irretrievable commitments of mineral resources, water resource needs and ground-water consumption, permanent vegetation and wildlife losses (e.g., unique habitat, species), and consumption of material resources such as processing chemicals and power or energy needs. The staff should review information presented concerning the percentage terms in which the expected resource loss is related to the total resource in the immediate region and in which the immediate region is related to the surrounding regions in terms of affected areas and distances from the site.

9.2 Review Procedures

The reviewer should determine that the benefit-cost statement has been summarized in the form of a narrative and accompanying tables and charts. The important benefits and costs should be contrasted and discussed appropriately to justify the issuance of the license.

The reviewer should determine that the applicant has developed criteria for assessing and comparing benefits and costs where they are expressed in nonmonetary or qualitative terms. Among the criteria that should be considered are (i) ground-water quality or quantity effects, (ii) radiological impact, and (iii) disturbance of the land. The applicant should present the rationales for the selection of process alternatives as well as subsystem alternatives. The reviewer should ascertain that any likely cumulative and symbiotic effects have been detailed along with appropriate rationales for any tradeoffs. If any apparent benefits or costs have been omitted by the applicant, the reviewer should determine that the applicant has presented the rationale for such omissions. The staff should determine that the applicant has related all the terms used in the benefit-cost analysis to the relevant sections of the application. Overall, the benefit-cost section should demonstrate to reviewer satisfaction that the proposed project is a positive economic and social activity.

The staff should determine whether sufficient detail is presented to evaluate irreversible and irretrievable commitments of resources because of the construction, operation, restoration,

reclamation, and decommissioning of the proposed facility. These commitments should be reviewed considering the facility description and operations discussed in other sections of this SRP to ensure consistency and completeness. Resource needs previously identified in existing environmental reports for similar facilities that are currently operating can be used in the staff's review for comparison.

NUREG–1748 (NRC, 2001) provides guidance for compliance with the socioeconomic and cost-benefit considerations required by the National Environmental Protection Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

9.3 Acceptance Criteria

The benefit-cost analysis is acceptable if it meets the following criteria:

(1) The economic benefits of the construction and operation of the proposed facility are acceptably summarized. These may include, but are not limited to

   (a) Tax revenues to be received by federal, state, and local governments

   (b) Temporary and permanent jobs

   (c) Incremental increases in regional productivity of goods and service

   (d) Enhancement of recreational values

   (e) Environmental enhancement in support of the propagation or protection of wildlife and the improvement of wildlife habitats

   (f) Creation and improvement of local roads, waterways, or other transportation facilities

   (g) Increased knowledge of the environment as a consequence of ecological research and environmental monitoring activities associated with plant operation and technological improvements from the applicant's research program

(2) Economic benefits are estimated based on realistic assumptions and objective sources such as census data, tax information, and other site characteristics reviewed in Section 2.0 of this standard review plan.

(3) The applicant provides a summary of internal costs, including capital costs of land acquisition and improvement, capital costs of facility construction, other operating and maintenance costs, plant decommissioning and site reclamation costs, and the costs of future improvements in the proposed facility. The costs of ground-water restoration,

decommissioning, and reclamation are considered as presented in the financial assessment for surety reviewed in Section 6.5 of this standard review plan.

(4) The applicant summarizes short-term external costs as they affect the interests of people other than the owners and operators of the proposed facility. These may include, but are not limited to

(a) Housing shortages

(b) Local inflation

(c) Noise and congestion

(d) Overloading of the water supply, water treatment facilities, and disposal landfills

(e) Crowding of schools, hospitals, recreational facilities, or other public facilities

(f) Disruption of people's lives (e.g., ranching, farming) through the acquisition of land

(5) The applicant summarizes long-term external costs as they affect the interests of people other than the owners and operators of the proposed facility. These may include, but are not limited to

(a) Impairment of recreational values through reduction in wildlife and sport animals

(b) Restrictions on access to land or water

(c) Aesthetic impacts

(d) Degradation or limited access to areas of historical, scenic, or cultural interests

(e) Lost income related to limitations on access to land and facilities

(f) Decreased real estate values

(g) Increased cost to provide government services for increased populations

(6) The applicant identifies who is most likely to be affected by the construction and operation of the proposed facility, and to the extent possible, identifies how long the disturbance is expected. This information should be consistent with the population information reviewed in Section 2.3 of this standard review plan.

(7) If the application is for a renewal, the applicant provides a summary of the actual economic benefits and costs of the facility since the last licensing action.

(8) A comparison of the benefits and costs is presented that acceptably justifies proceeding with the *in situ* leach operations.

(9) For special case environmental assessments (e.g., those that have substantial public interest, decommissioning cases involving on-site disposal, decommissioning/ decontamination cases that allow radioactivity in excess of release criteria, or cases where environmental justice issues have been previously raised) the applicant has provided sufficient data to assess environmental justice issues in accordance with NUREG–1748 (NRC, 2001).

(10) The irreversible and irretrievable commitments of resources for the construction, operation, restoration, reclamation, and decommissioning of the proposed facility are appropriate considering the following:

(a) Permanent land withdrawal

(b) Permanent commitment of mineral resources

(c) Permanent commitment of water resources

Post ground-water restoration impacts at public water supply wells are acceptable if the water quality at town wells is consistent with EPA primary and secondary drinking water standards and NRC standards for uranium

(d) Irreversible loss of surface vegetation

(e) Irreversible loss of wildlife or wildlife habitat

(f) Irreversible commitments of material resources including processing chemicals and energy needs

(11) For each resource area, the applicant identifies who is affected, the duration of impacts, and any mitigation measures proposed as necessary to alleviate or reduce impacts

9.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the benefit-cost analysis, the following conclusions may be presented in the environmental assessment.

NRC has completed its review of the benefit-cost analysis for the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to conduct the benefit-cost analysis and the results using the review procedures in standard review plan Section 9.2 and the acceptance criteria outlined in standard review plan Section 9.3.

The applicant has acceptably summarized the social and economic benefits of the construction and operation of the proposed _____ *in situ* leach facility including (i) additional tax

revenues, (ii) temporary and permanent jobs, (iii) incremental increases in regional product, (iv) enhancement of recreational values, (v) environmental enhancement including protection or propagation of wildlife, (vi) creation and improvements in local infrastructure, and (vii) increased awareness of the environment resulting from ecological research and monitoring and any technological improvements resulting from the applicant's program. The applicant has determined economic benefits from objective sources including (i) census data, (ii) tax information, and (iii) other data as evaluated in Section 2.0 of this standard review plan. The applicant has acceptably summarized costs including (i) internal, (ii) capital, (iii) other operating and maintenance, (iv) plant decommissioning and site reclamation, and (v) future improvements. The costs for ground-water restoration, decommissioning, and reclamation, as considered in the financial assessment for surety reviewed in Section 6.5 of this standard review plan, are acceptable. The applicant has identified all short-term *in situ* leach facility-driven external costs including (i) housing shortages, (ii) local inflation, (iii) noise and congestion, (iv) overloading of infrastructure (e.g., schools, water supply, transportation links), and (v) disruption of people's lives as a result of land acquisition. The applicant has acceptably determined all facility-driven long-term external costs including (i) impacts on recreation through reduction in wildlife or sport animals; (ii) restrictions to access to land or water; (iii) aesthetic impacts; (iv) degradation or limited access to historic, scenic, or cultural interests; (v) lost income related to limitations on access to land or recreational facilities; (vi) decreased real estate values; and (vii) increased costs to provide government services for any additional population. The applicant has acceptably identified and considered the extent and longevity of the effect of construction and operation on individuals. The applicant has presented a comparison of the benefits and costs that acceptably justifies the proposed *in situ* leach facility and operations.

The applicant has acceptably described all anticipated economic and social effects of resources committed at the facility covering the affected environment and the full extent of activities discussed in Sections 2.0, 3.0, 4.0, 5.0, and 6.0 of this standard review plan. The applicant has provided an acceptable analysis of probable effects consistent with the facility design and industry-wide experience. The applicant has included analyses of (i) permanent land withdrawal; (ii) permanent commitment of mineral resources; (iii) permanent commitment of water resources; (iv) irreversible loss of surface vegetation; (v) irreversible loss of wildlife or wildlife habitat; and (vi) irreversible commitments of material resources, including processing chemicals and energy needs. The applicant has acceptably identified, for each resource committed, who is affected, to what extent, and the expected duration of the effect. Overall, the applicant has demonstrated that its analysis of resources committed as a result of the construction, operation, restoration, reclamation, and decommissioning of the proposed *in situ* leach facility is supported by properly interpreted data, calculations, and model results.

Based on the information provided in the application and the detailed review conducted of the benefit-cost analysis for the _____ *in situ* leach facility, the staff concludes that the benefit-cost analysis is acceptable and is in compliance with 10 CFR Part 51.45(c) which requires that economic, technical, and other benefits and costs of the proposed action and alternatives be considered.

9.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 Areas of Review

The staff should review all licenses, permits, and other approvals of construction and operations required by federal, state, local, and regional authorities for the protection of the environment including a list of those federal and state approvals that have already been received, and the status of those pending approvals. The staff should also review similar information regarding approvals, licenses, and contacts with tribal authorities. The staff should examine previously submitted environmental assessments or environmental impact statements, if appropriate.

The staff should evaluate discussions of the status of efforts to obtain a water quality certification under Section 401 and discharge permits under Section 402 of the Federal Water Pollution Control Act, as amended, if required, including the rationale if certification is not required. The staff should also note the state, local, and regional planning authorities that have been contacted or consulted.

Finally, the staff should review descriptions and records of public meetings and of meetings held with environmental and other citizen's groups with reference to specific instances of the compliance with citizens' group recommendations.

10.2 Review Procedures

The reviewer should determine that the applicant has satisfied all license, permit, and other approvals of construction and operations that are required by federal, state, local, and regional authorities with jurisdiction for the protection of the environment. Types of licenses or permits may include but are not limited to (i) source materials, (ii) underground injection, (iii) surface impoundment construction, (iv) surface discharge, (v) industrial ground water, (vi) aquifer exemption, (vii) air quality, and (viii) disposal well. The federal and state approvals that have already been received should be listed, and those pending approval should be appropriately identified. The reviewer should determine that the applicant has presented the appropriate environmental assessment or full environmental impact statement for the proposed *in situ* leach site and surrounding area, regardless of whether the assessments are preexisting or prepared especially for this application. This section is intended to cover licensing and permitting of the process as a whole or parts of the process, and does not require a listing of certifications that may be required for equipment or personnel. Copies of associated documentation may be provided as an appendix to the application. NUREG–1748 (NRC, 2001) provides guidance for evaluating compliance with the consultation requirements of the National Environmental Policy Act.

For license renewals and amendment applications, Appendix A to this standard review plan provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

10.3 Acceptance Criteria

The status of environmental approvals and consultations is acceptable if it meets the following criteria:

(1) The applicant provides a summary of all permits or licenses obtained for the proposed facility. These should clearly identify

(a) The type of permit or license

(b) The granting authority (local, state, regional, tribal authorities, or federal)

(c) The permit or license number (if appropriate)

(d) The current status, with expiration date, if appropriate

(2) For permits not yet granted, the applicant provides a discussion of the current status of the application and objective evidence that the applicant has applied for, but has not yet received, the permit from the granting authority. Such evidence may include copies of documents such as letters from the granting authority or the permit application.

(3) For permits and licenses not yet granted, the applicant indicates when approval is expected. Consultations with the granting authority can be summarized.

(4) The granting authority is clearly defined and appropriate to the area being permitted or licensed. If permits are granted under Agreement State status, this should be identified in the application.

(5) The applicant summarizes public meetings and meetings held with environmental and other citizens' groups since the last licensing application, and responses to the concerns expressed at these meetings.

