Guidance for the Proposed Rule "Groundwater Protection at Uranium *In Situ* Recovery Facilities"

Dated *Month Year*

Introduction

Guidance for the Proposed Rule "Groundwater Protection at Uranium In Situ Recovery Facilities"

The guidance developed to implement the Proposed Rule, "Groundwater Protection at Uranium In Situ Recovery Facilities" is provided as revisions to sections of NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications."[1] The Nuclear Regulatory Commission (NRC)~~RC~~ extracted only those sections and appendices of NUREG-1569 that were substantively changed as a result of requirements contained in the proposed rule. Red text was used to show new text and black strikeout was used to show eliminated text. In general, entire sections were included to put the proposed changes in proper context.

This document provides guidance to applicants and licensees in the completion and submission of *in situ* recovery facility license applications, license amendment requests, and subsequent submittals, and to NRC staff reviewing these applications and submittals. This guidance does not substitute for regulations, and compliance with it is not required. Methods and solutions that differ from those set forth in this guidance will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a license by the Commission. Throughout this supplemental guidance, where the review procedures and acceptance criteria apply to the staff's review of an *in situ* recovery facility license application, the guidance refers to the "applicant." Where the review procedures and acceptance criteria refer to a license amendment request or a licensee's post-licensing submittal of information, such as the geological and hydrologic characterization of the wellfield, and wellfield restoration reports, the guidance refers to the "licensee." This distinction is necessary, in part, because an applicant for an *in situ* recovery facility will not have constructed the wellfields from which required information is collected. Wellfield construction, and related collection of data and information, can only begin after the issuance of the license because, pursuant to 10 CFR 40.32(e), commencement of *in situ* recovery (ISR) facility construction prior to the decision by the Director, Office of Nuclear Material Safety and Safeguards, that the action called for is the issuance of the proposed license, is grounds for denial of a license to possess and use source and byproduct material in the facility.

The guidance is provided as both revisions to existing sections of NUREG-1569, and as new sections, as follows:

- 2.1, "Site Location and Layout"
- 2.2, "Uses of Adjacent Lands and Waters"
- 2.6, "Geology and Seismology"
- 2.7, "Hydrology"
- 2.11, "Pre-Operational Wellfield Characterization" (*new*)
- 3.1, "*In Situ* Recovery Process and Equipment"
- 5.2, "Management Control Program"
- 5.7.8, "Operational Groundwater and Surface-Water Monitoring Programs"
- 6.1, "Wellfield Restoration"
- 6.1.1, "Wellfield Restoration Plan"
- 6.1.2, "Post-Restoration Monitoring Exceedance of Approved Hazardous Constituent Concentration Limit and Corrective Action"

[1] Agencywide Documents Access and Management System (ADAMS) Accession No. ML032250177.

- 6.1.3, “Wellfield Restoration Report”
- Appendix B, “Relationship of 10 CFR Part 40, Appendix A Requirements to Standard Review Plan Sections”
- Appendix F, “Alternate Concentration Limits” (*new*)

2 SITE CHARACTERIZATION

The purpose of this review is to determine whether the information provided by an applicant adequately describes the geographic, demographic, historic, scenic, cultural resources, meteorological, geologic, hydrologic, ecologic, and background characteristics of the site and the surrounding area. For some resource areas, the site characterization may be a summary of information that the applicant provided in a separate environmental report. The safety basis for an *in situ* recovery (ISR) facility includes site characterization information in order to provide reasonable assurance of recovery fluid isolation, properly located groundwater monitoring wells during and after operations, and adequate groundwater restoration. These safety measures provide protection of groundwater users, groundwater resources, and hydraulically-connected surface waters, if applicable. Site characterization occurs in phases, first regionally and across the proposed licensed site during the initial licensing, and then locally at each wellfield prior to operation.

This Standard Review Plan (SRP) chapter provides guidance for reviews performed by the NRC staff at two different times, or stages, in the licensing process. In the first stage, the NRC staff reviews site characterization information that an applicant or licensee provides to NRC before it receives a license to construct an ISR facility or a license amendment to expand or construct additional wellfields at an existing ISR facility. In the second stage, the NRC staff reviews post-licensing, pre-operational wellfield characterization information collected by a licensee after it receives a license or license amendment and constructs an ISR facility wellfield. This staging of the review is necessary because construction of injection and production wells, from which pre-operational wellfield characterization information is derived, falls within the definition of "commencement of construction" in 10 CFR 40.4, and commencement of construction prior to completion of the 10 CFR Part 51 environmental review is grounds for denial of a license to possess and use source and byproduct material in the plant or facility [10 CFR 40.32(e)]. In this SRP, the NRC staff's review of the applicant's pre-licensing wellfield characterization is addressed in SRP Section 2.6, "Geology and Seismology," and Section 2.7, "Hydrology." The NRC staff's review of pre-operational wellfield characterization information is addressed in SRP Section 2.11, "Pre-Operational Wellfield Characterization."

2.1 Site Location and Layout

2.1.1 Areas of Review

The staff should review geographic maps, topographic maps, and drawings that identify the site and its location relative to federal, state, county, and other political subdivisions. These should include maps provided to show the location and layout of the proposed facilities, wellfields~~well fields~~, and all principal structures such as surface impoundments, deep injection wells, recovery plant buildings, exclusion area boundaries and fences, applicant property and leases, and adjacent properties pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(a)(1).

The regional location and site layout for the proposed *in situ* ~~leach~~recovery operations should be reviewed using maps that show the relationship of the site to local water bodies (lakes and streams); geographic features (highlands, forests); geologic features (faults, folds, outcrops); transportation links (roads, rails, airports, waterways); political subdivisions (counties, townships); population centers (cities, towns); historical and archeological features; key species habitat; and non-applicant property (farms, settlements). A contour map of the site showing a

plan layout of constructions, significant topographic variations of the site environs, and drainage gradients, should be evaluated.

2.1.2 Review Procedures

The reviewer should establish the validity and completeness of the basic data, to determine that the site location and layout proposed in the application are complete and accurate, and that the site information is sufficient to evaluate the location of the proposed facilities relative to key features and activities. For new applications, the staff should conduct a site visit of the facility, after becoming familiar with the submitted materials, to develop an acceptable familiarization for the review and to verify the general aspects of the submitted materials.

The staff should examine maps and drawings provided in the application and associated environmental reports to determine whether they provide sufficient detail to locate the site regionally relative to local political subdivisions and natural and man-made features and that the maps allow the staff to determine the proposed layout within the existing topography at the site. On a regional scale, the reviewer should examine the location of the facility and all federal, state, County, and local political subdivisions that have a bearing on estimating the environmental impact of the proposed operations. The staff should verify that the total acreage that is owned or leased by the applicant and the portion of that real estate or any adjacent properties that could be affected by site activities have been identified. The reviewer should examine a contour map to determine that the contour intervals and information included on the map are sufficient to show any significant variations in site environs and important drainage gradients. The staff should also determine that the relationship between the site and surface drainage is readily apparent from the provided maps. Likewise, it should be possible to ascertain the likely areas of and effects of site activities on local flora and fauna from the location maps. The staff should determine that the scale and clarity of the maps are adequate to conduct the necessary environmental and safety reviews.

Reviewers should keep in mind that the development and initial licensing of an *in situ* ~~leach~~recovery facility is not based on comprehensive information. This is because *in situ* ~~leach~~recovery facilities obtain enough information to generally locate the ore body and understand the natural systems involved. More detailed information is developed as each ~~area~~ wellfield is brought into production. Therefore, reviewers should ensure that sufficient information is presented to reach only the conclusion necessary for initial licensing. However, reviewers should not expect that information needed to fully describe each aspect of all the operations will be available in the initial 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.

2.1.3 Acceptance Criteria

The characterization of the site location and layout is acceptable if it meets the following criteria:

1. Maps are provided that show the location and layout of the proposed facilities, including ~~geologic features, well field~~wellfields, and all planned principal structures such as surface impoundments, diversion channels, monitoring wells, deep injection wells, and recovery plant buildings. If detailed information on actual ~~well field~~wellfield design is not

available at the time of the initial facility application, the maps show the expected ~~well field~~wellfield locations with an indication that this information is preliminary.

2. Any maps previously submitted (e.g., maps from the original application in the case of renewals) are legible, and actual or proposed changes are highlighted.

3. Maps are provided that show exclusion area boundaries and fences.

4. Maps are provided that show the applicant property and leases and current adjacent properties, including water bodies, forests, and farms, and all federal, state, county, and local political subdivisions.

5. Maps are provided that show nearby population centers and transportation links such as railroads, highways, and waterways.

6. A topographic map is provided with elevation contours that show the locations of drainage basins and variations in the drainage gradient in the vicinity of the proposed *in situ* ~~leach~~recovery facility. The specific locations of natural streams and proposed diversion channels, relative to principal structures, should also be provided.

7. The proposed *in situ* ~~leach~~recovery facility is clearly labeled at a scale appropriate to the area being covered (regional and local) and with sufficient clarity and detail to allow identification and evaluation of the proposed *in situ* ~~leach~~recovery facility. Maps are at an appropriate scale and are clear and ~~readable~~legible.

8. Data sources are documented in reports such as U.S. Geological Survey (USGS) open files or existing published maps. If data have been generated by the applicant, the data documentation should include a description of the investigation and data reduction techniques.

9. Maps include designation of scale, orientation (e.g., north arrow), and geographic coordinates. In addition to maps, the applicant may provide tabular locations of facilities using universal transverse Mercator coordinates with appropriate Northing and Easting in meters.

2.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the description of the site location and layout, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information ~~concerned~~associated with site location and layout at the _____*in situ* ~~leach~~recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.1.2 and the acceptance criteria outlined in standard review plan Section 2.1.3.

The ~~licensee~~applicant has acceptably described the site location and layout with appropriately scaled and labeled maps showing site layout, principal facilities and structures, regional location, geology, boundaries, exclusion areas and fences, applicant property including leases and adjacent properties, nearby population centers and transportation links, and topography.

References are cited acceptably. Any maps previously submitted (e.g., maps from the original application in the case of renewals) are legible, and actual or proposed changes are highlighted.

Based on the information provided in the application, and the detailed review conducted of the characterization of site location and layout for the _____*in situ* ~~leach~~recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(a)(1), which requires a map showing the surface location of the proposed *in situ* recovery facility and associated infrastructure, including wellfields. The information is also in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.1.5 References

None

2.2 Uses of Adjacent Lands and Waters

2.2.1 Areas of Review

The staff should review the description of present and projected land and water uses at and surrounding the proposed *in situ* recovery facility, including the information provided to characterize water use in the local area surrounding the proposed site pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(a)(11).

The staff should review descriptions of the nature and extent of present and projected land use (e.g., agriculture, sanctuaries, hunting, mining, grazing, industry, recreation, roads), any recent trends or changes in population or industrial patterns, and any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site.

The staff should also review tables showing, for each of the 22½-degree sectors centered on each of the 16 compass points (i.e., north, north-northeast, etc.), the distances {to a distance of 3.3 km [2 mi]} from the center of the site to the nearest resident and to the nearest site boundary.

The staff review should include the location, nature, and amounts of present and projected surface- and ~~ground-water~~groundwater use (e.g., water supplies, irrigation, reservoirs, recreation, and transportation) within 3.3 km [2 mi] of the site boundary {0.8 km [0.5 mi] for research and development operations} and the present and projected population associated with each use point.

2.2.2 Review Procedures

The reviewer should determine whether the application provides sufficient information on the use of the lands and waters within a 3.3 km [2 mi] distance from the site boundary surrounding the proposed facilities {0.8 km [0.5 mi] for research and development operations} to assess the likely consequences of any impacts of *in situ* ~~leach~~recovery operations on adjacent properties.

The staff should determine that the application contains the location of residences, ~~ground-water~~groundwater supply wells, surface-water reservoirs, and the estimated use of water in the lands surrounding the site of the proposed facility. Data sources should be referenced. This

information should be evaluated to determine whether it is sufficient to delineate the likely impact(s) of the facility, under both normal operating conditions and accidents, on the ground water, surface water, and population (both human and animal) near the site. The reviewer should determine that within 3.3 km [2 mi] from the site boundary, the nature and extent of present and projected water and land use and any other trends or changes in population or industrial patterns have been reported. Any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site should be identified.

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

2.2.3 Acceptance Criteria

The characterization of the uses of adjacent lands and waters is acceptable if it meets the following criteria:

1. Information is presented in detail sufficient to understand the surrounding land and water uses, such that the likely consequences imposed by *in situ* ~~leach~~recovery operations can be adequately assessed. Although the specific requirements may vary from site to site, the general purpose for determining land and water use patterns is to provide supporting data for exposure calculations, cost-benefit analyses, and determinations of air emissions (e.g., dust). A 3.3-km [2-mi] distance from the site boundary is an acceptable area for which land and water use data should be collected. One acceptable method for presenting these data is for the applicant to provide the information requested in the Standard Format and Content of License Applications, Including Environmental Reports (NRC, 1982), Section 2.2. The information presented should include:

    a. Maps showing the locations of nearest residences, ~~ground-water supply wells, and abandoned wells,~~ surface bodies of water, mines (surface and subsurface), quarries and other pertinent surface features such as known or suspected faults and all residential, commercial, agricultural and industrial improvements.
    b. For each wellfield, reasonably available data from public records or otherwise known to the applicant about all boreholes and local wells within and near the proposed wellfield and those wells that are potentially hydraulically connected to any aquifer in the proposed wellfield. The data should, at a minimum, include a description of each borehole and well type, construction, date drilled, location, depth, and record of completion.
    c. Maps showing the number and location of all existing injection wells, production wells, abandoned wells, dry holes, public water systems, and water wells in and near the proposed site.
    ~~b.~~d. Types of past, present and projected (life of facility) water use (e.g., municipal, domestic, agriculture, livestock) and descriptions of the methodology and sources used to develop projections.
    ~~c.~~e. Past, ~~P~~present and projected (life of facility) water use estimates, by type, for both ground-water and surface water, including present and projected withdrawal, and descriptions of the methodology and sources used to develop projections.
    ~~d.~~f. For existing ~~ground-water~~groundwater wells, well depth, ~~ground-water~~groundwater elevations, flow rates, drawdown, and a description of the producing aquifer(s).

e.g. The locations of abandoned wells and drill holes, including the depth, type of use, condition of closing, plugging procedure used, and date of completion for each well or drill hole within the site area and within 0.4 km [.25 mi] of the well fieldwellfield boundary.

f.h. Descriptions of the nature and extent of projected land use (e.g., agriculture, recreation, industry, grazing, and infrastructure) and descriptions of the methodology and sources used to develop projections.

g.i. The location of any other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site.

2. For each of the 22½-degree sectors centered on the 16 cardinal compass points, the information identified in Section 2.2.3 of the Standard Format and Content of License Application, Including Environment Report (NRC, 1982) concerning human residences, nearest site boundary(ies) to residences, surface- and ground-watergroundwater use, and projected water use, is provided. As described in Section 2.2 of the Standard Format and Content of License Application, Including Environment Report (NRC, 1982), appropriate presentation of the data should include mapped data as appropriate, a tabular summary for each of the 22½-degree sectors centered on the 16 cardinal compass points, and for each, the distance from the center of the site to the site boundary and the nearest residence.

3. Data sources are documented in reports such as U.S. Geological Survey open files or existing published reports or maps. If data have been generated by the applicant, the data documentation should include a description of the investigations and data reduction techniques.

4. Maps include designation of scale, orientation (e.g., north arrow), and geographic coordinates.

2.2.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the described uses of adjacent lands and waters, the following conclusions may be presented in the technical evaluation report and in the environmental assessment.

NRC has completed its review of the site characterization information concerned with uses of adjacent lands and waters near the _____ *in situ* leachrecovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.2.2 and acceptance criteria outlined in standard review plan Section 2.2.3.

The applicant has acceptably described the present and projected land use, including residential, commercial, agricultural, industrial, flora and fauna sanctuaries, arboreal, grazing, recreation (e.g., hunting, swimming, skiing), and infrastructure. Appropriate information on the location and extent of each use has been provided. In particular, the description and associated tabulated data of the location, nature, amounts, and population associated with each use point of present and projected (life of the facility) surface and ground water adjacent to the site including water supplies, irrigation, reservoirs, recreation, and transportation within at least 3.3 km [2 mi] of the site boundary {0.8 km [0.5 mi] for research and development operations} are acceptable for determination of likely impacts of the proposed *in situ* leachrecovery facility. Tabulated data on present and projected water withdrawal rates, return rates, types of water use (e.g., municipal, domestic, agriculture, and livestock); source, and water -use estimates,

~~and abandoned well locations~~ are acceptable. The applicant has identified and located (or has noted the absence of) other nuclear fuel cycle facilities located or proposed within an 80-km [50-mi] radius of the site.

The applicant has acceptably described information on past, current, and anticipated future groundwater use in the local area surrounding the proposed licensed site, including a description of local groundwater well locations, type of use, amounts used, and screened intervals sufficient to evaluate the potential impact from ISR facility operations. This information included data reasonably available from public records or otherwise known to the applicant about all boreholes and local wells within and near the proposed wellfield, and those wells that are potentially hydraulically connected to the proposed wellfield and were shown on maps. Borehole and local well data included a description of each borehole and well type, construction, date drilled, location, depth, and record of completion and/or plugging. The applicant also provided maps showing the number and location of all existing injection wells, production wells, abandoned wells, dry holes, public water systems, and water wells in and near the proposed site. These maps also showed surface bodies of waters, mines (surface and subsurface), quarries and other pertinent surface features such as known or suspected faults and all residential, commercial, agricultural, and industrial improvements.

Based on the information provided in the application, and the detailed review conducted of the characterization of uses of adjacent lands and waters for the _____*in situ* ~~leach~~recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45 which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis. In addition, the staff concludes that the information on water use is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(a)(11), which requires characterization of water use in the local area surrounding the proposed site.

2.2.5 Reference

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.

2.6 Geology and Seismology

2.6.1 Areas of Review

The area of review is the applicant's description of the site geology and seismology, including the characterization of the site geology pursuant to 10 CFR Part 40, Appendix A, Paragraphs 14(a)(2)–14(a)(6), which require information on the regional and local geology, stratigraphy, geologic structure, and ore bodies of the proposed *in situ* recovery facility. This area of review also includes the geological conceptual model of the site and its technical basis pursuant to the regulation in Paragraph 14(a)(12).

The reviewer should examine information on the geologic aspects of the site acquired through standard geologic analyses, including a survey of pertinent literature and field investigations.

This information should include regional seismicity and seismic history, local stratigraphy, petrology or lithology of rock units, tectonic features (faulting, folding, fracturing), and the continuity of the geologic strata at the site and in nearby regions.

Geologic, structural, and stratigraphic maps and cross sections, including representative core and geophysical well-log data of the site and its environs, should be reviewed. An isopach map of the intended production unit~~zone of injection or production~~ and associated confining units~~beds~~ should be evaluated. All conclusions regarding the lateral continuity and vertical thickness of the ~~mineralized zone(s)~~production unit, surrounding lithologic units, and confining ~~zones~~units, as based on lithologic logs from core and drill cuttings, geophysical data, remote-sensing measurements, and the results of other appropriate investigations should be reviewed. Some of the applicant's supporting information for this review area might be included in the documents submitted to satisfy the hydrology review area (Section 2.7).

The staff should review the information presented on any economically important minerals and energy-related deposits in addition to the uranium mineralization, including the likely consequences of any production of such ~~related~~ deposits on the *in situ* ~~leach~~recovery facility.

Data on the geochemistry of the ore body ~~zone~~ and the geologic zones immediately surrounding the ~~mineralized zone~~ production unit that will or could be affected by injected lixiviant should be evaluated. Information on unique minerals (including those that might be affected by fluid movement associated with the proposed project, such as bentonite) or palaeontologic deposits of particular scientific interest, should also be reviewed. The staff should examine descriptions of any effects that planned operations at the site might have on the future availability of other mineral resources.