10.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the environmental approvals and consultations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the environmental approvals and consultations for the _____ *in situ* leach facility. This review included an evaluation of the methods that will be used to acquire the environmental approvals and consultations using the review procedures in standard review plan Section 10.2 and the acceptance criteria outlined in standard review plan Section 10.3.

The applicant has acceptably identified the environmental approvals and consultations obtained or required for the proposed _____ *in situ* leach facility. The applicant has provided a summary of all permits and licenses obtained for the proposed facility that identifies the type

of permit (license), the granting authority, the assigned number, and the current status with expiration date (if appropriate). For permits not yet received, the applicant has provided a discussion of the status of the application and evidence that the applicant has requested the appropriate permits, and an indication of when the approval is expected. The applicant has identified all permits issued under Agreement State status and demonstrated that the granting authority is appropriate for all permits. Any meetings held with environmental and citizens' groups are acceptably documented.

Based on the information provided in the application and the detailed review conducted of the environmental approvals and consultations for the _____ *in situ* leach facility, the staff concludes that the environmental approvals and consultations are acceptable and are in compliance with 10 CFR Part 51.45(d) which requires that the environmental report list all federal permits licenses, approvals and other entitlements that must be obtained in connection with the proposed action and describe the status of compliance with these requirements.

10.5 Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Washington, DC: NRC. 2001.

APPENDIX A

GUIDANCE FOR REVIEWING HISTORICAL ASPECTS OF SITE PERFORMANCE FOR LICENSE RENEWALS AND AMENDMENTS

For license renewals and amendments, the historical record of site operations, including air and ground-water quality monitoring provides valuable information for evaluating the licensing actions. Following are specific areas where a compliance history or record of site operations and changes should be provided for review:

- Amendments and changes to operating practices or procedures
- License violations identified during U.S. Nuclear Regulatory Commission or Agreement State site inspections
- Excursions and resultant cleanup histories or status
- Exceedences of any radiation exposure, contamination, or release limits
- Exceedences of any nonradiation contaminant exposure or release limits
- Updates and changes to any site characterization information important to the evaluation of exposure pathways and doses; including site location and layout; uses of adjacent lands and waters; population distributions; meteorology; the geologic or hydrologic setting; ecology; background radiological or nonradiological characteristics; and other environmental features
- Effects of site operations including data on radiological and nonradiological effects, accidents, and the economic and social effects of operations
- Updates and changes to factors that may cause reconsideration of alternatives to the proposed action
- Updates and changes to the economic costs and benefits for the facility since the last application
- The results and effectiveness of any mitigation proposed and implemented in the original license.

If after a review of these historical aspects of site operations, the staff concludes that the site has been operated so as to protect health and safety and the environment, and that no unreviewed safety-related concerns have been identified, only those changes proposed by the license renewal or amendment or application should be reviewed using the appropriate sections of this standard review plan. Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined.

APPENDIX B

RELATIONSHIP OF 10 CFR PART 40, APPENDIX A REQUIREMENTS TO STANDARD REVIEW PLAN SECTIONS

The criteria in 10 CFR Part 40 Appendix A were written specifically for conventional uranium mills. Therefore, they are not all applicable to *in situ* leach facilities. This appendix identifies the specific standard review plan sections where the applicable criteria are addressed.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
Criterion 1: Optimize site selection to achieve permanent isolation of tailings without maintenance.	Not applicable.
Criterion 2: Avoid proliferation of small waste disposal sites.	3.1.4, 4.2.4, 6.2.4, 6.3.4
Criterion 3: Dispose of tailings below grade or provide equivalent isolation.	Not applicable.
Criterion 4: Adhere to siting and design criteria.	
(a) Minimize upstream rainfall catchment areas.	Not applicable to *in situ* leach facilities.
(b) Select topographic features that provide good wind protection.	Not applicable to *in situ* leach facilities.
(c) Provide relatively flat embankment and cover slopes.	Not applicable to *in situ* leach facilities.
(d) Establish a self-sustaining vegetative cover or rock cover considering stability, erosion potential, and geomorphology.	Not applicable to *in situ* leach facilities.
(e) Locate away from faults capable of causing impoundment failure.	2.6.4
(f) Design to promote deposition, where feasible.	Not applicable to *in situ* leach facilities.
Criterion 5A: Meet the primary ground-water protection standard.	
(1) Design, construct, and install an impoundment liner that prevents migration of wastes to subsurface soil, groundwater, or surface water.	3.1.4, 4.2.4
(2) Construct liner of suitable materials, place it on an adequate base, and install it to cover surrounding earth likely to be in contact with wastes or leachate.	3.1.4, 4.2.4

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(3) Apply alternate design or operating practices that will prevent migration of hazardous constituents into ground water or surface water.	3.1.4, 4.2.4
(4) Design, construct, maintain, and operate impoundments to prevent overtopping.	3.1.4, 4.2.4
(5) Design, construct, and maintain dikes to prevent massive failure.	3.1.4, 4.2.4
Criterion 5B: Conform to the secondary ground-water protection standards.	
(1) Prevent hazardous constituents from exceeding specified concentration limits in the uppermost aquifer beyond the point of compliance.	3.1.4, 5.7.8.4
(2) Define hazardous constituents as those expected to be in or derived from the byproduct material, those detected in the uppermost aquifer, and those listed in Criterion 13.	3.1.4
(3) Exclude hazardous constituents if they are not capable of posing a substantial present or potential hazards to human health or the environment.	3.1.4
(4) Consider identification of underground sources of drinking water and exempted aquifers.	2.2.4, 3.1.4
(5) Ensure hazardous constitutents at the point of compliance do not exceed the background concentration, the value in Paragraph 5C, or an approved alternate concentration limit.	3.1.4, 5.7.8.4
(6) Establish alternate concentration limits, if necessary, after considering practical corrective actions, as low as is reasonably achievable requirements, and potential hazard to human health or the environment.	3.1.4
Criterion 5C: Comply with maximum values for ground-water protection.	3.1.4, 5.7.8.4
Criterion 5D: Implement a ground-water corrective action program if secondary ground-water protection standards are exceeded.	5.7.8.4
Criterion 5E: Consider appropriate measures when developing and conducting a ground-water protection program.	

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(1) Incorporate leak detection systems for synthetic liners and conduct appropriate testing for clay/soil liners.	4.2.4
(2) Use process designs that maximize solution recycling and water conservation.	4.2.4
(3) Dewater tailings by process devices or properly designed and installed drainage systems.	4.2.4
(4) Neutralize hazardous constituents to promote immobilization.	4.2.4
Criterion 5F: Alleviate seepage impacts where they are occurring and restore ground-water quality.	4.2.4
Criterion 5G: Provide appropriate information for a disposal system.	
(1) Define the chemical and radioactive characteristics of waste solutions.	4.1.4, 4.2.4
(2) Describe the characteristics of the underlying soil and geologic formations.	2.6.4
(3) Define the location, extent, quality, capacity, and current uses of ground water.	2.2.4
Criterion 5H: Minimize penetration of radionuclides into underlying soils when stockpiling.	Not applicable.
Criterion 6: Install an appropriate cover and close the waste disposal area.	
(1) Ensure the cover meets lifetime and radioactive material release specifications.	Not applicable to *in situ* leach facilities.
(2) Demonstrate the effectiveness of the final radon barrier prior to placement of erosion protection barriers or other features.	Not applicable to *in situ* leach facilities.
(3) Demonstrate the effectiveness of phased emplacement of radon barriers as each section is completed.	Not applicable to *in situ* leach facilities.
(4) Document verification of radon barrier effectiveness to the U.S. Nuclear Regulatory Commission (NRC) and maintain records of this verification.	Not applicable to *in situ* leach facilities.
(5) Ensure that radon exhalation is not significantly above background because of the cover material.	Not applicable to *in situ* leach facilities.

10 CFR Part 40, Appendix A Criterion	Locations in NUREG–1569 Where the Criterion is Addressed
(6) Cleanup residual contamination from byproduct material consistent with the radium benchmark dose. (7) Prevent threats to human health and the environment from non-radiological hazards.	4.2.4, 6.2.4, 6.4.4 2.11.4, 6.2.4
Criterion 6A: Ensure expeditious completion of the final radon barrier. (1) Complete the radon barrier as expeditiously as practical after ceasing operations in accordance with a written, Commission-approved reclamation plan. (2) Extend milestone completion dates if justified by radon release levels, cost considerations consistent with available technology. (3) Authorize disposal of byproduct materials or similar materials from other sources if appropriate criteria are met.	Not applicable.
Criterion 7: Conduct pre-operational and operational monitoring programs.	2.5.4, 5.7.8.4, 5.7.9.4
Criterion 7A: Establish a detection monitoring program to set site-specific ground-water protection standards, a compliance monitoring system once groundwater protection standards have been established, and a corrective action monitoring program in conjunction with a corrective action program.	5.7.8.4, 5.7.9.4
Criterion 8: Conduct milling operations, including ore storage, tailings placement, and yellowcake drying and packaging operations so that airborne releases are as low as is reasonably achievable .	4.1.4, 5.3.1.4, 5.3.2.4, 5.7.1.4, 5.7.3.4
Criterion 8A: Conduct and record daily inspections of tailings or waste retention systems and report failures or unusual conditions to NRC.	5.3.1.4, 5.3.2.4
Criterion 9: Establish appropriate financial surety arrangements for decontamination, decommissioning, and reclamation.	6.2.4, 6.5.4
Criterion 10: Establish sufficient funds to cover the costs of long-term surveillance and control.	6.5.4

10 CFR Part 40, Appendix A Criterion		Locations in NUREG–1569 Where the Criterion is Addressed
Criterion 11A:	Comply with effectivity dates for site and byproduct material ownership requirements.	Applies to Commission—not addressed in NUREG–1569.
Criterion 11B:	Establish license conditions or terms to ensure that licensees comply with ownership requirements prior to license termination for sites used for tailings disposal.	Applies to Commission—not addressed in NUREG–1569.
Criterion 11C:	Transfer title to byproduct material and land to the United States or the state in which the land is located.	Not applicable.
Criterion 11D:	Permit use of surface and subsurface estates if the public health, safety, welfare, or environment will not be endangered.	Applies to the Commission—not addressed in NUREG–1569.
Criterion 11E:	Transfer material and land to the United States or a state without cost other than administrative a legal costs.	Not applicable.
Criterion 11F:	Follow specific requirements for land held in trust for or owned by Indian Tribes.	Not applicable.
Criterion 12:	Minimize or avoid long-term active maintenance and conduct and report on annual inspections.	Applicable to the long-term custodian—not addressed in NUREG–1569.
Criterion 13:	Establish standards for constitutents reasonably expected to be in or derived from byproduct materials and detected in ground water.	3.1.4

APPENDIX C

EFFLUENT DISPOSAL AT LICENSED *IN SITU* LEACH URANIUM EXTRACTION FACILITIES

C1.0 BACKGROUND

U.S. Nuclear Regulatory Commission (NRC)-licensed *in situ* leach uranium extraction facilities generate liquid wastes (i.e., effluent) that require proper disposal. At *in situ* leach facilities, liquid waste streams originate from the uranium recovery plant, from the production bleed, and from ground-water restoration activities. Production bleed is ground water extracted from the aquifer during the uranium recovery operation in excess of injected water to maintain a net ground-water inflow into the recovery zone. Effluent produced by the uranium recovery plant and by production bleed is defined as "process wastewater." Ground-water effluent is produced at the end of a uranium recovery operation, during restoration of ground-water quality in the recovery zone. In accordance with NRC Regulatory Issue Summary 2000-23 (NRC, 2000) all liquid effluents from uranium *in situ* leach facilities are classified as 11e.(2) by product material and are to be regulated as such.

At *in situ* leach facilities, management of liquid waste has involved such disposal practices as release to surface waters, evaporation from lined ponds, onsite land applications including irrigation, and injection in deep wells. NRC policy for appropriate disposal of liquid effluents for these approaches is presented in this appendix.