2.6.2 Review Procedures

The staff should review the application to determine whether a thorough evaluation of the geologic setting for the proposed *in situ* ~~leach~~recovery activity has been presented along with the basic data supporting all conclusions. In addition to a description of the basic geology, both at the surface and at the depths of interest, the establishment of the continuity of the geologic strata at the site should be reviewed for applicability, correctness, inclusivity, and likely ability of the strata to isolate *in situ* ~~leach~~recovery fluids. The reviewer should particularly focus attention on fractures or faults, permeable stratigraphic units, and lateral facies changes that might preclude the applicant-identified geologic barriers to fluid migration from performing adequately.

The reviewer should determine that the application contains accurate geologic maps, isopach maps of the ~~mineralized strata~~production unit and of the confining layers, geologic cross sections at places critical to a thorough understanding of the ~~selected~~ site, descriptions of representative supporting core samples, geophysical and lithologic logs, and other data required for a thorough understanding of the pertinent geology. The reviewer should determine that regional stratigraphic and geologic information is discussed in sufficient detail to give clear perspective and orientation to the site-specific material presented. The discussion of regional geology and stratigraphy should be assessed to determine if it is adequately referenced and is illustrated by regional surface and subsurface geologic maps, stratigraphic columns, and cross sections. Seismic information should be evaluated to assess its suitability for evaluating seismic hazard for the proposed facility.

The staff may also perform an independent analysis of the data provided to assess whether reasonable and conservative alternative interpretations are indicated.

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.

2.6.3 Acceptance Criteria

The characterizations of the site geology and seismology are acceptable if they meet the following criteria:

1. The application includes a description of the local and regional stratigraphy based on techniques such as

    a. Surface sampling and descriptions

    b. Cuttings and core logging reports

    c. Well logging by ~~W~~wireline geophysical logs, such as electrical resistivity, neutron density, and gamma logs

    d. Geologic interpretations of surface geology and balanced cross sections. These interpretations may be based either on original work submitted by the applicant, or on an appropriate evaluation of previous work in the region performed by state or federal agencies (e.g., U.S. Geological Survey, U.S. Bureau of Land Reclamation, U.S. Bureau of Mines), universities, mining companies, or oil and gas exploration companies. The interpretations should be accompanied by

        i. Maps such as geologic, topographic, and isopach maps that show surface and subsurface geology and locations for all wells used in defining the stratigraphy

        ii. Cross sections through the ore deposit roughly perpendicular and parallel to the principal ore trend

        iii. Fence diagrams showing stratigraphic correlations among wells

2. All maps and cross sections are at sufficient scale and resolution to show clearly the intended geologic information. Maps show the locations of all site explorations such as borings, trenches, seismic lines~~, piezometer readings~~, and geologic cross sections.

3. In the local stratigraphic section, all ~~mineralized horizons,~~production units containing targeted ore bodies and confining units, ~~and other important units such as drinking water aquifers and deep well injection zones~~ are clearly shown, with their depths from the surface clearly indicated. Isopach maps are prepared showing the variations in thickness of the ~~mineralized zones~~production units and the confining units over the area of the proposed ~~mining area~~site.

4. A geologic and geochemical description of ~~the mineralized zone~~each ore body in the production unit and the geologic units immediately surrounding the ~~mineralized zone~~production unit is provided.

5. An inventory of economically significant mineral and energy-related deposits, in addition to the uranium mineralization in the production unit, is provided. ~~Locations of all known wells, surface and underground mine workings, and surface impoundments that may have an effect on the proposed operations are provided~~.

   ~~These items should be located on a map of sufficient scale and clarity to identify their relationship to the proposed facility. For existing wells, the depth should be shown, if possible. To allow evaluation of connections between the mineralized zone and underground sources of drinking water, plugging and abandonment records provided from state, federal, and local sources, as appropriate, should be provided. The applicant should provide evidence that action has been undertaken to properly plug and abandon all wells that cannot be documented in this manner.~~

6. ~~A~~ Maps and a description of the local and regional geologic structure, including folds and faults, is provided.

   Folds and faults can be shown on the geologic maps and cross sections used to describe the stratigraphy. Major and minor faults traversing the proposed site should be evaluated for the likely consequences of any future effects of faulting on the *in situ* recovery ~~uranium production~~ activities and on the ability of the strata to contain lixiviant should fault motion occur. Geologic structures that are preferential pathways or barriers to fluid flow must be described and the basis for likely effects on flow given.

7. The applicant has provided a geological conceptual model for the *in situ* recovery site and surrounding region and the supporting technical bases for the conceptual model. The conceptual model provides a sufficient framework for the staff to understand the geological conditions that will influence uranium recovery from the production unit.

~~7.~~8. A discussion of the seismicity and the seismic history of the region is included.

   Historical seismicity data should be summarized on a regional earthquake epicenter map, including magnitude, location, and date of all known seismic events. Where possible, seismic events should be associated with the tectonic features described in the geologic structures.

~~8.~~9. A generalized stratigraphic column, including the thicknesses of rock units, representation of lithologies, and ~~definition~~ location of the ore body in the production unit~~mineralized horizon~~, is presented.

~~9.~~10. The sources of all geological and seismological data are documented in U.S. Geological Survey open files or other published documents. If data have been generated by the applicant, the documentation should include a description of the investigations and data reduction techniques.

~~10.~~11. Maps have designation of scale, orientation (e.g., North arrow), and geographic coordinates.

~~11.~~12. Short-term seismic stability has been demonstrated for the *in situ* ~~leach~~recovery facility in accordance with Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills,” Section 2.6 (NRC, 1977).

~~12.~~13. A general description of the site soils and their properties has been provided to support an evaluation of the environmental effects of construction and operation on erosion.

~~13.~~14. A detailed description of soils and their properties has been provided for any areas where land application of water is anticipated to support an assessment of the impacts.

2.6.4 Evaluation Findings

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

NRC has completed its review of the site characterization information concerned with geology and seismology at the _____ *in situ* ~~leach~~recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.6.2 and acceptance criteria outlined in standard review plan Section 2.6.3.

The ~~licensee~~applicant has acceptably described the geology and seismology by providing (i) a description of the local and regional stratigraphy; (ii) geologic, topographic, and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and site explorations used in defining stratigraphy; (iii) a geologic and geochemical description of the ~~mineralized zone~~ore body in the production unit and the geologic units adjacent to the ~~mineralized zone~~production unit; (iv) an inventory of nearby economically significant minerals and energy-related deposits; (v) a description of the local and regional geologic structure; (vi) a discussion of the seismicity and seismic history of the region; (vii) a generalized stratigraphic column that includes thickness of rock units, representation of lithologies, and definition of the ~~mineralized horizon~~production unit; and (viii) a description and map of the soils.

Based on the information provided in the application, and the detailed review conducted of the characterization of the geology and seismology at the _____*in situ* ~~leach~~recovery facility, the staff concludes that the information is ~~acceptable to allow evaluation of the geologic and seismologic characteristics of the site, supports associated conceptual and numerical models, and is~~ in compliance with 10 CFR Part 40, Appendix A, Paragraphs 14(a)(2) – 14(a)(6), which require characterization of the regional and local geology, stratigraphy, geologic structure and ore bodies of the proposed *in situ* recovery facility and Paragraph 14(a)(12) that requires a geological conceptual model of the site. The information provided is also in compliance with 10 CFR 40.31(f), which requires inclusion of an environmental report in the application, and 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis. ~~The characterization is sufficient to meet the requirements of 10 CFR Part 40, Appendix A, Criteria 4(e), which requires locations away from faults capable of causing impoundment failure, and 5G(2), which requires adequate descriptions of the characteristics of the underlying soils and geologic formations~~

2.6.5 References

NRC. Regulatory Guide 3.11, “Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1977.

2.7 Hydrology

2.7.1 Areas of Review

The area of review is the applicant's characterization of the site surface water and groundwater hydrology, including the characterization of groundwater hydrology pursuant to 10 CFR Part 40, Appendix A, Criterion 7, Paragraphs 14(a)(2) and 14(a)(7)-(10), which require characterization of the regional and local groundwater hydrology, hydrostratigraphy, groundwater quality, and hydrologic parameters in the uppermost aquifer, the production unit, and the aquifers immediately overlying, underlying, and adjacent to the production unit. This area of review also includes the hydrologic conceptual model of the site pursuant to the regulation in Paragraph 14(a)(12).

Characterization of the hydrology at *in situ* ~~leach~~recovery uranium extraction facilities must be sufficient to establish potential effects of *in situ* ~~leach~~recovery operations on the adjacent surface-water and ~~ground-water~~groundwater resources and the potential effects of surface-water flooding on the *in situ* ~~leach~~recovery facility. The areas of review include:

1. Descriptions of surface water features in the site area including type, size, pertinent hydrologic~~al~~ or morphological characteristics, and proximity to *in situ* ~~leach~~recovery processing plants, ~~well field~~wellfields, evaporation ponds, or other facilities that might be negatively affected by surface erosion or flooding.

2. Assessment of the potential for erosion or flooding that may require special design features or mitigation measures to be implemented.

3. A description of site hydrogeology, including (i) identification of aquifer and aquitard formations that may affect or be affected by the *in situ* ~~leach~~recovery operations; (ii) a description of aquifer properties, including material type, formation thickness, effective porosity, hydraulic conductivity, anisotropy, and hydraulic gradient; (iii) estimated thickness and lateral extent of aquitards~~, and other information relative to the control and prevention of excursions~~; (iv) information related to whether the production unit is hydraulically isolated from overlying and~~,~~ underlying aquifer to the production unit; and (v~~iv~~) data to support conclusions concerning the local ~~ground-water~~groundwater flow system, based on well borings, core samples, water ~~-~~level measurements, pumping tests, laboratory tests, soil surveys, and other methods

4. Assessment of available ~~ground-water~~groundwater resources and site ~~ground-water~~groundwater quality within the proposed permit boundaries and adjacent properties, including quantitative description of the ~~chemical and~~ radiological and non-radiological characteristics of the ground~~-~~water in the production unit and aquifers immediately overlying, underlying and adjacent to the production unit, and potential changes in ground~~-~~water quality caused by operations

5. An assessment of typical seasonal ranges and averages and the historical extremes for levels of surface-water bodies and aquifers

~~6. Information on past, current, and anticipated future water use, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals~~

In conducting these evaluations, the reviewer shall consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. ~~Ground-water~~Groundwater compliance and protection reviews are the primary technical areas impacted by overlapping authorities. 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.

2.7.2 Review Procedures

At a minimum, the reviewer should evaluate whether the applicant has developed an acceptable conceptual model of the site hydrology and whether the conceptual model is adequately supported by the data presented in the site characterization. To this end, the reviewer should:

1. Review surface-water data, including maps that identify nearby lakes, rivers, surface drainage areas, or other surface-water bodies; stream flow data; and the applicant's assessment of the likely consequences of surface-water contamination from *in situ* ~~leach~~recovery operations. Verify that the applicant has generally characterized perennial surface-water bodies, such that an assessment of impacts from operations can be made.

2. Evaluate the applicant's assessment of the potential for erosion or flooding. If surface water or erosion modeling is used by the applicant, verify that acceptable models and input parameters have been used in the flood analyses and that the resulting flood forces have been acceptably accommodated in the design of surface impoundments. Regardless of whether modeling is used, ensure that the evaluation of flooding and erosion potential is consistent with available geomorphological, and topographic data or analysis of paleodischarge information.

3. Evaluate the site ~~hydrogeologic~~ hydrologic conceptual model for ~~ground-water~~groundwater flow in potentially affected aquifers. Review available data from well logs and hydrologic tests and measurements to obtain confidence that sufficient data have been collected and that the data support the applicant's hydrologic conceptual model for ~~ground-water~~groundwater flow within and around the permit boundary. The applicant's interpretation of ~~ground-water~~groundwater hydraulic gradients (used to infer flow direction), horizontal hydraulic conductivity, and the thickness, areal extent, and vertical hydraulic conductivity of confining formations should be evaluated. Examine pumping tests, analyses, and/or other measurement techniques used to determine the hydrologic properties of the local aquifers and aquitards that affect or may be affected by the proposed *in situ* ~~leach~~recovery activities. Also examine pumping tests that are used to establish hydraulic confinement of the proposed production units, including evidence that supports ~~investigate~~ vertical confinement or hydraulic isolation between the ~~ore~~ production unit~~zone~~ and immediately overlying and underlying~~upper and lower~~ aquifers.

4. Evaluate the applicant's assessment of site groundwater quality ~~of potentially affected ground-water resources.~~, including radiological and non-radiological constituents present in the uppermost aquifer, the production unit, and the aquifers immediately overlying, underlying, and adjacent to the production unit. This information will provide the basis for

evaluating potential effects of *in situ* recoveryleach extraction on the quality of local ground-watergroundwater resources. Verify that a sufficient number of baseline ground-watergroundwater samples are collected to provide meaningful statistics, that samples are spaced in time sufficiently to capture temporal variations, and that the chemical constituents and water quality parameters evaluated are sufficient to establish pre-operational site groundwater quality, including classes of use.

5. Review the applicant's assessment of seasonal and, if data are available, the historical variability for levels of surface-water bodies and water levels or potentiometric heads in aquifers and ensure that sufficient time intervals have elapsed between measurements to allow assessment of seasonal variability.

6. Verify that the applicant has provided information on past, current, and anticipated future water uses in and near the proposed license area and evaluated the impact of the past and present water use on current groundwater flow system and potential impact of future use on the groundwater flow system.,including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals.

In conducting an evaluation of ground-watergroundwater activities, the reviewer should follow the reviews conducted by the state. Where appropriate, the evaluation should not duplicate state regulatory efforts. Although NRC must make its own independent findings, reviewers need not duplicate questions if a state or other federal regulatory agency has already addressed the issue. If the applicant response to questions from a state or other federal agency is submitted to NRC so that it becomes part of the license application to NRC, then the reviewer can use the information to prepare the technical evaluation report on ground-watergroundwater issues.

2.7.3 Acceptance Criteria

The hydrologic characterization should establish a hydrologic conceptual model for the *in situ* leach site and surrounding region. The conceptual model provides a framework for the applicant to make decisions on the optimal methods for extracting uranium from the mineralized zones, and to minimize environmental and safety concerns caused by *in situ* leach operations. Hydrologic characterizations that accomplish this objective are considered acceptable.
The characterization of the site hydrology, including the hydrologic conceptual model, is acceptable if it meets the following criteria:

1. The applicant has provided a hydrologic conceptual model for the *in situ* recovery site and surrounding region. The conceptual model provides a sufficient framework for the staff to understand the hydrologic conditions that will influence the uranium recovery from the production unit and demonstrate hydraulic isolation of overlying and underlying aquifers.

1.2. The applicant has characterized surface-water bodies and drainages within the proposed licensed sitearea and affected surroundings. Maps provided in the application identify the location, size, shape, hydrologic characteristics, and uses of surface-water bodies near the proposed site, including likely surface drainage areas near the proposed facilities. An acceptable application should also identify the zones of interchange between surface water and ground-water.

2.3. The applicant has provided an assessment of the potential for flooding and erosion that could affect the *in situ* leachrecovery processing facilities or surface impoundments. The

staff recognizes that the flooding and erosion protection design of impoundments for *in situ* facilities may be relatively simple. This is true when impoundments are located near or on a drainage divide and little or no diversion of runoff is necessary to protect the impoundment side slopes from erosion. In such cases, it will be easy to demonstrate that no erosion to the slopes will occur. In flood-prone areas, however, it may be necessary to conduct surface water and erosion modeling. Information regarding acceptable models may be found in NUREG–1623 (NRC, 1999). The reviewer should recognize, however, that the staff guidance (NRC, 1999) was prepared for use in evaluating a 1,000-year design life for large tailings impoundments, whereas the design life of the surface impoundments at *in situ* ~~leach~~recovery facilities is on the order of tens of years.

~~3.~~4. The applicant has described the local and regional hydraulic gradient and hydrostratigraphy. The applicant has shown that subsurface water level measurements were collected by acceptable methods, such as American Society for Testing and Materials D4750 (American Society for Testing and Materials, 2001). Potentiometric maps are the recommended means for presenting hydraulic gradient data. These maps should include two levels of detail: regional and local. The regional map should be at a scale that encompasses and extends outside the entire proposed licensed area and should include all regional hydrologic features that may influence the potentiometric surface of the regional scale aquifers including aquifer recharge and discharge areas (e.g., rivers, streams)~~represent mineralized zone aquifer and should encompass the likely consequences on any affected highly populated areas~~. The local (site-scale) map should ~~encompass the entire~~ focus on the proposed licensed site~~area~~ and production unit in the proposed wellfields. If overlying and underlying aquifers to the production unit are present ~~exist~~, local-scale potentiometric or water surface elevation maps of these aquifers should also be included. These maps should clearly show the locations, depths, and screened intervals of the wells used to determine the potentiometric surface elevations. Alternatively, this information can be provided in separate maps and/or tables. The appropriate contour interval will vary from site to site; however, contour intervals should be sufficient to clearly show the ~~ground-water~~groundwater flow direction in the ~~ore zone~~ production unit and in the overlying, ~~and~~ underlying, and adjacent aquifers. The number of piezometer elevation measurements used to construct each map should be sufficient to determine the direction of ~~ground-water~~groundwater flow in the uppermost aquifer, production unit ~~mineralized zone~~(s), and in immediately overlying, underlying, and adjacent aquifers to the production unit. ~~and the overlying aquifer~~. To construct a regional potentiometric map, a reasonable effort should be made to consider as many existing wells as possible.

Hydrogeologic cross sections are recommended for illustrating the interpreted hydrostratigraphy. These cross sections should be constructed for the area within the license boundary. For very large or irregularly shaped ~~well field~~wellfield areas, more than one cross section may be necessary. Cross sections must be based on borehole data collected during well installation or exploratory drilling. All significant borehole data should be included in an appendix. Staff should verify that~~,~~ an adequate number of boreholes is used to support the assertion of hydrogeologic unit continuity, if shown as such in the cross sections.

The applicant should describe all ~~hydraulic~~ hydrologic parameters used to determine expected operational and restoration performance in the production unit and its hydraulic isolation. The hydrologic properties of the production unit ~~A~~aquifer and any overlying and

underlying aquitards ~~hydraulic properties~~ may be determined using aquifer pumping tests for parameters such as hydraulic conductivity, transmissivity, and specific storage. Pumping tests should also characterize any anisotropy of the aquifers which contain the production unit. Any of a number of commonly used aquifer pumping tests may be used including single-well drawdown and recovery tests, drawdown versus time in a single observation well, and drawdown versus distance pumping tests using multiple observation wells. The methods or standards used to analyze pumping test data should be described and referenced: acceptable methods of analysis include use of curve fitting techniques for drawdown or recovery curves that are referenced to peer-reviewed journal publications, texts, or American Society for Testing and Materials Standards. It is important for the reviewer to ensure that where fitted curves deviate from measured drawdown, the applicant explains the probable cause of the deviation (e.g., leaky aquitards, delayed yield effects, boundary effects, etc.). For estimates of porosity, it is acceptable to use laboratory analysis of core samples, borehole geophysical methods, and analysis of the barometric efficiency of the aquifer (e.g., Lohman, 1979). The applicant should distinguish between total porosity estimated from borehole geophysical methods and effective porosity that determines transport of chemical constituents.

~~4.~~5. Reasonably comprehensive assessment of the site groundwater quality, including radiological and non-radiological constituents present~~chemical and radiochemical analyses of water samples, obtained within and at locations away from the mineralized zone(s), have been made to determine pre-operational baseline conditions. Baseline water quality should be determined for the mineralized and surrounding aquifers~~. These data should include groundwater quality ~~parameters~~ constituents that are expected to increase in concentration as a result of *in situ* recovery~~leach~~ activities and that are of concern to the water use of an ~~the~~ aquifer (i.e., drinking water, etc.). The applicant should show that groundwater samples were collected by acceptable sampling procedures, such as American Society for Testing and Materials D4448 (American Society for Testing and Materials, 1992).