C2.0 ON-SITE EVAPORATION

For a surface impoundment, it must be demonstrated that the proposed disposal facility is designed, operated, and decommissioned in a manner that prevents migration of waste from the surface impoundment to subsurface soil, ground water, or surface water in accordance with 10 CFR Part 40, Appendix A. Applicants must also demonstrate that monitoring requirements are adequately established to detect any migration of contaminants to the ground water. Surface impoundments will be found acceptable if they comply with the design provisions for surface impoundments [Criteria 5A(1) through 5A(5)]; installation of liners and leak detection (Criterion 5E); seepage control (Criterion 5F); and radium cleanup standards [Criterion 6(6)] of 10 CFR Part 40, Appendix A. Detailed technical criteria to meet these requirements are provided in Sections 2.7, 3.1, 6.3, 6.4, and Appendix F of this standard review plan. The pond design and monitoring requirements are described in enough detail for staff to evaluate the environmental impacts of the facility. Furthermore, based on evaluation of cumulative impacts, NRC may require specific license conditions to remediate the anticipated impacts of the surface impoundments.

Solid waste from surface impoundments is 11e.(2) byproduct material. This material must be disposed of in an existing tailings impoundment or 11e.(2) disposal cell in accordance with 10 CFR Part 40, Appendix A, Criterion 2.

C3.0 RELEASE IN SURFACE WATERS

Two alternatives now exist for licensees discharging 11e.(2) byproduct material to surface waters in accordance with 10 CFR 20.1302(b). One is to comply with the limits in Table 2 of

Appendix B of 10 CFR Part 20. The other is to demonstrate that the discharges are in compliance with the dose limits for individual members of the public. This option merely prescribes that surface discharges comply with nationally recognized dose standards for protection of public health and safety.

C4.0 LAND APPLICATIONS

For the land application of waste water the applicant must demonstrate that doses are maintained as low as reasonably achievable and within the dose limits in 10 CFR 20.1301. Proposed land application activities must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. This may require analysis to assess the chemical toxicity of radioactive and nonradioactive constituents. Specifically, licensees must provide (i) a description of the waste, including its physical and chemical properties that are important to risk evaluation; (ii) the proposed manner and conditions of waste disposal; (iii) projected concentrations of radioactive contaminants in the soil; and (iv) projected impacts on ground-water and surface-water quality and on land uses, especially crops and vegetation. In addition, projected exposures and health risks that may be associated with radioactive constituents reaching the food chain must be analyzed to ensure that doses are as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301. Proposals should include provisions for periodic soil surveys to verify that contaminant levels in the soil do not exceed those projected, and should also include a remediation plan that can be implemented if projected levels are exceeded. Appropriate State and Federal agency permits must be obtained in accordance with the requirements of 10 CFR 20.2007, and the applicant must comply with NRC regulatory provisions for decommissioning This includes the soil cleanup criteria of 10 CFR Part 40, Appendix A, Criterion 6(6).

C5.0 DEEP-WELL INJECTION

Proposals for disposal of liquid waste by injection in deep wells must meet the regulatory provisions in 10 CFR 20.2002 and demonstrate that doses are as low as is reasonably achievable and within the dose limits in 10 CFR 20.1301. The injection facility must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. Specifically, proposals must include (i) a description of the waste, including its physical and chemical properties important to risk evaluation; (ii) the proposed manner and conditions of waste disposal; (iii) an analysis and evaluation of pertinent information on the nature of the environment; (iv) information on the nature and location of other potentially affected facilities; and (v) analyses and procedures to ensure that doses are as low as is reasonably achievable, and within the dose limits in 10 CFR 20.1301.

In addition, pursuant to the provisions of 10 CFR 20.2007, proposals for disposal by injection in deep wells must also meet any other applicable federal, state, and local government regulations pertaining to deep well injection. Applicants must obtain any necessary permits for this purpose. In particular. proposals must satisfy the U.S. Environmental Protection Agency (EPA) regulatory provisions in 40 CFR Part 146: Underground Injection Control Program: Criteria and Standards, and applicants must obtain necessary permits from U.S. Environmental Protection Agency and/or states authorized by EPA to enforce these provisions. In general, applications

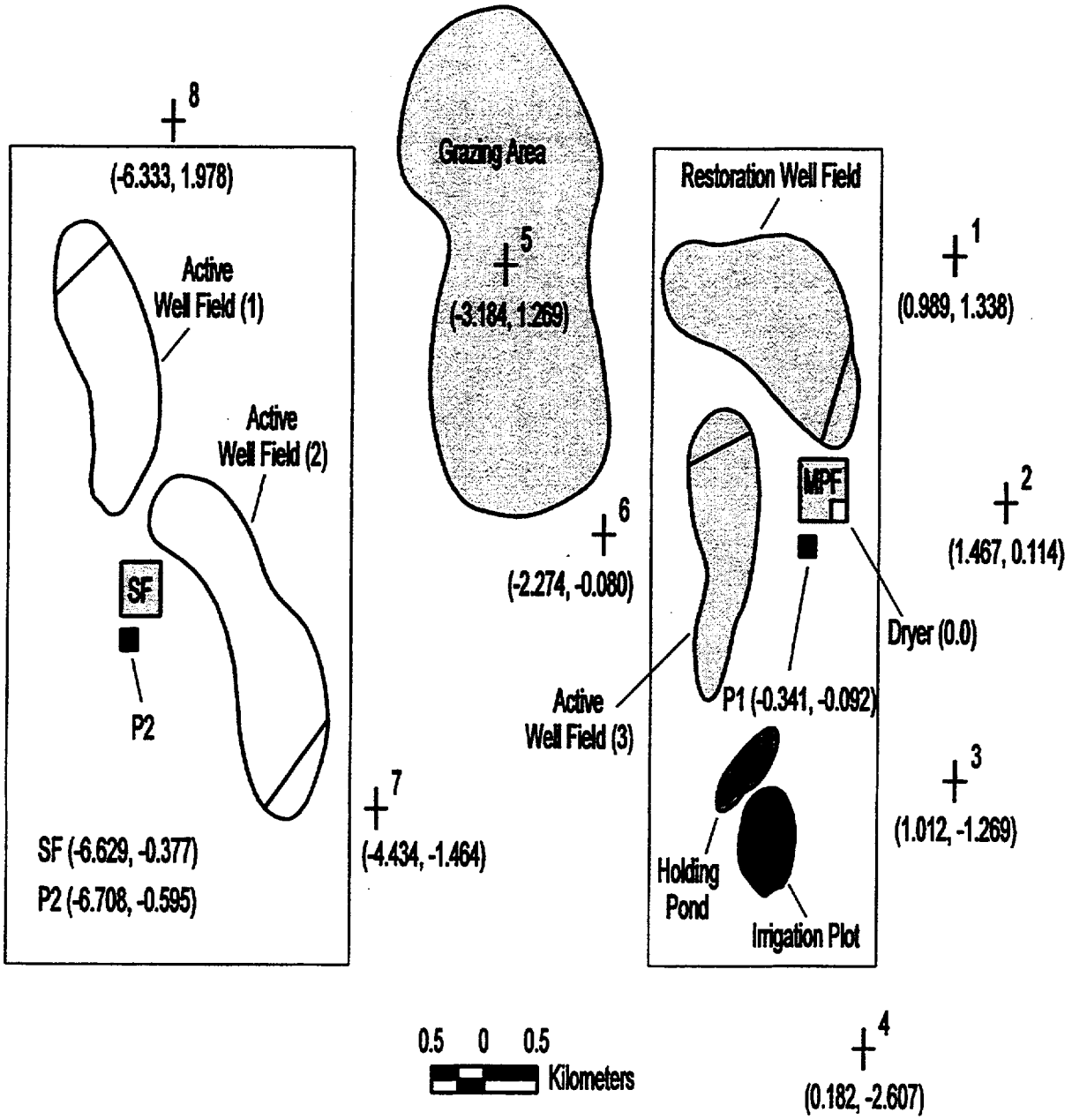
that satisfy EPA regulations under the Underground Injection Control Program and the applicable provisions of 10 CFR Part 20 will be approved by the staff.

Licensees and applicants disposing of liquid waste by injection in deep wells are further required to comply with NRC regulatory provisions for decommissioning.

Reference

NRC. "NRC Regulatory Issue Summary 2000-23 Recent Changes to Uranium Recovery Policy." Washington, DC: NRC. 2000.

Appendix C


8
(-6.333, 1.978)
Active
Well Field (1)
Active
Well Field (2)
SF
P2
SF (-6.629, -0.377)
P2 (-6.708, -0.595)
7
(-4.434, -1.464)
Grazing Area
5
(-3.184, 1.269)
6
(-2.274, -0.080)
Restoration Well Field
1
(0.989, 1.338)
MPF
2
(1.467, 0.114)
Dryer (0.0)
P1 (-0.341, -0.092)
Active
Well Field (3)
3
(1.012, -1.269)
Holding
Pond
Irrigation Plot
4
(0.182, -2.607)
0.5 0 0.5
Kilometers
Receptor Location
Site Boundary
Radium-Setting Pond
SF - Satellite Facility
MPF - Main Processing Facility

APPENDIX D

RECOMMENDED OUTLINE FOR SITE-SPECIFIC *IN SITU* LEACH FACILITY RECLAMATION AND STABILIZATION COST ESTIMATES

As required under Criteria 9 and 10 of 10 CFR Part 40, Appendix A, the licensee shall supply sufficient information for the U.S. Nuclear Regulatory Commission (NRC) to verify that the amount of coverage provided by the financial assurance will permit the completion of all decontamination, decommissioning, and reclamation of sites, structures, and equipment used in conjunction with byproduct material and for any long-term surveillance. Cost estimates for the following activities (where applicable) should be submitted to NRC with the initial license application or reclamation plan and should be updated annually; as specified in the license. Cost estimates must be calculated on the basis of completion of all activities by a third party.[1] Unit costs, calculations, references, assumptions, equipment and operator efficiencies, *et cetera*, must be provided. The annual surety estimate must be prospective of all work to be performed at the site. The licensee must provide estimated costs for all decommissioning, reclamation, and ground-water restoration work remaining to be performed at the site, not simply deduct the cost of work already performed from the previous surety estimate [see NRC Generic Letter 97-03 (NRC, 1997)].

The detailed cost information necessary to verify the cost estimates for the above categories of closure work is summarized in the following recommended outline. For each area, estimates should include costs for equipment; materials; labor and overhead; licenses, permits and miscellaneous site-specific costs; and any other activity or resource that will require expenditure of funds.

(I) FACILITY DECOMMISSIONING

This includes dismantling and decontamination, or disposal of all structures and equipment. This may be accomplished in two phases. In the first phase, only the equipment not used for ground-water restoration (including the stability monitoring period) is removed. Well plugging and removal of the remaining equipment would be performed in a second phase, after the approved completion of ground-water restoration. The buildings used for the *in situ* leach operations may be decontaminated and released for unrestricted use.

(A) Salvageable building and equipment decontamination (list). For each building or piece of equipment listed, the following data should be provided:

(B) Nonsalvageable building and equipment disposal:

(1) List of major categories of buildings and equipment to be disposed of and their corresponding quantities:

(a) Structures (list each major) [tons of material and building volume cubic meters (cubic feet)]

[1]A third party is an independent contractor or operator who is not financially affiliated with the licensee.

(b) Foundation concrete [cubic meters (cubic yards)]

(c) Process equipment (tons)

(d) Piping and insulation (lump sum)

(e) Electrical and instrumentation (lump sum)

(2) Disposal of chemical solutions within the facility

(C) Restoration of contaminated areas (process area, affected ground water, surface impoundment residues, etc.)

Removal and Disposal of 11(e).2 byproduct material—Criterion 2 of 10 CFR Part 40, Appendix A, requires that these materials be transported and disposed of at a licensed tailings area or licensed disposal site. The quantity of material to be removed, the distance to the disposal site, and the fees charged by the receiving facility are important considerations in determining the costs of disposal.