For example, *in situ* ~~leach~~recovery operations are not expected to mobilize aluminum, and unless an ammonia-based lixiviant is used, ammonia concentrations in the ground water should not increase as a result of *in situ* ~~leach~~recovery operations. Therefore, little is gained by sampling these ~~parameters~~constituents. Studies have shown that thorium-230 is mobilized by bicarbonate-laden leaching solutions. However, studies have also shown that after restoration, thorium in the ground water will not remain in solution because the chemistry of thorium causes it to precipitate and chemically react with the rock matrix (Hem, 1970). As a result of its low solubility in natural waters, thorium is found in only trace concentrations. Additionally, chemical tests for thorium are expensive, and are not commonly included in water analyses at *in situ* ~~leach~~recovery facilities.

Table 2.7.3-1. Typical Site Radiological and Non-Radiological Constituents~~Baseline Water Quality Indicators~~ to be Collected Pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(a)(9)~~Determined During Pre-operational Data Collection~~

A. Trace and Minor Elements		
Arsenic	Iron	Selenium
Barium	Lead	Silver
Boron	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
Copper	Nickel	
Fluoride	Radium-226@	
B. Common Indicator Constituents		
Alkalinity	Chloride	Sodium
Bicarbonate	Magnesium	Sulfate
Calcium	Nitrate	
Carbonate	Potassium	
C. Physical Indicators		
Specific Conductivity*		Total Dissolved Solids#
pH*		
D. Radiological Parameters		
Gross Alpha†	Gross Beta	

*Field and Laboratory determination.
#Laboratory only.
†Excluding radon, radium, and uranium.
@ If site initial sampling indicates the presence of Th-232 then Ra-228 should be considered in the base line sampling or an alternative may be proposed.

The applicant should identify the list of constituents to be sampled in its assessment of site groundwater quality~~for baseline concentrations~~. The list of constituents in Table 2.7.3-1 is accepted by the NRC for *in situ* recovery~~leach~~ facilities that use alkaline lixiviant. Alternatively, applicants may propose a list of constituents that is tailored to a particular location and lixiviant type. In such cases, sufficient technical bases must be provided for the selected constituent list.

~~At least~~ To evaluate the groundwater quality across the licensed area before licensing, four sets of samples, spaced ~~at least~~ quarterly~~sufficiently in time~~ to assess~~indicate~~ seasonal variability, should be collected and analyzed from the uppermost aquifer and the overlying and underlying aquifers to the production unit for each listed constituent ~~to evaluate groundwater quality~~ for one year immediately before filing an application~~for~~

~~determining baseline water quality conditions~~. Some samples should be split and sent to different laboratories as part of a quality assurance program~~. Sets of samples should be taken with a minimum of a week or two between sampling to provide an indication of how the water quality of the aquifers changes with time~~. The applicant should document any variability in the ~~ground-water~~groundwater flow rates or recharge that are observed in the collected data. Additional sampling to establish the natural cyclical fluctuations of the water quality may be~~is~~ necessary if natural ~~ground-water~~groundwater flow rates and recharge conditions vary considerably. The average water quality for each aquifer zone and the range of each constituent in the zone have been tabulated and evaluated. If zones of distinct water quality characteristics are identified, they are delineated and referenced on a topographic map. For example, since uranium rollfront deposits are formed at the interface between chemically oxidizing and reducing environments, water quality characteristics may differ significantly across the rollfront.

6. Where perennial surface-water sources are present, surface-water quality measurements should be taken on a seasonal basis for a minimum of one year before implementation of *in situ* recovery~~leach~~ operations. Surface-water samples can be obtained by grab sampling and should be taken at the same location each time. ~~The average water quality for each aquifer zone and the range of each indicator in the zone have been tabulated and evaluated. If zones of distinct water quality characteristics are identified, they are delineated and referenced on a topographic map. For example, since uranium rollfront deposits are formed at the interface between chemically oxidizing and reducing environments, water quality characteristics may differ significantly across the rollfront.~~

~~5.~~7. The applicant has provided an assessment of seasonal and the historical variability for potentiometric heads and hydraulic gradients in aquifers and water levels of surface-water bodies. This assessment should include water levels or water potentials measurements over at least one year and collected periodically to represent any seasonal variability.

~~6.~~8. The applicant has provided information on past, current, and anticipated future water use, including descriptions of local ~~ground-water~~groundwater well locations, type of use, amounts used, and screened intervals. The applicant has provided an analysis of how the past and present water use has influenced the current groundwater flow system and evaluated the influence of expected future use on the groundwater flow system. This information ~~must be~~provided is sufficient to evaluate potential risks to the applicant's ability to create and maintain an inward gradient in the production unit and to estimate the impact of the facility groundwater use on ~~ground-water~~groundwater or surface-water users in the vicinity of the *in situ* ~~leach~~recovery facility.

For license renewals and amendment applications, most or all of the preceding acceptance criteria may previously have been met. 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.

2.7.4 Evaluation Findings

If the staff's review as described in this section results in the acceptance of the site hydrology, the following conclusions may be presented in the technical evaluation report and in the environmental assessment. NRC has completed its review of the hydrologic site

characterization information for the _____ *in situ* ~~leach~~recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.7.2 and acceptance criteria outlined in standard review plan Section 2.7.3.

The ~~licensee~~ applicant has acceptably described the hydrology by providing (i) estimates of the local and regional hydraulic gradients, using potentiometric surface maps with acceptable contour intervals, in~~cluding~~ the ~~mineralized~~production unit ~~aquifer~~ and the aquifers immediately ~~other~~ overlying, ~~or~~ underlying and adjacent ~~aquifers~~ to the production unit, and the likely consequences to affected populated areas; (ii) hydrologic cross-sections, based on an appropriate number of boreholes; (iii) acceptable comprehensive analyses of ~~chemical and radiochemical~~radiological and non-radiological constituents ~~analyses of water samples from~~ in and near the ~~mineralized zone(s)~~production unit that characterize~~define~~ the ~~pre-operational baseline~~ground water quality conditions in the uppermost aquifer, production unit and aquifers immediately overlying, underlying and adjacent ~~aquifers~~ to the production unit; (iv) all hydrologic~~aulic~~ parameters used to determine expected operational and restoration performance; and (v) characterization of surface water in the *in situ* ~~leach~~recovery facility and nearby areas, including presentation of such information on maps. Zones of interchange between surface water and ground water have been identified. The applicant has provided acceptable erosion protection against the effects of flooding from nearby streams and for drainage and diversion channels, such that the suggested criteria in NUREG–1620 (NRC, 2002) have been followed and that the design meets the requirements of 10 CFR Part 40, Appendix A.

Based on the information provided in the application, and the detailed review conducted of the characterization of the hydrology at the _____*in situ* ~~leach~~recovery facility, the staff concludes that the information is acceptable and in compliance with 10 CFR Part 40, Appendix A, Paragraphs 14(a)(2) and 14(a)(7)-(10), which require characterization of the regional and local groundwater hydrology, hydrostratigraphy, groundwater quality and the hydrologic parameters in the uppermost aquifer, the production unit, and in aquifers immediately overlying, underlying, and adjacent to the production unit. The information is also in compliance with paragraph 14(a)(12) that require a hydrologic conceptual model. The information provided ~~to allow evaluation of the site and associated conceptual and numerical models and~~ is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.7.5 References

American Society for Testing and Materials. “Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).” Test Method D4750-87. West Conshohcken, Pennsylvania: American Society for Testing and Materials. 2001.

———. “Standard Guide for Sampling Groundwater Monitoring Wells.” Guide D4448-85a. West Conshohcken, Pennsylvania: American Society for Testing and Materials. 1992.

~~Crippen, J.R. and C.D. Bue. “Maximum Floodflows in the Conterminous United States.” USGS Water Supply Paper No. 1887. Denver, Colorado: U.S. Geological Survey. 1977.~~

Hem, J.D. “Study and Interpretation of the Chemical Characteristics of Natural Water.” USGS Water Supply Paper 1473. Denver, Colorado: U.S. Geological Survey. 1970.

Lohman, S.W. “Groundwater Hydraulics.” USGS Professional Paper 708. Reston, Virginia: U.S. Geological Survey. 1979.

NRC. NUREG–1620, “Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act.” Rev. 1. Washington, DC: NRC. 2002.

~~U.S. Army Corps of Engineers. “Flood Hydrograph Package.” HEC–1. Washington, DC: U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1997a.~~

~~———. “Water Surface Profiles.” HEC–2. Davis, California: Hydrologic Engineering Center. 1997b.~~

~~———. “Wave Runup and Wind Setup on Reservoir Embankments.” ETL 1110-2-221. 1966.~~

~~U.S. Bureau of Reclamation. “Comparison of Estimated Maximum Flood Peaks with Historic Floods.” Washington, DC: U.S. Department of the Interior. 1986.~~

2.11 Pre-Operational Wellfield Characterization

This SRP section provides guidance for NRC staff reviews of pre-operational wellfield characterization information collected by a licensee after it receives a license or license amendment and constructs an ISR facility wellfield. This is because construction of injection and production wells, from which pre-operational wellfield characterization information is derived, falls within the definition of “commencement of construction” in 10 CFR 40.4, and commencement of construction prior to completion of the 10 CFR Part 51 environmental review is grounds for denial of a license to possess and use source and byproduct material in the plant or facility (10 CFR 40.32(e)).

The purpose of this review is to determine if information provided by the licensee on pre-operational wellfield characterization is sufficient to demonstrate compliance with 10 CFR Part 40, Appendix A, Paragraphs 5B(1)(b), 7A, and 14(b)(1)-(4). Specifically, this section describes the pre-operational wellfield characterization information needed for the staff to evaluate the suitability of the wellfield to isolate byproduct material in the production unit during ISR operations, establish the background hazardous constituent concentration levels at ~~point of compliance~~point of compliance wells in the production unit and in the immediately overlying, underlying, and adjacent aquifers to the production unit and indicator constituents and their upper control limits for excursion detection. The review procedures in this section are therefore used to determine if the information provided by the licensee on pre-operational wellfield characterization is sufficient to demonstrate compliance with 10 CFR Part 40, Appendix A, Paragraphs 5B(1)(b) that requires points of compliance, the hazardous constituent concentration limits pursuant to 5(B)(5)(a) or(b), and the excursion detection monitoring program pursuant to Criteria 7A including the indicator constituents for excursion detection.