Reclamation—This entails recontouring the well fields and surface impoundments and placing top soil or other materials acceptable to the NRC. This may also include revegetation.

(1) Removal:

(a) Area, depth, and quantity of material to be removed

(b) Excavation, loading, transportation, and deposition

(2) Revegetation:

(a) Area to be revegetated (acre)

(b) Obtaining fill material, replacing topsoil, and revegetating)

(II) GROUND-WATER RESTORATION AND WELL PLUGGING

In most cases, ground-water restoration consists of ground-water sweeping and water treatment with partial reinjection. The water treatment equipment used during the uranium recovery phase of the operation is generally suitable for the restoration phase. The capital cost of this equipment is usually absorbed during the initial stages of the operation, leaving only the costs of operation, maintenance, and replacement filters for the restoration phase. However, if additional equipment will be required for restoration, associated costs should be detailed here. Replacement costs of some water treatment equipment may need to be included in the surety if the equipment used for restoration is near the end of its serviceable life.

(A) Method of restoration

(B) Volume of aquifer required to be restored, area and thickness of aquifer, number of required pumping cycles, and cycling time. The aquifer volume should include the volume of the exploited ore zone, the flow factor, and any contaminated ground water outside the well field (vertical and horizontal excursions)

(C) Equipment associated with aquifer restoration (e.g., reverse osmosis unit)

(D) Verification sample analysis:

(E) Well plugging:

(1) Number of drill holes to be plugged

(2) Depth and size of each drill hole

(3) Material to he used for plugging including acquisition, transportation, and plugging

(III) RADIOLOGICAL SURVEY AND ENVIRONMENTAL MONITORING

Radiological Survey—Surveys and soil samples for radium are required in areas to be released for restricted use. Soils around the well fields, surface impoundments, and process buildings should be analyzed for radium content. A gamma survey of all areas should be made before release for unrestricted use. All equipment released for unrestricted use should be surveyed and the records should be maintained.

(A) Soil samples

(B) Decommissioning equipment and building smear samples

(C) Gamma survey

(D) Environmental monitoring

(IV) PROJECT MANAGEMENT COSTS AND MISCELLANEOUS

Itemize estimated costs associated with project management; engineering design, review, and change; mobilization; legal expenses, power during reclamation; quality control; radiological safety; and any other costs not included in other estimation categories.

(V) LABOR AND EQUIPMENT OVERHEAD, CONTRACTOR PROFIT

Overhead costs for labor and equipment and contractor profit may be calculated as separate items or loaded into hourly rates. If included in hourly rates, the unit costs must identify the percentages applied for each area.

(VI) CONTINGENCY

The licensee should include a contingency amount to the total cost estimate for the final site closure. The staff considers a 15-percent contingency to be an acceptable minimum amount.

(VIII) ADJUSTMENTS TO SURETY AMOUNTS

The licensee is required by 10 CFR Part 40, Appendix A, Criterion 9 to adjust cost estimates annually to account for inflation and changes in reclamation plans. The submission should be in the form of a request for amendment to the license.

(A) Adjustments for inflation:

The licensee should submit a revised surety incorporating adjustments to the cost estimates for inflation 90 days before each anniversary of the date on which the first reclamation plan and cost estimate were approved. The adjustment should be made using the inflation rule indicated by the change in the Urban Consumer Price Index published by the U.S. Department of Labor, Bureau of Labor Statistics (http://stats.bls.gov).

(B) Changes in Plans:

(1) Changes in the process such as size or method of operation

(2) Licensee initiated changes in reclamation plans or reclamation/ decommissioning activities performed

(3) Adjustments to reclamation plans required by NRC

(4) Proposed revisions to reclamation plans with cost estimates and the basis for cost estimates detailed for NRC review and approval.

To avoid unnecessary duplication and expense, NRC shall take into account surety arrangements required by other federal agencies, state agencies, or other local governing bodies. However, the Commission is not required to accept such sureties if they are not sufficient. Similarly, no reduction to surety amounts established with other agencies shall be effected without NRC approval. Copies of all correspondence relating to the surety between the licensee and the state should be provided to NRC. If authorized by NRC to maintain a surety with a state as the beneficiary, it is the responsibility of the licensee to provide NRC with verification of same; ensure that the agreement with the state specifically identifies the financial

surety's application, *in situ* leach facility, and decommissioning/reclamation requirements; and transfer the long-term surveillance and control fee to the U.S. Department of the Treasury before license termination.

All costs (unit and total) are to be estimated on the basis of third party, independent contractor costs (include overhead and profit in unit costs or as a percentage of the total). Equipment owned by the licensee and the availability of licensee staff should not be considered in the estimate, to reduce cost calculations. All costs should be based on current-year dollars. Credit for salvage value is generally not acceptable in the estimated costs.

NRC staff review may include a comparison of unit cost estimates with standard construction cost guides (e.g., Dodge Guide, Data Quest) and discussions with appropriate state or local authorities (e.g., highway cost construction). The licensee should provide supporting information or the basis for selection of the unit cost figures used in estimates. The staff may elect to use a publicly available computer code such as RACER™ (Talisman Partners, Ltd., 2000) or spreadsheet to assess these costs.

References

NRC. "Annual Financial Surety Update Requirements for Uranium Recovery Licensees." Generic Letter 97-03. Washington, DC: NRC. July 1997.

Talisman Partners, Ltd. "Introduction to RACER 2000™ (Version 2.1.0)—A Quick Reference." Englewood, Colorado: Talisman Partners, Ltd. 2000.

APPENDIX E

MILDOS-AREA: AN UPDATE WITH INCORPORATION OF *IN SITU* LEACH URANIUM RECOVERY TECHNOLOGY

Letter Report

MILDOS-AREA: An Update with Incorporation of *In Situ* Leach Uranium Recovery Technology*

E.R. Faillace, D.J. LePoire, S.-Y. Chen, and Y. Yuan**

Environmental Assessment Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

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**Yuan is affiliated with Square Y Consultants, Orchard Park, NY

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1.0 INTRODUCTION

The MILDOS-AREA computer code was developed at Argonne National Laboratory in 1989 (Yuan, et al, 1989) for evaluating radiological impacts of uranium processing facilities. The code was modified from the

original MILDOS code (Strenge and Bander, 1984) to include large-area sources and to incorporate changes in methods for dosimetry calculations. MILDOS-AREA estimates the radiological impacts of airborne emissions of radioisotopes of the uranium-238 series. Two different measures are calculated: dose commitments to human receptors and annual average air concentrations.

MILDOS-AREA incorporated dose conversion factors derived by the International Commission on Radiological Protection (ICRP) recommendations of 1978. The annual average air concentrations were compared with the maximum permissible concentrations (MPCs) in the U.S. Nuclear Regulatory Commission's *Standards for Protection against Radiation* (10 CFR Part 20). On January 1, 1994, a revision to 10 CFR Part 20 (revised Part 20) went into effect. The revised Part 20 updated its dosimetry to the ICRP 1978 recommendations. The dose limit to the general public also changed. The changes led to a revision of the calculated allowable concentrations for unrestricted areas, with MPC being replaced by the term "effluent concentrations." Therefore, the calculations performed by MILDOS–AREA were not consistent with the current terminology and data contained in the revised Part 20.

In addition, a new method of recovering uranium gained popularity in the late 1980s, and now the majority of operating licensees use the *in situ* leach (ISL) method. In a typical ISL mining site (Hunter, 1996), a licensee uses a series of injection wells that introduce dissolved oxygen and sodium carbonate/bicarbonate into the ore zone. The uranium is mobilized and is extracted through a series of pumping wells. The uranium-rich water is routed through a processing building, where the uranium is removed from the water by ion-exchange (IX) columns. The loaded IX resin is then processed to remove the uranium (elution). The eluted uranium is further processed into a concentrated uranium slurry. The slurry is then dried into yellow cake (U_3O_8). The dried U_3O_8 is packaged and shipped for further processing into enriched uranium and reactor fuel.

Some ISL facilities have smaller processing plants remote from the main processing plant. These plants, called satellite facilities, generally will collect the uranium in resin tanks and then ship the loaded resin to the main processing plant for elution, drying, and packaging. The satellite facilities allow the licensee to economically mine uranium a distance away from the main processing plant.

2.0 PROJECT OBJECTIVES

The overall objective of this project is to update the MILDOS-AREA code data structures and terminology to be consistent with revised 10 CFR Part 20. Another objective is the creation of an example problem for ISL facilities. Finally, the above objectives result in the creation of a patch program that will update current versions of MILDOS-AREA to the new version.

This report consists of three components: (1) modification of the data structure of the MILDOS-AREA code, (2) source term derivation for the ISL mining technology, and (3) application of this methodology in the sample problem. Finally, a computer patch program containing this updated information is described. This patch program is to be attached to MILDOS-AREA as an update for the particular application.

3.0 MODIFICATIONS TO THE MILDOS-AREA CODE

Two sets of modifications are made to the MILDOS-AREA code. These changes reflect both the semantic and the dosimetric revisions implemented in the revised 10 CFR Part 20.

The first modification consists of replacing all occurrences of MPC with allowable concentration (ALC). These changes affect the last page(s) of output for each time step, where the concentrations of radionuclides in air at each receptor location are reported. These pages are now referred to as the "Results of the ALC Check at this Location."

The second modification consists of replacing the old MPC values in the MILDOS-AREA database with the numbers currently tabulated under Effluent Concentrations (Air - Column 1) in Table 2 of Appendix B to the revised 10 CFR Part 20. An exception is radon-222 (Rn-222), where the ALC is expressed in units of working level (WL). The value for Rn-222 is derived as specified in the text of Appendix B; to revised Part 20; the occupational derived air concentration of 1/3 WL has been divided by 300. Table 3-1 lists the radionuclides and the ALCs used in MILDOS-AREA.

TABLE 3-1 Allowable Concentrations Used in MILDOS-AREA

Radionuclide	AC (Inhalation Class) (pCi/m^3)	Default Inhalation Class
Uranium-238	3(D), 1(W), 0.06(Y)	Y
Uranium-234	3(D), 1(W), 0.05(Y)	Y
Thorium-230	0.02(W), 0.03(Y)	W
Radium-226	0.9 (W)	W
Radon-222	1/900 (*)	(*)
Lead-210	0.6 (D)	D
Bismuth-210	500 (D), 40 (W)	W
Polonium-210	0.9 (D), 0.9 (W)	W

(*) Radon-222 is gaseous; the AC is reported in WIs.

4.0 SOURCE TERM ESTIMATION FOR A SAMPLE ISL FACILITY

The sources of radioactive effluent from an operating ISL uranium recovery facility include (1) the drilling operation at new well fields, (2) uranium extraction operations at production well fields, (3) drying and packaging of yellow cake, (4) restoration operations at old well fields, and (5) land application areas. The following sections describe a methodology for source term derivation for ISL sites that may be used instead of the methodology presented in NUREG/CR-4088 (Hartley, et al, 1985). *Other methodologies may be more appropriate for a particular operating site.*

4.1 New Well Field

Conventional rotary rigs are commonly employed for all drilling activities at an ISL facility. Because all exploration drill holes are drilled by using and are sealed with high-viscosity bentonitic mud to maintain aquifer isolation, no particulates are expected to be released during drilling operations. The only source of radioactive release is the Rn-222 from radium-containing ore cuttings temporarily stored in the mud pit.

During the period when the ore cuttings are awaiting disposal while stored in a mud pit, radioactive decay of radium-226 (Ra-226) is producing radon continuously. The amount of Rn-222 available for release, or the maximum release rate, in a year as a result of Ra-226 decay from ore cuttings in storage is assumed to be given by the following expression:

$$Rn_{nw} = 10^{-12}\ E\ L\ [Ra]\ T\ M\ N \qquad (1)$$

where

Rn_{nw} = Rn-226 release rate from new well field (Ci/yr),

10^{-12} = unit conversion factor (Ci/pCi),

$[Ra]$ = concentration of Ra-226 in ore (pCi/g),

E = emanating power (dimensionless),

L = decay constant of Rn-222 (0.181/d),

T = storage time in mud pit (d),

M = average mass of ore material in the pit (g), and

N = number of mud pits generated per year.

4.2 Production Well Field

No particulate materials are expected to be released from the production well field because its process streams, from production and injection wells to IX columns in the satellite facility, are all in a closed-loop circuit. The primary radioactive emission from the process streams of the production well field is Rn-222 gas. In the natural environment, radon emanates continuously in the ground and migrates through the rock or soil by both diffusion and convection. The movement of radon in ground water in most cases is governed by water transport, rather than by diffusion (Hess, et al, 1985; Mueller Associates, Inc., 1986). In an ISL production well field, the radon released from the ore body is readily removed by the process water ("lixiviant") moving through the well field by injection and production wells. The 3.8-day half-life of Rn-222 allows it to circulate along with the process water in the well field over a long time before it decays.

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The general equation describing the change in Rn-222 concentration over time in the process water of a well field can be expressed as:

$$V \frac{dC_{Rn}}{dT} = f S - (L + v) V C_{Rn} - (F_p + F_i) C_{Rn} \quad (2)$$

where

V = volume of water in circulation (L),

C_{Rn} = Rn-222 concentration in process water (pCi/L),

f = fraction of radon source carried by circulating water (dimensionless),

S = radon source (pCi/d),

L = decay constant of Rn-222 (0.181/d),

v = rate of radon venting from piping and valves during circulation (1/d),

F_p = "purge" rate of treated water (L/d), and

F_i = water discharge rate from resin unloading of IX columns (L/d).

The balance of the fraction of radon source carried by circulating water accounts for any radon in the mined area that is not swept into the injection-production well loop and remains trapped in the ore zone. The "purge" or "bleed" in the production well field is necessary to maintain a hydraulic cone of depression around each well field to prevent leakage of mining solutions outside the production zone.

The radon source term, S, can be expressed as

$$S = 10^6 \times L E [Ra] A D P \quad (3)$$

where

10^6 = unit conversion factor (cm^3/m^3),

E = emanating power of active ore zone (dimensionless),

[Ra] = Ra-226 concentration in ore zone (pCi/g),

A = active area of ore zone (m^2),

D = average thickness of ore zone (m), and

P = bulk density of ore material (g/cm^3).

The water discharge rate from resin unloading, F_i, can be calculated by

$$F_i = N_i \, V_i \, P_i \qquad (4)$$

where

V_i = volume content of IX column (L),

N_i = number of IX column unloadings per day, and

P_i = porosity of resin material.

Under steady-state conditions, the Rn-222 concentration in the process water, C_{Rn}, can be written as

$$C_{Rn} = \frac{10^6 \, [Ra] \, A \, D \, P \, E \, L \, f}{(L+v) \, V + F_p + F_i} \qquad (5)$$

When pressure is reduced during purging or when water is aerated during irrigation, radon is readily released to the atmosphere. The amount of Rn-222 available for release from the "purge" is dependent on the water volume purge rate, F_p, and on the Rn-222 concentration in the purged liquid, C_{Rn}. By conservatively assuming that all available radon in the purge water is released, the annual Rn-222 emission is

$$Rn_w = 3.65 \times 10^{-10} \, C_{Rn} \, F_p \qquad (6)$$

where

3.65×10^{-10} = unit conversion factor (Ci/pCi)(d/yr), and

Rn_w = Rn-222 release rate from purge water (Ci/yr).

The annual Rn-222 releases from occasional venting from wellheads and leaking transport piping are

$$Rn_v = 3.65 \times 10^{-10} \, v \, C_{Rn} \, V \qquad (7)$$

where Rn_v is the annual Rn-222 release from venting (Ci/yr).

The annual radon-222 discharge from the unloading of the IX column contents is

$$Rn_x = 3.65 \times 10^{-10} F_i C_{Rn} \quad (8)$$

where Rn_x annual Rn-222 release from unloading of IX column content (Ci/yr).

The total annual Rn-222 release from the production well field is the sum of Rn_w, Rn_v, and Rn_x.
The occurrence of radon in water is controlled by the chemical concentration of radium in the host soil or rock and the emissivity of radon into water. Radon enters air-filled pores in the soil mainly because of the recoil of radon atoms on the decay of Ra-226. The fraction of radon formed in the soil which enters the pores is called the emanating power; reported values range from about 1% to 80%, with an average of 20%, depending on soil type, pore space, and water content (Mueller Associates, Inc., 1986). Varying environmental conditions have been found to affect the rate of radon emanation. In particular, moisture has been found to have significant effects on the radon emanation rate. For purposes of conservatively estimating the radon release from ISL well fields, the emanating power is assumed to be 0.25.

4.3 Drying and Packaging of Yellow Cake

For facilities using rotary vacuum dryers for processing yellow cake, no particulate emissions are expected under normal operating conditions. For facilities using thermal drying, stack releases may be estimated on the basis of information provided by a number of operating ISL uranium recovery facilities. Although more data are needed, the stack release of yellow cake has been estimated to be about 0.05% of the amount produced; however, because the day-to-day variations of particulate release rates can vary by several times, the assumption is that 0.1% of the uranium produced escapes as particulates into the atmosphere, as suggested in the *Final Generic Environmental Impact Statement on Uranium Milling* (U.S. Nuclear Regulatory Commission, 1980).

The particulate release of nuclides other than uranium isotopes is estimated by grab samples reported by ISL facilities (e.g., Semiannual Reports for Highland Uranium Project, Irigary and Christensen Ranch

Projects, Crownpoint, and others). On the basis of the field measurements, the conservative assumption is that the activities of thorium (0.15-0.4% of measured values), radium (0.2-0.3%), lead, polonium, and its decay progeny are 0.5% of the U-238 activity in the yellow cake. Furthermore, it may be assumed that the fraction of this activity that is released is the same as the fraction of uranium (0.1%) that is released.

4.4 Restoration Well Field

The basic operating processes of the restoration well field are similar to those of the production well field. Ground water affected by leaching processes in the production well fields is restored to its premining levels (1) by the "pump and treat" (ground-water sweep) method and by flushing with fresh water injection, and (2) by using the permeative stream from reverse-osmosis treatment units. Like the production well field, no particulate materials are expected to be released from the restoration well field operations. The primary source of radioactive release is the Rn-222 gas in the process water circulating within and discharged from the restoration operations. The annual Rn-222 releases from the restoration well field therefore can be calculated by Equations 6 and 7.

4.5 Releases from Land Application Areas

Radionuclide-containing water, either from purge water from production well fields or from restoration wastewater from restoration well fields, is treated to unrestricted release levels and disposed of by irrigation. Release onto the soil surface will contaminate the soil at the land application areas. The radionuclides adsorbed by the soil will become a source term for radioactive release through wind erosion processes. To estimate this wind-generated source term by using MILDOS-AREA, the radionuclide concentration in the soil needs to be estimated first. The radionuclide concentration in the contaminated surface soil region of the land application area, C_s, is calculated by

$$C_s = \frac{10^{-3}\ C_{tw}\ V_o\ R_s}{A_s\ S_d\ P_s} \qquad (9)$$

where

C_s = radionuclide concentration in the surface soil (pCi/g),

10^{-3} = unit conversion factor (L/cm^3),

V_o = total volume of water released onto the land application area (m^3),

C_{tw} = radionuclide concentration in treated water (pCi/L),

A_s = area of land application (m^2),

S_d = assumed depth of contaminated area (m),

P_s = bulk density of surface soil (g/cm^3), and

R_s = fraction of radionuclide in irrigation water retained in the soil particles (dimensionless).

The fraction of radionuclides in irrigation water retained in the soil particles, R_s, can be calculated with the following formula:

$$R_s = (1 - \frac{1}{R_d}) \quad \textbf{(10)}$$

The retardation factor, R_d, can be calculated with the following formula:

$$R_d = 1 + \frac{P_s K_d}{w} \quad \textbf{(11)}$$

where

K_d = radionuclide distribution coefficient (cm^3/g), and

w = soil volume water content (dimensionless).

The volumetric water content of the soil, w, is the fraction of the total porosity of the soil material occupied by water. The radionuclide distribution coefficient is the ratio of the radionuclide equilibrium concentration of the adsorbed radionuclide in soil to the desorbed radionuclide in water. Representative distribution coefficients can be found in the report by Yu, et al, 1993.

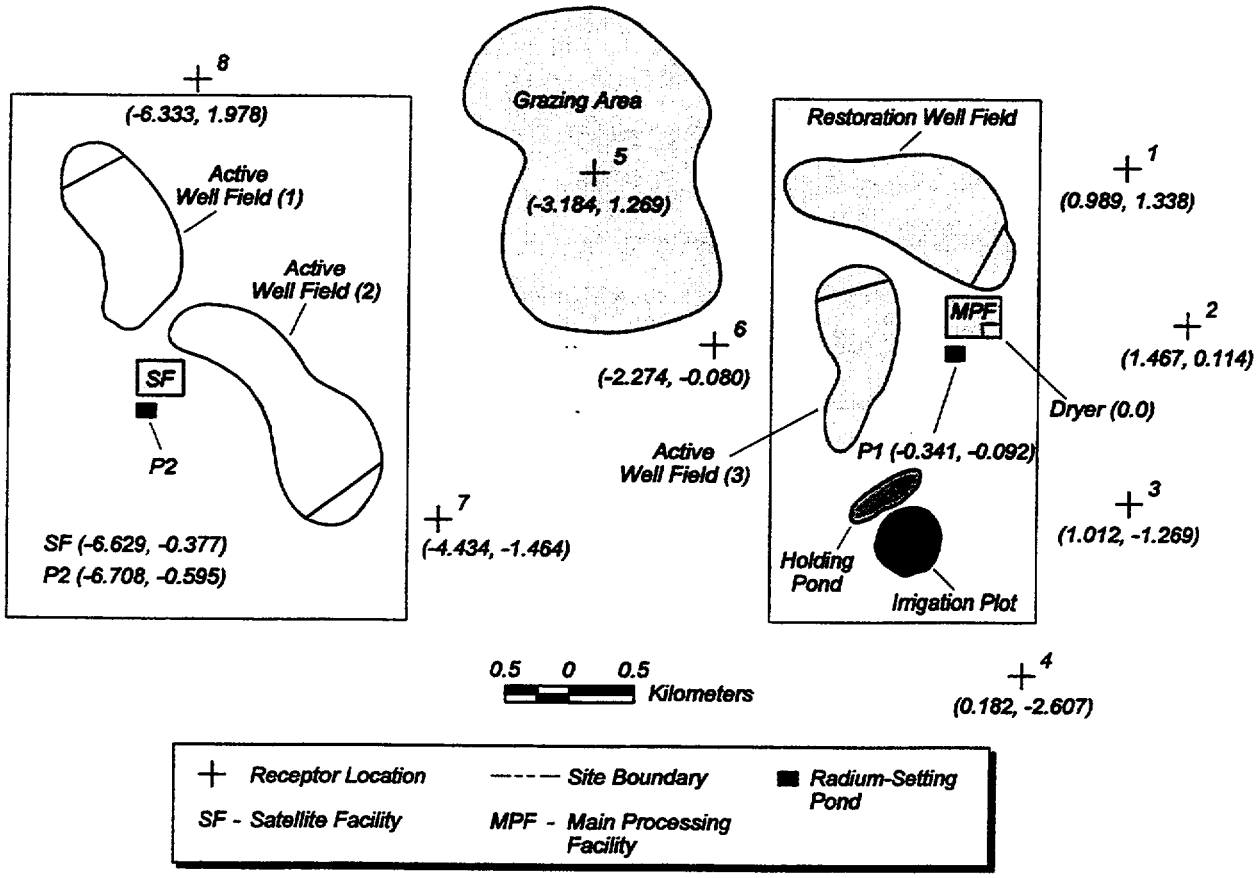
5.0 EXAMPLE OF SOURCE TERM CALCULATION FOR SAMPLE ISL FACILITY

The following example illustrates some typical calculations that may be used to derive the source term at

a hypothetical operating ISL uranium recovery facility. The example covers the potential operations that may result in radionuclide releases to the air from a typical facility. Note that reasonable assumptions for input parameters have been used for this hypothetical site, *but these input data are not intended to serve as substitutes for data collected at actual operating facilities.*

The layout of the hypothetical site is shown in Figure 5-1. It consists of a main processing facility, a satellite facility, one well field under development (active well field 1, two production well fields (active well fields 2 and 3), a restoration well field, two radium-settling ponds (P1 and P2), a holding pond, and an irrigation plot. Only small portions of the well fields are assumed to be active over any one-year period of operations. Eight receptor locations are identified. Of these, location 5 is included within a cattle grazing area to estimate the dose from consumption of livestock products that may become contaminated from site releases. Source and receptor locations are reported in kilometers east (x coordinate) and north (*y* coordinate) of the dryer stack in the main processing facility. Negative values of *x* and *y* coordinates indicate west and south directions, respectively. Table 5-1 lists the coordinates, used in the input data file for each source and receptor. The meteorology for the site is assumed to be the generic file provided with the code.