In addition, the licensee must submit the pre-operational wellfield information required in 10 CFR Part 40, Appendix A, Paragraphs 14(b)(1) through 14(b)(5) to the NRC after the completion of the installation of each wellfield, but before lixiviant injection begins. This information is typically submitted to NRC in a document known as a wellfield package. The NRC reviews the wellfield package and approves the background hazardous constituent concentration levels and indicator constituent and upper control limits for excursion detection

submitted in accordance with Paragraphs 14(b)(3) and 14(b)(4) before the licensee can begin wellfield operations. The NRC also reviews and approves the wellfield restoration plan required in Paragraph 14(b)(5).

The guidance in Sections 2.11.1-2.11.4 addresses how the staff should review the information provided by the licensee in the wellfield package that: (1) characterizes the wellfield geology and hydrology to demonstrate the ability to control byproduct material within the production unit; (2) identifies the hazardous constituents in the production unit, and immediately overlying, underlying and adjacent aquifers to the production unit; (3) describes the sampling, analysis, and assignment of background hazardous constituent concentration levels to all- ~~point of compliance~~point of compliance wells in the production unit and in the aquifers immediately overlying, underlying and adjacent to the production unit; and (4) describes the sampling, analysis, and assignment of indicator constituents and their upper control limits at ~~point of compliance~~point of compliance wells in the immediately overlying, underlying and adjacent to the production unit. The guidance for staff review of the wellfield restoration plan required in Paragraph 14(b)(5), however, is provided separately in Section 6.1.3.

2.11.1 Wellfield Site Characterization

2.11.1.1 *Area of Review*

The area of review is the licensee's characterization of the geology and hydrology of an ISR wellfield, including the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit. The area of review includes the information required by 10 CFR Part 40, Appendix A, Paragraph 14(b)(1)(i)-(vi).

2.11.1.2 *Review Procedures*

Staff will use the following review procedures to determine if the licensee has demonstrated compliance with the applicable regulations:

1. Verify that the licensee has adequately characterized the geology and hydrology of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.
2. Verify that the licensee has provided a description of all hydrologic parameters used to determine expected operational and restoration performance of the production unit, including the methods used to determine them.
3. Verify that the license has provided a demonstration of a horizontal hydraulic connection between injection and production wells within the production unit and between the production wells and the ~~point of compliance~~point of compliance wells in the immediately adjacent aquifer surrounding the production unit.
4. Verify that the licensee has provided a demonstration of isolation of the production unit through either a lack of hydraulic connection between the injection and production wells and the ~~point of compliance~~point of compliance wells in the immediately overlying and underlying aquifers to the production unit, or a method to mitigate any existing hydraulic connection between the production unit and the overlying and underlying aquifers.

2.11.1.3 *Acceptance Criteria*

1. The licensee has adequately characterized the geology and hydrology of the production unit~~,~~ by providing:

a. An as-built map of the wellfield and infrastructure, including the location of the injection and production wells and ~~point of compliance~~point of compliance wells.
b. Geological cross sections of the ISR wellfield that demonstrates clear delineation of stratigraphic layers hosting the production unit(s) and the overlying and underlying confining layers and strata.
c. Potentiometric maps and estimates of the groundwater flow direction and magnitude in the production unit and in immediately overlying and underlying aquifers the production unit.

2. The licensee has acceptably described all hydrologic parameters used to determine expected operational and restoration performance of the production unit and the methods used by providing:
   a. Results of aquifer pumping tests or other suitable tests for determining hydrologic parameters (e.g., hydraulic conductivity, transmissivity, and specific storage), and for characterizing anisotropy in the production unit in the wellfield
   b. Results of aquifer pumping tests or other suitable tests for determining hydrologic parameters (e.g., hydraulic conductivity, transmissivity, specific storage, leakage) of the overlying and underlying confining units to the production unit.
3. The licensee has acceptably demonstrated a hydraulic connection between the injection and production wells in the production unit and the ~~point of compliance~~point of compliance wells in the immediately adjacent aquifer surrounding the production unit by providing:
   a. Results of an aquifer pumping test or other suitable tests within the production unit in the wellfield that demonstrates a hydraulic connection between injection and production wells within the production unit (e.g., a reduction in water levels in the injection and production wells in response to pumping in the production unit.)
4. The licensee has acceptably demonstrated the isolation of the production unit from immediately overlying and underlying aquifers to the production unit by providing:
   a. Maps of potentiometric surfaces that support the hydraulic separation of the production unit from overlying and underlying aquifers.
   b. An aquifer pumping test or other suitable tests that demonstrates a lack of hydraulic connection between the injection and production wells and the ~~point of compliance~~point of compliance wells in the aquifers immediately overlying and underlying to the production unit (e.g., no reduction in water levels in overlying and underlying aquifer observation wells, no significant leakage through overlying and underlying confining layers).
   c. A method to mitigate any existing hydraulic connection if one is determined to exist between the production unit and the immediately overlying and underlying aquifers to the production unit (e.g., designing and managing the injection and production well rates to minimize the hydraulic connection.)

2.11.1.4 *Evaluation Findings*

If the staff review as described in this section results in the acceptance of the description of the wellfield site characterization, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the wellfield site characterization information associated with wellfield geologic and hydrologic conditions at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.11.1.2 and the acceptance criteria outlined in standard review plan Section 2.11.1.3.

The licensee has adequately characterized the wellfield by providing the geology and hydrology of the production unit and the aquifers immediately overlying, underlying, and adjacent to the production unit; a description of all hydrologic parameters used to determine expected operational and restoration performance of the production unit including the methods used to determine them; a demonstration of a horizontal hydraulic connection between injection and production wells within the production unit and between the production unit and the ~~point of compliance~~point of compliance wells in the immediately adjacent aquifer surrounding the production unit; and a demonstration of isolation of the production unit through either a lack of hydraulic connection between the injection and production wells and the ~~point of compliance~~point of compliance wells in the immediately overlying and underlying aquifers to the production unit, or a method to mitigate any existing hydraulic connection between the production unit and the overlying or underlying aquifers.

Based on the information provided in the application, and the detailed review conducted of wellfield site characterization for the _____ *in situ* recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(1), which requires the geologic and hydrologic characterization of the ISR wellfield including the production unit and the aquifers immediately overlying, underlying and adjacent to the production unit in an ISR wellfield before operations.

2.11.2 Identification of Hazardous Constituents

2.11.2.1 *Areas of Review*

The area of review is the licensee's identification of radiological and non-radiological hazardous constituents in the production unit and in the aquifers immediately overlying, underlying, and adjacent to the production unit in an ISR wellfield, as required in 10 CFR Part 40, Appendix A, Paragraph 14(b)(2)(i)-(iii).

2.11.2.2 *Review Procedures*

Staff will employ the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee has identified the hazardous constituents listed in Criterion 13 that are expected to be in the production unit, and in immediately overlying, underlying, and adjacent aquifers to the production unit, whether present naturally, added or mobilized by lixiviant, or present in other materials injected during operations or restoration.
2. Verify that the if the licensee has identified a radiological or non-radiological hazardous constituent that is not listed in Criterion 13, it has provided the technical basis for its inclusion as a hazardous constituent and provided a hazardous constituent concentration limit that is protective of human health and the environment.

2.11.2.3 *Acceptance Criteria*

The licensee's identification of radiological and non-radiological hazardous constituents is acceptable if it meets the following criteria:

1. The licensee has identified the hazardous constituents listed in Criterion 13 that are naturally present in the production unit, and in immediately overlying, underlying, and

adjacent aquifers to the production unit or added or mobilized by injection into the production unit, including:

a. Hazardous constituents that are present naturally in these aquifers. Table 2.11.2-1 provides a listing of the probable hazardous constituents that have been found in the production unit at ISR wellfields.
b. Hazardous constituents that will be present in the lixiviant injected into the production unit
c. Hazardous constituents that will be mobilized by the lixiviant injected into the production unit
d. Hazardous constituents that will be added to the lixiviant injected into the production unit by processing circuits
e. Hazardous constituents that may added to the production unit through any fluids injected during corrective action, including reductants or other amendments used for the restoration of the production unit.

2. The expected range of concentrations for each hazardous constituent identified in the production unit and their minimum detection levels based on available standard methods.

3. If the licensee has identified hazardous constituents that are not listed in Criterion 13, the licensee has provided, for each such constituent:

a. A technical justification for including the constituent which demonstrates that although the constituent is not typically identified as hazardous, it does present a hazard to human health and the environment under the wellfield site-specific ~~specific~~ circumstances[2].
b. A concentration limit for the constituent that is protective of public health and the environment, with technical basis for selecting the limit. For example, the licensee may provide a concentration limit of nitrate at 10 mg/L (nitrate, expressed as nitrogen), which is the Environmental Protection Agency (EPA)~~PA~~ drinking water maximum contaminant level (MCL). If no MCL is reported for a constituent, the licensee may assign a concentration limit that has a lifetime risk of 10^{-4}.

Table 2.11.2-1 Probable Hazardous Constituents in 10 CFR Part 40 Appendix A Criterion 13

Arsenic	Nickel
Barium	Radium
Chromium	Selenium
Lead	Thorium 230
Molybdenum	Uranium
Ra-226	Vanadium

2.11.2.4 *Evaluation Findings*

If the staff review as described in this section results in the acceptance of the identification of hazardous constituents in the production unit and the aquifers immediately overlying, underlying, and adjacent to the production unit in the ISR wellfield, the following conclusions may be presented in the technical evaluation report.