Figure 5-1. Layout of Hypothetical ISL Facility



5.1 Summary of Principal Operating Characteristics of the Sample ISL Facility

The following parameters apply to the entire facility:

Yellow cake production rate = 520 metric ton (MT)/yr

Average ore activity, U-238 and each progeny in secular equilibrium = 280 pCi/g

Ore porosity = 0.28

Ore density = 1.8 g/cm^3

5.2 New Well Field Drilling/Construction Area (Well Field 1):

A portion of well field 1, located north of the satellite facility, is under development, as follows:

Number of new wells per peak year = 600

Number of new wells per mud pit = 12

Number of mud pits = 600/12 = 50

Ore zone thickness = 5 m

Drill hole diameter = 8 in.

Average ore material per well (g)=3.14 × (8 in / 2 × 2.54 cm/in)^2 × 500 cm ×

1.8 g/cm^3 = 2.9 × 10^5

Total ore material in mud pit per year (g) = 3.5 × 10^6

Average storage time of ore grade material in mud pits = 12d

Radon emanating power = 0.25

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TABLE 5-1 Source and Receptor Coordinates

Source		East (km)	North (km)	Receptor	East (km)	North (km)
1.	Yellow Cake Dryer Stack	0.000	0.000	Receptor 1 (Individual)	0.989	1.338
2.	Main Processing Facility IX Columns	0.000	0.000	Receptor 2 (Individual)	1.467	0.114
3.	Satellite-Facility	-6.629	-0.377	Receptor 3 (Individual)	1.012	-1.269
4.	Radium-Setting Pond 1	-0.341	-0.092	Receptor 4 (Individual)	0.182	-2.607
5.	Radium-Setting Pond 2	-6.708	-0.595	Receptor 5 (Grazing)	-3.184	1.269
6.	Active Well Field 1 (Area Source)	-7.363	1.162	Receptor 6 (Individual)	-2.274	-0.08
		-7.380	1.313	Receptor 7 (Individual)	-4.434	-1.464
		-7.145	1.464	Receptor 8 (Individual)	-6.333	1.978
		-6.893	1.380			
7.	Active Well Field 2 (Area Source)	-5.449	-1.489			
		-4.879	-1.053			
		-5.080	-1.438			
		-5.282	-1.556			
8.	Active Well Field 3 (Area Source)	-1.423	0.307			
		-1.305	0.525			
		-1.104	0.575			
		-0.886	0.441			
9.	Restoration Well Field (Area Source)	-0.248	0.407			
		0.054	0.927			
		0.137	0.575			
		-0.014	0.374			
10.	Irrigation Plot (Area Source)	-0.669	-1.825			
		-0.830	-1.704			
		-0.952	-1.448			
		-0.911	-1.448			

For this location, on the basis of an average Ra-226 concentration of 280 pCi/g, the annual Rn-222 emission from the mud pit can be estimated by using Equation 1:

$$Rn_{nw} = 10^{-12} \text{ Ci/pCi} \times 0.25 \times 0.181/\text{d} \times 280 \text{ pCi/g} \times 12 \text{ d} \times 3.5 \times 10^{6} \text{ g} \times 50/\text{yr}$$

$$= 0.027 \text{ Ci/yr}$$

The radon flux can then be estimated by dividing the total emission rate by the area under development as follows:

Area of active drilling per year = 60,000 m^2

Average Rn-222 flux rate = (10^{12} pCi/Ci × 0.027 Ci/yr) / [60,000 m^2 × (3.15×10^7 s/yr)]

= 0.0143 pCi/m^2/s

5.3 Production Well Field 2

The following assumptions are used for the production well field located just to the east of the satellite facility:

Operating days per year = 365

Dimensions of the active ore body:

Peak area per year to be mined = 50,000 m^2

Average thickness of ore bodies = 3 m

Total flow volume in circulation in well field = 50,000 × 3 × 0.28 = 42,000 m^3

= 4.2×10^7 L

The following assumptions are made for the satellite facility:

Dimensions or capacity of resin column = 3,500 gal

Resin porosity = 0.4

Number of loaded resin unloadings per day = 3

Water discharge rate from unloading of IX column

= 3,500 gal × 0.4 × 3.785 L/gal × 3/d = 1.6×10^4 L/d

Total wastewater "purge" rate = 100 gallons per minute (gpm)

= 100 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 5.5×10^5 L/d

Fraction of radon source carried by circulating water = 0.8

Rate of radon venting during circulation = 0.01/d

The radon concentration in circulating water is derived by using Equation 5*:

$$C_m = [(10^6 \times 280 \times 50{,}000 \times 3 \times 1.8 \times 0.25 \times 0.181) \times 0.8] / \{[0.191 \times (4.2 \times 10^7)] + [(5.5 \times 10^5) + (1.6 \times 10^4)]\}$$

$$= [(3.4 \times 10^{12}) \times 0.8] / (8.6 \times 10^6) = 3.2 \times 10^5 \text{ pCi/L}$$

---

*To reduce the length of this and other calculations, most of the units have been omitted. The reader is referred back to the equations in Chapter 4 for details on parameter descriptions and units.

The radon release rate from purge water into settling pond P2 is derived by using Equation 6:

$$Rn_w = (3.65 \times 10^{-10}) \quad (3.2 \times 10^5) \quad (5.5 \times 10^5)$$

$$= 64 \text{ Ci/yr}$$

The radon release rate from gas venting and leaking during circulation is derived by using Equation 7:

$$Rn_v = (3.65 \times 10^{-10}) \times 0.01 \times (3.2 \times 10^5) \times (4.2 \times 10^7)$$

$$= 49 \text{ Ci/yr}$$

The radon release rate from IX unloading is derived by using Equation 8:

$$Rn_x = (3.65 \times 10^{-10}) \times (3.2 \times 10^5) \times (1.6 \times 10^4)$$

$$= 1.9 \text{ Ci/yr}$$

The total radon release from production well field 2 = 115 Ci/yr.

5.4 Production Well Field 3

The following assumptions are used for the production well field located just to the west of the main processing facility:

Operating days per year = 365

Dimensions of the active ore body:

Peak area per year to be mined = 55,000 m^2

Average thickness of ore bodies = 5 m

Total flow volume in circulation in well field

= 55,000 × 5 × 0.28 = 77,000 m^3 = 7.7×10^7 L

The same parameters used for the satellite facility servicing well field 2 apply to the IX facility used for well field 3. The following source terms have been derived by using Equations 5 to 8.

The radon concentration in circulating water for well field 3 is given by

$$C_m = [(10^6 \times 280 \times 55{,}000 \times 5 \times 1.8 \times 0.25 \times 0.181) \times 0.8] /$$

$$\{[0.191 \times (7.7 \times 10^7)] + [(5.5 \times 10^5) + (1.6 \times 10^4)]\}$$

$$= [(6.3 \times 10^{12}) \times 0.8] / (1.53 \times 10^7) = 3.3 \times 10^5 \text{ pCi/L}$$

The radon release rate from purge water into settling pond P1 is given by

$$Rn_w = (3.65 \times 10^{-10}) \times (3.3 \times 10^5) \times (5.5 \times 10^5)$$

= 66 Ci/yr

The radon release rate from gas venting and leaking during circulation is given by

$Rn_v = (3.65 \times 10^{-10}) \times 0.01 \times (3.3 \times 10^5) \times (7.7 \times 10^7)$

= 93 Ci/yr

The radon release rate from IX unloading is given by

$Rn_x = (3.65 \times 10^{-10}) \times (3.3 \times 10^5) \times (1.6 \times 10^4)$

= 1.9 Ci/yr

The total radon release from production well field 3 = 161 Ci/yr.

5.5 Restoration Well Field

The following assumptions were used for the restoration well field north of the main processing facility:

Expected restoration operation time = 7 yr

Operating days per year = 240

Dimensions of restoration ore body:

Area per year to be restored = 100,000 m^2

Average thickness of ore bodies = 5 m

Total flow volume in circulation in well field

= 100,000 × 5 × 0.28 = 140,000 m^3 = 1.4×10^8 l

Total treated water "purge" rate = 200 gpm

= 200 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 1.1×10^6 L/d

Fraction of radon source carried by circulating water = 0.8

Rate of radon venting during circulation = 0.01/d

The following source terms have been derived by using Equations 5 to 7.

The radon concentration in circulating water for the restoration well field is given by

$C_m = [(10^6 \times 280 \times 100{,}000 \times 5 \times 1.8 \times 0.25 \times 0.181) \times 0.8] /$

$\{[0.191 \times (1.4 \times 10^8)] + (1.1m \times 10^6)]\}$

$= [(1.1 \times 10^{13}) \times 0.8] / (2.8 \times 10^7) = 3.3 \times 10^5$ pCi/L

The radon release rate from purge water into settling pond P1 is given by

$Rn_w = (240/365) \times (3.65 \times 10^{-10}) \times (3.3 \times 10^5) \times (1.1 \times 10^6)$

= 87 Ci/yr

The radon release rate from gas venting and leaking during circulation is given by

$$Rn_v = (240/365) \times (3.65 \times 10^{-10}) \times 0.01 \times (3.3 \times 10^5) \times (1.4 \times 10^8)$$

$$= 110 \text{ Ci/yr}$$

The total radon release from the restoration well field = 197 Ci/yr.