[2] For example, three constituents, nitrate, sulfate, and ammonia, may be present in the production unit or in aquifers immediately overlying, underlying, and adjacent to the production unit in the ISR wellfield at levels that are considered a hazard to human health

NRC has completed its review of the site characterization information concerned with identification of hazardous constituents at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.11.2.2 and the acceptance criteria outlined in standard review plan Section 2.11.2.3.

The licensee has acceptably identified the hazardous constituents listed in Criterion 13 that are expected to be in the production unit, and in immediately overlying, underlying, and adjacent aquifers to the production unit, whether present naturally, added, or mobilized by lixiviant, or from other materials injected during operations or restoration in the ISR wellfield. In addition, if the licensee has identified any radiological or non-radiological hazardous constituents not listed in Criterion 13, it has provided, for each such constituent, the technical basis for its inclusion as a hazardous constituent and a hazardous constituent concentration limit that is protective of human health and the environment.

Based on the information provided in the application and the detailed review conducted of the identification of the radiological and non-radiological hazardous constituents in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in an ISR wellfield before operations for the _____ *in situ* recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph14(b)(2)(i)-(iii).

2.11.3 Background Hazardous Constituent Concentration Levels

The staff should review if the information provided by the licensee that describes the sampling, analysis, and assignment of the background hazardous concentration levels at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit is sufficient to demonstrate compliance with 10 CFR 40, Appendix A, Paragraph 14(b)(3)(i)-(iii). These regulations require that for each radiological and non-radiological hazardous constituent identified, the licensee must sample the groundwater and, prior to beginning operations in a wellfield, submit to the NRC for approval an analysis of hazardous constituents at all ~~point of compliance~~point of compliance wells sufficient to establish the background hazardous constituent concentration levels pursuant to Paragraph 5B(1)(b) in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

2.11.3.1 ~~*Point of Compliance*~~*Point of compliance Wells*

2.11.3.1.1 Areas of Review

The areas of review are the points of compliance identified and used by the licensee pursuant to Paragraph 5B(1)(b) and Paragraph 14(b)(3)(i). The points of compliance in an ISR wellfield are the well locations in the production unit, and immediately overlying, underlying, and adjacent aquifers to the production unit, where the groundwater is sampled to measure the hazardous constituents in each aquifer that are used to establish the background hazardous constituent concentration levels pursuant to Paragraphs 5B(5)(a) or (b) before wellfield operations begin.

2.11.3.1.2 Review Procedures

The staff will employ the following review procedures to determine if the licensee has adequately identified points of compliance:

1. Verify that the licensee has adequately characterized the geologic setting and hydrogeology of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in the ISR wellfield to appropriately select surface locations and subsurface completion intervals for ~~point of compliance~~point of compliance wells.
2. Verify that the licensee has provided an acceptable number of ~~point of compliance~~point of compliance wells that demonstrate adequate spatial horizontal and vertical coverage of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in the ISR wellfield.
3. Verify that the licensee will use appropriate methods to ensure the ~~point of compliance~~point of compliance monitoring wells were drilled, completed, and adequately developed to provide representative background hazardous constituent concentration levels in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in the ISR wellfield.
4. Verify that the licensee has provided an acceptable process for how it will select the surface location and completion interval for any replacement ~~point of compliance~~point of compliance well if the original well is damaged and cannot be repaired and demonstrated that any replacement ~~point of compliance~~point of compliance well will be sufficiently representative of the original well.

2.11.3.1.3 Acceptance Criteria

The licensee's identification of ~~point of compliance~~point of compliance wells in the production unit and the immediately overlying, underlying, and adjacent aquifers to the production unit in an ISR wellfield are acceptable if:

1. The licensee has adequately characterized the geology and hydrology of the production unit to appropriately select ~~point of compliance~~point of compliance well locations and well completion screen intervals, as supported by:
    a. Geological cross sections of the ISR wellfields that demonstrate clear delineation of stratigraphic layers hosting the production unit, the overlying and underlying confining layers such as aquitards, and the immediately overlying and underlying strata that host the overlying and underlying aquifers.
    b. Well electrical logs such as spontaneous potential, electrical resistivity, and gamma to support identification of stratigraphic layer(s) that contain the production unit, the overlying and underlying confining layers such as aquitards, and the immediately overlying and underlying aquifers.
2. The licensee has identified an acceptable number and locations of ~~point of compliance~~point of compliance wells to demonstrate adequate spatial coverage of the production unit and the aquifers immediately overlying, underlying and adjacent the production unit, and sufficient to obtain representative background hazardous constituent levels, by providing:
    a. At least one ~~point of compliance~~point of compliance well per acre in the production unit or, if the licensee proposes a greater spacing (i.e., less than one well per acre), the technical basis to demonstrate that the resulting number of ~~point of compliance~~point of compliance wells is sufficient to evaluate the background hazardous constituent concentration level in the production unit using acceptable statistical methods (EPA, 2009; ASTM D6312).
    b. At least one ~~point of compliance~~point of compliance well per four acres in the immediately overlying and underlying aquifers.

c. ~~Point of compliance~~Point of compliance wells in the immediately adjacent aquifer whose locations meet the following criteria:
   i. The ~~point of compliance~~point of compliance wells are placed on a perimeter that is close enough to production units to be used for timely excursion detection.
   ii. The licensee has provided the appropriate spacing between ~~point of compliance~~point of compliance wells on the perimeter of the production unit.

3. The licensee has drilled and completed the ~~point of compliance~~point of compliance wells into the appropriate interval of production unit and immediately overlying, underlying, and adjacent aquifers to the production unit, as supported by:
   a. Drilling mud logs to confirm the production unit location and correct placement of the screened interval.
   b. ~~Point of compliance~~Point of compliance well completion reports to confirm correct placement of the screened interval.
4. The licensee has appropriately developed the completion interval in the ~~point of compliance~~point of compliance wells in the production unit in the ISR wellfield, as supported by:
   a. Acceptable well development procedures.
   b. Well development reports for completed wells.
5. The licensee has provided a process for the selection of the appropriate location and completion interval for a replacement for a damaged and irreparable ~~point of compliance~~point of compliance well by providing:
   a. A procedure to select any replacement well location and completion interval to be sufficiently representative of the original ~~point of compliance~~point of compliance well.
   b. A technical basis to demonstrate that any replacement ~~point of compliance~~point of compliance well will provide water quality representative of the original ~~point of compliance~~point of compliance well

2.11.3.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the location and completion of the ~~point of compliance~~point of compliance wells in the production unit and the aquifers immediately overlying, underlying, and adjacent to the production unit in the ISR wellfield before operations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the identification of the points of compliance in the ISR wellfield at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Section 2.11.3.1.2 and the acceptance criteria outlined in standard review plan Section 2.11.3.1.3.

The licensee has adequately identified the points of compliance in the ISR wellfield before operations by demonstrating it has provided an acceptable number of ~~point of compliance~~point of compliance well locations that demonstrate adequate spatial horizontal and vertical coverage of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in the ISR wellfield; it will or has used appropriate methods to ensure the ~~point of compliance~~point of compliance monitoring wells were drilled, completed, and adequately developed to provide representative background hazardous constituent concentration levels in the production unit and immediately overlying, underlying, and adjacent aquifers to the

production unit in the ISR wellfield; it has established an acceptable process for how it will select the surface location and completion interval for any replacement ~~point of compliance~~point of compliance well if the original is damaged and cannot be repaired; and it will demonstrate that any replacement ~~point of compliance~~point of compliance well will be sufficiently representative of the original well that it can be used to show compliance with the approved hazardous constituent concentration limits based on the original ~~point of compliance~~point of compliance well background water quality measurements.

Based on the information provided in the application, and the detailed review conducted of the points of compliance for the *in situ* recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(3)(i), which requires the licensee to identify the points of compliance in the production unit and the aquifers immediately overlying, underlying, and adjacent to the production unit.

2.11.3.2 *Background Concentration Level of Hazardous Constituent*

2.11.3.2.1 Areas of Review

The area of review is the information provided by the licensee that describes the collection of samples, analysis, and assignment of the background hazardous constituent concentration levels at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit to determine if it is sufficient to comply with 10 CFR Part 40, Appendix A, Paragraph 5B(b)(1), 5B(5)(a) and Paragraphs 14(b)(3)(ii) and (iii).

2.11.3.2.2 Review Procedures

Staff will employ the following review procedures to determine if the licensee has adequately identified background concentration levels of hazardous constituents:

1. Verify that an acceptable groundwater sampling and analysis plan was used to collect and analyze background hazardous constituent concentration levels from all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations.
2. Verify that sample collection and analysis methods were appropriate for each hazardous constituent at each ~~point of compliance~~point of compliance well.
3. Verify the number and timing between samples was sufficient to ensure independent samples were obtained to enable statistical evaluation of the background hazardous constituent concentration levels.
4. Verify the licensee has provided an acceptable statistical evaluation of the sampling results including: descriptive statistics of the measured background groundwater hazardous constituent concentration levels; an appropriate spatial analysis to determine if there are different water quality zones for specific hazardous constituents; the underlying distribution of the hazardous constituent was appropriately determined (e.g., parametric or nonparametric); an outlier analysis was conducted to remove or retain any measured background concentration levels for a hazardous constituent.
5. Verify that the appropriate parametric or nonparametric ~~parametric~~ statistical method was used to evaluate and assign the background concentration level to all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production units before wellfield operations.