5.6 Land Application (Irrigation) Area

The following assumptions are made for the irrigation plot:

Radionuclide concentrations in the holding pond:

U-238 = 1,200 pCi/L

Th-230 = 5 pCi/L

Ra-226 and all progeny = 30 pCi/L

Land irrigation operation water flow rate = 400 gpm

= 400 gpm × 3.785 L/gal × 60 min/h × 24 h/d = 2.2×10^6 L/d

Land irrigation operation = 122 d/yr

Land irrigation operation lifetime = 7 yr

Total volume water released over operation lifetime

= $(2.2 \times 10^6$ L/d) × 122 d/yr × 7 yr × 10^{-3} m^3/L = 1.9×10^6 m^3

Total area of clean wastewater land application = 185,000 m^2

Assumed depth of contaminated area = 0.15 m

Density of soil = 1.6 g/cm^3

Soil volume water content = 0.25

Distribution coefficient of soil (cm^3/g):

Uranium = 50

Thorium = 60,000

Radium = 70

Lead = 100

The retardation factors of surface soil, calculated by using Equation 11, are

Uranium = 320

Thorium = 380,000

Radium = 450

Lead = 640

The fraction of radionuclides in irrigation water that is retained in the surface soil, calculated by using Equation 10, is

Uranium = 1

Thorium = 1

Radium = 1

Lead = 1

The land application area peak surface soil radionuclide concentrations, calculated by using Equation 9, are

U-238 = $(10^{-3} \times 1{,}200 \times 1.9 \times 10^{6} \times 1) / (185{,}000 \times 0.15 \times 1.6)$

= 0.043 1,200 = 51 pCi/g

Th-230 = 0.043 5 = 0.21 pCi/g

Ra-226 = 0.043 30 = 1.3 pCi/g

Pb-210 = 0.043 30 = 1.3 pCi/g

Radon flux = 1.3 pCi/g 1.0 $(pCi/m^2/s)/(pCi/g) = 1.3$ $(pCi/m^2/s)$

5.7 Main Processing Facility

The following assumptions apply to the main processing facility:

Yellow cake (U_3O_8) production = 520 MT/yr

Stack release rate:

U-238

= 520 MT/yr × 0.001 × 10^6 g/MT × 0.85 g U-nat/g U_3O_8 × (3.3×10^{-7} Ci U-238/g U-nat)

= 0.146 Ci/yr

Th-230

= 0.146 × 0.005 = 0.00073 Ci/yr

Ra-226, Pb-210, and Po-210

= 0.146 × 0.005 = 0.00073 Ci/yr

Appendix E

6.0 DESCRIPTION OF PATCH PROGRAM

The revisions to the MILDOS-AREA code are incorporated in the following files:

MILMAIN.EXE. This file is the FORTRAN executable file containing the revisions discussed in Chapter 3. It replaces the old MILMAIN.EXE.

SAMPISL.DAT. This file is the input data file for the example ISL facility described in Chapter 5. A copy of the input data file and output file can be obtained upon request to the U.S. Nuclear Regulatry Commission.

MILDOS.UPD. This data file contains the updated allowable concentration levels for the radionuclides listed in Table 3-1.

README.TXT. This text file contains instructions to MILDOS-AREA on how to replace the old MILMAIN.EXE with the new version and how to copy the other two files to the user's MILDOS directory.

7.0 REFERENCES

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APPENDIX F

GUIDANCE TO THE U.S. NUCLEAR REGULATORY COMMISSION STAFF ON THE RADIUM BENCHMARK DOSE APPROACH

F1.0 BACKGROUND

In 10 CFR 40.4, byproduct material is defined as the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Uranium milling is defined as any activity resulting in byproduct material. Therefore, 10 CFR Part 40, Appendix A, applies to *in situ* leach, heap leach, and ion-exchange facilities that produce byproduct material, as well as to conventional uranium and thorium mills. This guidance only addresses uranium recovery facilities because there are no currently licensed or planned thorium mills.

The final rule,"Radiological Criteria for License Termination of Uranium Recovery Facilities," became effective on June 11, 1999, and added the following paragraph after the "radium in soil" criteria in Appendix A, Criterion 6(6):

Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more that one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide, of concentration present to the concentration limit, will not exceed 1 (unity). A calculation of the peak potential annual total effective dose equivalent within 1,000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site, must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 100 mrem/yr, before application of as low as is reasonably achievable, requires the approval of the Commission after consideration of the recommendation of the U.S. Nuclear Regulatory Commission (NRC) staff. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before June 11, 1999.

F2.0 RADIUM BENCHMARK DOSE APPROACH

The general requirements for a decommissioning plan, including verification of soil contamination cleanup, are addressed in Chapter 6.0 of the standard review plan. This appendix discusses the NRC staff evaluation of the radium benchmark dose approach, specifically dose modeling and its application to site cleanup activities that should be addressed in the decommissioning plan for those uranium recovery facilities licensed by the NRC and subject to the new requirements for cleanup of contaminated soil and buildings under 10 CFR Part 40, Appendix A, Criterion 6(6), as amended in 1999. The facilities that did not have an approved decommissioning plan at the time the rule became final are required to reduce residual radioactivity, that is, byproduct material, as defined by 10 CFR Part 40, to levels based on the potential dose, excluding radon, resulting from the application of the radium (Ra-226) standard at the site. This is referred to as the radium benchmark dose approach.

This guidance also applies to any revised decommissioning plan submitted for NRC review and approval, after the final rule is effective. However, if a subject licensee can demonstrate that no contaminated buildings will remain, and that soil thorium-230 (Th-230) does not exceed 5 pCi/g (above background) in the surface and 15 pCi/g in subsurface soil in any 100-square-meter area that meets the radium standard, and the natural uranium (U-nat, i.e., U-238, U-234, and U-235) level is less than 1 pCi/g above background, radium benchmark dose modeling is not required. If future modeling with site-specific parameters for uranium recovery sites indicates that this is not a protective approach, the guidance will be revised. Therefore, it would be prudent for a uranium recovery licensee to consider the potential dose from any residual thorium and uranium.

The unity "rule" mentioned in the new paragraph of Criterion 6(6) applies to all licensed residual radionuclides. Therefore, if the ore (processed by the facility), tailings, or process fluid analyses indicate that elevated levels of Th-232 could exist in certain areas after cleanup for Ra-226, some verification samples in those areas should be analyzed for Th-232 or Ra-228. The thorium (Th-232) chain radionuclides (above local background levels) in milling waste would have soil cleanup criteria similar to the uranium chain radionuclides. The staff considers the EPA memorandum of February 12, 1998, (Directive No. 9200.4–25) concerning use of 40 CFR Part 192 soil criteria for Comprehensive Environmental Response, Compensation and Liability Act sites, an acceptable approach. This means that the Th-230 and Th-232 should be limited to the same concentration as their radium progeny with the 5 pCi/g (0.19 Bq/g) criterion applying to the sum of the radium (Ra-226 plus Ra-228) as well as the sum of the thorium (Th-230 plus Th-232) above background.

F2.1 Radium Benchmark Dose Modeling

F2.1.1 Areas of Review

The radium benchmark dose approach involves calculation of the peak potential dose for the site resulting from the 5 pCi/g [0.19 Bq/g] concentration of radium in the surface 15 cm [6 in.] of soil. The dose from the 15 pCi/g [0.56 Bq/g] subsurface radium limit would be calculated for any area that may require subsurface cleanup. The dose modeling review involves examining of the computer code or other calculations employed for the dose estimates, the code or calculation input values and assumptions, and the modeling results (data presentation).

Evaluation of the radium benchmark dose modeling as proposed in the decommissioning plan, requires an understanding of the site conditions and site operations. The relevant site information presented in the plan or portions of previously submitted documents (e.g., environmental reports, license renewal applications, reclamation plan, and characterization survey report) should be summarized and referenced.

F2.1.2 Review Procedures

The radium benchmark dose modeling review consists of ascertaining that an acceptable dose modeling computer code or other type of calculation has been used, that input parameter values appropriate (reasonable considering long-term conditions and representative of the

application) for the site have been used in the modeling, that a realistic (overly conservative is not acceptable as it would result in higher allowable levels of uranium or thorium which would not be as low as is reasonably achievable) dose estimate is provided, and that the data presentation is clear and complete.

F2.1.3 Acceptance Criteria

The radium benchmark dose modeling results will be acceptable if the dose assessment (modeling) meets the following criteria:

(1) Dose Modeling Codes and Calculations

The assumptions are considered reasonable for the site analysis, and the calculations employed are adequate. Reference to documentation concerning the code or calculations is provided [e.g., the RESRAD Handbook and Manual (Argonne, 1993a,b)].

The RESRAD code developed by the U.S. Department of Energy (Version 5.82, 1998) (see website http://www.ead.anl.gov/~resrad/avail.html), may be acceptable for dose calculations because, although the RESRAD ground-water calculations have limitations, this does not affect the uranium recovery sites that have deep aquifers (ground-water exposure pathway is insignificant). The DandD code developed by the NRC (see website ftp://nwerftp.nwer.sandia.gov/nrc/DandD/; also see http://techconf.llnl.gov/radcri/ then dose assessment) provides conservative default values, but does not, at this time, allow for modeling subsurface soil contamination and does not allow calculation of source removal due to soil erosion. Neither the RESRAD nor the DandD code would be adequate to model the dose from off-site contamination, but codes such as GENII are acceptable.

If the code or calculations assumptions are not compatible with site conditions, adjustments have been made in the input to adequately reflect site conditions. For example, the RESRAD code assumes a circular contaminated zone. The shape factor (external gamma, code screen R017) must be adjusted for an area that is not circular.

The code and/or calculation provides an estimated annual dose as total effective dose equivalent in mrem/yr. The DandD code provides the annual dose, but RESRAD calculates the highest instantaneous dose. However, RESRAD results are acceptable for long-lived radionuclides that do not move rapidly out of surface soils.

(2) Input Parameter Values

The code/calculation input data are appropriate for the site and represent current or long-term conditions, whichever is more applicable to the time of maximum dose. When code default values are used, they are justified as appropriate (representative) for the site. Excessive conservatism (i.e., upper bound value) is not used, as this would result in a higher dose and thus higher levels of uranium and thorium could be allowed to remain on site.

Previously approved MILDOS code input parameter values may not be appropriate, because derived operational doses in the restricted area may be an order of magnitude higher than acceptable doses for areas to be released for unrestricted use.

Site-specific input values are demonstrated to be average values of an adequate sample size. Confidence limits are provided for important parameters so that the level of uncertainty can be estimated for that input value. Alteration of input values considers that some values are interrelated [see draft NUREG–1549, Appendix C (NRC, 1998a)], and relevant parameters are modified accordingly. The preponderance of important parameter values are based on site measurements and not on conservative estimates. One or more models consider the annual average range of parameter values likely to occur within the next 200 years, for important parameters that can reasonably be estimated. Some other considerations for the input parameter values follow:

(a) Scenarios for the Critical Group and Exposure Pathways

The scenario(s) chosen to model the potential dose to the average member of the critical group[1] from residual radionuclides at the site reflect reasonable probable future land use. The licensee has considered ranching, mining, home-based business, light industry, and residential farmer scenarios, and has justified the scenarios modeled.

On the basis of one or more of these projected (within 200 years is reasonably foreseeable) land uses to define the critical group(s), the licensee has determined and justified what exposure pathways are probable for potential exposure of the critical group to residual radionuclides at the site. Dairies are not likely to be established in the area of former uranium recovery facilities because the climate and soil restrict feed production. Even if some dairy cows were to graze in contaminated areas, the milk would probably be sent for processing (thus diluted), and not be consumed directly at the site. Therefore, milk consumption is not a likely ingestion exposure pathway. Also, a pond in the contaminated area providing a significant quantity of fish for the resident's diet is not likely, so the aquatic exposure pathway may not have to be modeled. However, the external gamma, plant ingestion, and inhalation pathways are likely to be important.

The radon pathway is excluded from the benchmark dose calculation as defined in Criterion 6(6) of Appendix A to 10 CFR Part 40. This also reflects the approach in the decommissioning rule (radiological criteria for license termination, 10 CFR Part 20, Subpart E).

[1]As defined in 10 CFR Part 20, "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

(b) Source Term

If the RESRAD code is used, the input includes lead-210 (Pb-210) at the same input value as for Ra-226. The other radium progeny are automatically included in the code calculations. The chemical form of the contamination in the environment is considered in determining input values related to transport, or inhalation class (retention in the lung) for dose conversion factors.

(c) Time Periods

The time periods for calculation of the dose from soil Ra-226 include the 1,000-year time frame. The calculated maximum annual dose and the year of occurrence are presented in the results.

(d) Cover and Contaminated Zone

A cover depth of zero is used in the surface contamination model, and a depth of at least 15 cm [6 in.] is used for the subsurface model. The values for area and depth of contamination are derived from site characterization data. The erosion rate value for the contaminated zone is less than the RESRAD default value because in regions drier than normal, the erosion rate is less, as discussed in the RESRAD Data Collection Handbook (Argonne, 1993a), and the proposed value is justified. The soil properties are based on site data (sandy loam or sandy silty loam are typical for uranium recovery sites), and other input parameters are based on this demonstration of site soil type [see RESRAD handbook, pp., 23, 29, 77, and 105 (Argonne, 1993a)].

The evapotranspiration coefficient for the semi-arid uranium recovery sites is between 0.6 and 0.99. The precipitation value is based on annual values averaged over at least 20 years, obtained from the site or from a nearby meteorological station.

The irrigation rate value may be zero, or less than a code's default value, if supported by data on county or regional irrigation practices (e.g., zero is acceptable if irrigation water is obtained from a river not a well). The runoff coefficient value is based on the site's soil type, expected land use, and regional morphology.

(e) Saturated Zone

The dry bulk density, porosity, "b" parameter, and hydraulic conductivity values are based on local soil properties. The hydraulic gradient for an unconfined aquifer is approximately the slope of the water table. For a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.

If the RESRAD code is used, the non-dispersion model parameter is chosen for areas greater than 1,000 square meters (code screen R014), and the well pump rate is based on irrigation, stock, or drinking water well pump rates in the area.

(f) Uncontaminated and Unsaturated Strata

The thickness value represents the typical distance from the soil contamination to the saturated zone. Since the upper aquifer at uranium recovery sites is often of poor quality and quantity, the depth of the most shouldow well used for irrigation or stock water in the region is chosen for the unsaturated zone thickness. A value of 18 m [60 ft] is typical for most sites {15 m [50 ft] for the Nebraska site}, but regional data are provided for justification. The density, porosity, and "b" parameter values are similar to those for the saturated zone, or any changes are justified.

(g) Distribution Coefficients and Leach Rates

The distribution coefficient (Kd) is based on the physical and chemical characteristics of the soil at the site. The leach rate value of zero in the RESRAD code is acceptable as it allows calculation of the value. If a value greater than zero is given, the value is justified.

(h) Inhalation

An average inhalation rate value of approximately 8,395 m^3/yr is used for the activity assumed for the rancher or farmer scenario based on a draft letter report (Sandia, 1998a). The mass loading for inhalation (air dust loading factor) value is justified based on the average level of airborne dust in the local region for similar activities as assumed in the model.

(i) External Gamma

The shielding factor for gamma is in the range of 0.4 to 0.8 (60 to 20 percent shielding) based on DandD Parameter data (NRC, 1998a) (the DandD code screening default value is 0.55). The factor is influenced by the type (foundation, materials) of structures likely to be built on the site and the gamma energy of the radionuclides under consideration.

The time fractions for indoor and outdoor occupancy are similar to default values in RESRAD and draft guidance developed for the decommissioning rule [NUREG/CR–5512, Volume 3 (NRC, 1996b)]. For example, the staff would consider fraction values approximating 0.7 indoors and 0.15 outdoors for a resident working at home, and 0.5 outdoors and 0.25 indoors for the farmer scenario (the remaining fraction allocated to time spent off site).

The site-specific windspeed value is based on adequate site data. The average annual windspeed for the uranium recovery sites varies from 3.1 to

5.5 meters/sec [7 to 13 mph]. The maximum and annual average windspeed are also considered when evaluating proposed erosion rates.

(j) Ingestion

Average consumption values (g/yr) for the various types of foods are based on average values as discussed in NUREG/CR–5512, Volume 3 (NRC, 1996b), or the Sandia Draft Letter Reports (1998a,b), or are otherwise justified. Livestock ingestion parameters are default values, or are otherwise justified.

For sites with more than 100 acres of contamination, the fraction of diet from the contaminated area is assumed to be 0.25 for the farmer scenario (Sandia, 1998a), or is otherwise justified based on current or anticipated regional consumption practices for home-grown food. Because of the low level of precipitation in the areas in which uranium recovery facilities are located, extensive gardens or dense animal grazing is not likely, so the percentage of the diet obtained from contaminated areas would be lower than the code default value.

Note that the default plant mass loading factor in the DandD code can reasonably be reduced to 1 percent (Sandia, 1998c). The depth of roots is an important input parameter for uranium recovery licensees using the RESRAD code. The value is justified based on the type of crops likely to be grown on the site in the future. For vegetable gardens, a value of 0.3 is more appropriate than the RESRAD default value of 0.9 meters that is reasonable for alfalfa or for a similar deep-rooted plant.

(3) Presentation of Modeling Results

The radium benchmark dose modeling section of the decommissioning plan includes the code or calculation results as the maximum annual dose (total effective dose equivalent) in mrem/yr, the year that this dose would occur, and the major exposure pathways by percentage of total dose. The modeling section also includes discussion of the likelihood of the various land-use scenarios modeled (reflecting the probable critical groups), and provides the variations in dose (dose distribution) created by changing key parameter values to reflect the range of dose values that are likely to occur on the site. The section also contains the results of a sensitivity analysis (RESRAD can provide a sensitivity analysis via the graphics function) to identify the important parameters for each scenario.

F2.1.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the radium benchmark dose modeling, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the site benchmark dose modeling for the _____ uranium *in situ* leach facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.1 of Appendix F of the *in situ* leach standard review plan.

The licensee has provided an acceptable radium benchmark dose model, and the staff evaluation determines that (1) the computer code or set of calculations used to model the benchmark dose is appropriate for the site, (2) input parameter values used in each dose assessment model are site-specific or reasonable estimates, and (3) the dose modeling results include adequate estimates of dose uncertainty.

On the basis of the information presented in the application, and the detailed review conducted of radium benchmark dose modeling for the _____ uranium *in situ* leach facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which provides requirements for soil and structure cleanup.

F2.2 Implementation of the Benchmark Dose

F2.2.1 Areas of Review

The results of the radium benchmark dose calculations are used to establish a surface and subsurface soil dose limit for residual radionuclides other than radium, as well as a limit for surface activity on structures that will remain after decommissioning. The staff should review the licensee's conversion of the benchmark dose limit to soil concentration (pCi/g) or surface activity levels (dpm/100 cm^2) as a first step to determine cleanup levels. Alternatively, the licensee can derive the estimated dose from the uranium or thorium contamination (as discussed in Section 2.1.3) and compare this to the radium benchmark dose.

The reviewer should also evaluate the proposed cleanup guideline levels (derived concentration limit) in relation to the as low as is reasonably achievable requirement and the unity rule.

F2.2.2 Review Procedures

The decommissioning plan section on cleanup criteria will be evaluated for appropriate conversion of the radium standard benchmark dose to cleanup limits for soil uranium and thorium and/or surface activity. The plan will also be examined to ensure reasonable application of as low as is reasonably achievable to the cleanup guideline values and application of the unity rule where appropriate.

F2.2.3 Acceptance Criteria

(1) The soil concentration limit is derived from the site radium dose estimate. The modeling performed to estimate mrem/year per pCi/g of Th-230 and/or U-nat follows the criteria listed in Section 2.1.3. In addition, the U-nat source term input is represented as percent activity by 48.9 percent U-238, 48.9 percent U-234, and 2.2 percent U-235, or is based on analyses of the ore processed. For a soil uranium criterion (derived

concentration limit), the chemical toxicity is considered in deriving a soil concentration limit if soluble forms of uranium are present.

(2) Detailed justification for the inhalation pathway parameters is provided, such as the determination of the chemical form in the environment, to support the inhalation class.

(3) The derived Th-230 soil limit will not cause any 100 square meter (m^2) area to exceed the Ra-226 limit at 1,000 years (i.e., current concentrations of Th-230 are less than 14 pCi/g surface and 43 pCi/g subsurface, if Ra-226 is at approximately background levels).

(4) In conjunction with the activity limit, the as low as is reasonably achievable principle is considered in setting cleanup levels (derived concentration guideline levels). The as low as is reasonably achievable guidance in Draft Regulatory Guide 4006 (NRC, 1998b) is considered. The proposed levels allow the licensee to demonstrate that the 10 CFR 40.42 (k) requirements (the premises are suitable for release, and reasonable effort has been made to eliminate residual radioactive contamination) can be met.

(5) In recent practice at mill sites, the as low as is reasonably achievable principle is implemented by removing about 2 more inches [5 cm] of soil than is estimated to achieve the radium standard (reduce any possible excess or borderline contamination). At mills, it is generally cheaper to remove more soil than to do sampling and testing that may indicate failure and require additional soil removal with additional testing.

(6) The unity rule is applied to the cleanup if more than one residual radionuclide is present in a soil verification grid (100 m^2). This means that the sum of the ratios for each radionuclide of the concentration present/concentration limit may not exceed 1 (i.e., unity).

(7) The subsurface soil standard, if it is to be used, is applied to small areas of deep excavation where at least 15 cm [6 in.] of compacted clean fill is to be placed on the surface and where that depth of cover is expected to remain in place for the foreseeable future. The long-term cover depth used in the model is justified.

(8) The surface activity limit for remaining structures is appropriately derived using an approved code or calculation. Because recent conservative dose modeling by NRC staff has indicated that more than 2,000 dpm/100 cm^2 alpha (U-nat or uranium chain radionuclides) in habitable buildings [2,000 hr/yr] could exceed an effective dose equivalent of 25 mrem/yr, the licensee proposes a total (fixed plus removable) average surface activity limit for such buildings that is lower than 2,000 dpm/100 cm^2, or a higher value is suitably justified.

(9) If the DandD code is used, data are provided to support that 10 percent or less of the activity is removable; otherwise the resuspension factor is scaled to reflect the site-specific removable fraction. Note that this code assumes that the contamination is only on the floor, which can be overly conservative. If the RESRAD-Build code is used, the modeled distribution of contamination on walls and floor is justified.

F2.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the application of the radium benchmark dose modeling to the site cleanup criteria, the following conclusions may be presented in the technical evaluation report.

The staff has completed its review of the proposed implementation of the benchmark dose modeling results for the _____ uranium *in situ* leach facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.2 of Appendix F of the *in situ* leach standard review plan.

The licensee has provided an acceptable implementation plan of the benchmark dose modeling results to the proposed site cleanup activities, and the staff evaluation determines that (1) the cleanup criteria will allow the licensee to meet 10 CFR Part 40.42(k) and 10 CFR Part 40, Appendix A, Criterion 6(6) requirements; (2) the soil and structures of the decommissioned site will permit termination of the license because public health and the environment will not be adversely affected by any residual radionuclides.

H3.0 REFERENCES

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John H. Lusher
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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

A Nuclear Regulatory Commission source and byproduct material license is required to cover uranium by in situ leach extraction techniques under the provisions of Title 10 Code of Federal Regulations, Part 40 (10 CFR 40), Domestic Licensing of Source Material. An applicant for a research and development or commercial-scale license, or for the renewal or amendment of an existing license is required to provide detailed information on the facilities, equipment, and procedures used and an environmental report that discusses the effects of proposed operations on the health and safety of the public and on the environment.

The Standard Review Plan (SRP) is for the guidance of staff reviewers in the Office of Nuclear Material Safety and Safeguards, in performing safety and environmental reviews of applications to develop and operate uranium in situ leach facilities. It provides guidance for new license applications, renewals, and amendments. The principal purpose of the SRP is to assure the quality and uniformity of staff reviews and to present a well-defined base from which to evaluate changes in the scope and requirements of a review.

The SRP is written to cover a variety of site conditions and facility designs. Each section is written to provide a description of the areas of review, review procedures, acceptance criteria, and evaluation of findings. However, for a given application, the staff reviewers may select and emphasize particular aspects of each standard review plan section as is appropriate for the application.

The issue of a new draft SRP is the result of Commission policy decisions affecting uranium recovery issues, which were described in NRC Regulatory Issue Summary 2000-23, November 30, 2000.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

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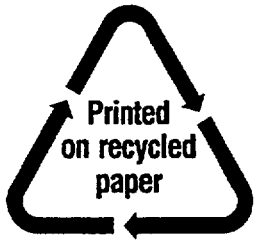

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