2.11.3.2.3 Acceptance Criteria

The licensee's description of its sampling, analysis, and assignment of background hazardous constituent concentration levels at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operation is acceptable if:

1. The licensee has employed an acceptable groundwater sampling and analysis plan to determine background hazardous constituent levels in each aquifer that includes:
    a. Appropriate data objectives to ensure that sample collection and analysis methods are satisfactory and will be followed to provide representative field values of background hazardous constituent concentration levels at all ~~point of compliance~~point of compliance wells
    b. Satisfactory quality assurance and quality control plans for sample collection, handling and hazardous constituent analysis that are specific for and will be followed at both on-site and off- site facilities and laboratories that conduct any sample collection or analysis
2. The licensee has demonstrated that sample collection and analysis methods are used that are appropriate (e.g., American Public Health Association [APHA], 2005) for each hazardous constituent in each aquifer by providing:
    a. Sample collection techniques that are appropriate and take into consideration the depth of sample and possible interference from other sample constituents.
    b. Sample preservation methods that are appropriate for each hazardous constituent.
    c. Sample analysis methods that are standard methods that are widely accepted for each hazardous constituent and consider the effects of sample depth and interference from other sample constituents.
    d. If a non-standard sample analysis method for a hazardous constituent or other constituent is used, the technical basis to justify its use.
3. The licensee has demonstrated that the timing between sample collection is sufficient to ensure independent samples are taken to enable statistical evaluation of the background groundwater hazardous constituent concentration levels in each aquifer by providing:
    a. At least four samples from each ~~point of compliance~~point of compliance well at least two weeks apart
        i. If two weeks is not sufficient, a discussion of factors that influence independence of samples (e.g., groundwater flow, stabilization of parameters before sample collection, etc.) or
        ii. Other evidence to demonstrate independence from acceptable statistical guidance (e.g. , EPA, 2009) or other published standards (e.g., ASTM D6312).
    b. An analysis of existing temporal groundwater quality in the aquifer that demonstrates the absence of seasonal or other temporal variation.
4. The licensee has conducted an acceptable statistical evaluation of the measured background hazardous constituent concentration levels for each aquifer using methods from widely-accepted sources such as EPA's Unified Guidance (e.g., EPA, 2009) or other standard (e.g., ASTM D6312) and provided:
    a. Descriptive statistics of the overall population for each hazardous constituent including:

i. The original and final sample size, and general statistical parameters (e.g., mean, median, variance, etc.) for each hazardous constituent with a description of how censored data and non-detects are addressed.

ii. Visual representation of the underlying distribution of each hazardous constituent in each aquifer (e.g., box plots, histograms, etc.) using accepted statistical software packages such as ProUCL 5.1 (e.g., EPA, 2016).

b. The licensee has evaluated the sampling data to determine if there are different zones of background hazardous constituent concentration levels in each aquifer by providing a spatial analysis using techniques to different distributions of water quality (e.g., interpolated contours, box plots, bimodal distribution plots).

c. ~~,~~The licensee has evaluated the parametric or nonparametric ~~parametric~~ distribution to the background hazardous constituent concentration levels in each aquifer and provided:

i. The appropriate parametric distribution if the population is parametric (e.g., normal, log normal) and the associated mean, standard deviation, skewness, median, minimum, and maximum is used for each constituent.

ii. The associated median, minimum, and maximum is used for each constituent if the population distribution is nonparametric ~~parametric~~.

d. The licensee has conducted an outlier analysis to remove or retain any measured background hazardous constituent concentration levels

5. The licensee has assigned the background hazardous constituent levels to all ~~point of compliance~~point of compliance wells in each aquifer on a wellfield or well-by-well basis using acceptable statistical methods as described in EPA's Unified Guidance (e.g., EPA, 2009) or other standard (e.g., ASTM D6312) and provided:

a. The standard statistical parameter values (e.g., mean and variance) for each hazardous constituent that have been determined based on the applicable parametric or nonparametric ~~parametric~~ distribution of the hazardous constituent for all measured values or a subset of measure values if different water quality zones are present for the hazardous constituent in each aquifer.

b. An Upper Prediction Limit (UPL), Upper Tolerance Limit (UTL), or Upper Simultaneous Limit (USL), or a confidence interval that brackets the range of a specified population parameter (e.g., the mean) at a designated level of confidence (e.g., 95%) for each hazardous constituent that has been determined based on the applicable parametric or nonparametric distribution of the hazardous constituent for all measured values or a subset for different water quality zones in each aquifer.

c. A mean or median value for the hazardous constituent at each ~~point of compliance~~point of compliance well that has been determined for each hazardous constituent from measured values solely within the well itself in each aquifer

2.11.3.2.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of evaluation of the background concentration levels of hazardous constituents in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of sampling, analysis, and assignment of the background hazardous constituent concentration levels to all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations. This review included an evaluation using the review procedures in standard review plan Section 2.11.3.2.2 and the acceptance criteria outlined in standard review plan Section 2.11.3.2.3.

The licensee has demonstrated that an acceptable groundwater sampling and analysis plan was used to collect and analyze samples for hazardous constituent concentration levels from all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit. The licensee demonstrated that sample collection and analysis methods were appropriate for each hazardous constituent at each ~~point of compliance~~point of compliance well and that the timing between samples was sufficient to ensure independent samples were obtained to enable statistical evaluation of the background hazardous constituent concentration levels. The licensee conducted a satisfactory statistical evaluation of the sampling results including descriptive statistics of the measured background hazardous constituent concentration levels; provided an acceptable spatial analysis to determine if there were different water quality zones for specific hazardous constituents; determined the data distribution of the hazardous constituent (e.g., parametric or nonparametric); and conducted an acceptable outlier analysis to remove or retain any measured background concentration levels for a hazardous constituent. Finally, the licensee used an appropriate parametric or nonparametric ~~parametric~~ statistical analysis to assign the background hazardous constituent concentration level to all ~~point of compliance~~point of compliance wells on a wellfield or well-by-well basis in each aquifer.

Based on the information provided and the detailed review conducted on the sampling, analysis, and assignment of the background concentration levels of hazardous constituents for all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying and adjacent aquifers to the production unit before wellfield operations at the _____ *in situ* recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(3)(iii).

2.11.4 Indicator Constituents

2.11.4.1 *Areas of Review*

The staff should review if the information provided by the licensee that describes the sampling and analysis plan it used to evaluate the indicator constituent concentration levels at ~~point of compliance~~point of compliance wells, the statistical evaluation of the indicator constituent concentration levels, and the statistical methods used to assign the upper control limit to the ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit before operations is sufficient to comply with 10 CFR Part 40, Appendix A, Criterion 7A for detection monitoring and Paragraph 14(b)(4).

2.11.4.2 *Review Procedures*

Staff will employ the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify the licensee has selected three acceptable indicator constituents for excursion detection.

2. Verify the licensee has established the background indicator constituent concentration levels for excursion detection at ~~point of compliance~~point of compliance wells in the aquifers overlying, underlying, and immediately adjacent to the production unit prior to wellfield operations using acceptable sample collection and analysis methods and evaluated at least four independent samples.
3. Verify that the licensee has established the upper control limits for each indicator constituent.
4. Verify the licensee established the location of ~~point of compliance~~point of compliance wells and screen intervals to detect vertical excursions in the immediately overlying and underlying aquifers and horizontal excursions in the immediately adjacent aquifer to the production unit.

2.11.4.3 *Acceptance Criteria*

The staff should review the sampling, analysis, and assignment of indicator constituent concentration levels at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operation to verify that they have been provided consistent with the following acceptance criteria:

1. The licensee has selected at least three indicator constituents for excursion detection using the NRC-approved technical basis described in the license application or license amendment request.
2. The licensee has employed an acceptable groundwater sampling and analysis plan to determine indicator constituent levels in each aquifer that included:
    a. Appropriate data objectives to ensure that sample collection and analysis methods are satisfactory and will be followed to provide representative field values of indicator levels at all ~~point of compliance~~point of compliance wells
    b. Satisfactory quality assurance and quality control plans for sample collection, handling and indictor analysis that are specific for and will be followed at both on-site and off- site facilities and laboratories that conduct any sample collection or analysis.
3. The licensee has demonstrated that it has used the appropriate spacing and density for ~~point of compliance~~point of compliance well locations for excursion detection in the aquifers immediately overlying, underlying, and adjacent to the production unit in the ISR wellfield including:
    a. ~~Point of compliance~~Point of compliance wells to detect horizontal excursions in the adjacent aquifer to the production unit are located on a perimeter that surrounds the entire wellfield and are screened over the entire production unit.
    b. ~~Point of compliance~~Point of compliance wells to detect horizontal excursions in the adjacent aquifer to the production unit are located close enough to the wellfield to provide timely detection of excursions, but far enough away from the wellfield to avoid false excursion detections (e.g., within a distance of 180 m [600 ft] to 75 m [250 ft] from boundary of the production unit (NRC, 2001, Table 4-6) and a technical justification is provided for distances greater than about 150 m [500 ft]).
4. The licensee has demonstrated that sample collection and analysis methods (e.g., APHA 2005) used were appropriate for each selected indicator constituent in each aquifer including:
    a. Sample collection techniques that were appropriate and took into consideration the depth of sample and possible interference from other sample constituents.

b. Sample preservation methods that were appropriate for each indicator.
c. Sample analysis methods that are standard methods that are widely accepted for each indicator constituent and consider the effects of sample depth and interference from other sample constituents.
d. If a non-standard sample analysis method for an indicator constituent or other constituent is was used, the technical basis was provided to justify its use.

5. The licensee has demonstrated that the timing between sample collection was sufficient to ensure independent samples are taken to enable statistical evaluation of the indicator constituent concentration levels in each aquifer by providing:
   a. At least four samples from each ~~point of compliance~~point of compliance well at least two weeks apart. If samples could not be collected at least two weeks apart, the licensee provides either:
      i. A discussion of factors that influenced independence of samples (e.g., groundwater flow, stabilization of parameters before sample collection, etc.); or
      ii. Other evidence to demonstrate independence from acceptable statistical guidance (e.g. EPA, 2009) or other published standards (e.g., ASTM D6312).
   b. An analysis of existing groundwater quality in the aquifer that demonstrates the absence of seasonal or other temporal variation in the selected indicator constituents.
6. The licensee has conducted an acceptable statistical evaluation of the measured indicator constituent concentration levels for each aquifer using methods from widely-accepted sources (e.g. EPA, 2009) or other standard (e.g., ASTM D6312) and provided:
   a. Descriptive statistics of the overall population for each indicator constituent including:
      i. The original and final sample size, and general statistical parameters (e.g., mean, median, variance, etc.) for each indicator constituent with a description of how censored data and non-detects are addressed.
      ii. Visual representation of the underlying distribution of each indicator constituent in each aquifer (e.g., box plots, histograms, etc.) using accepted statistical software packages such as ProUCL 5.1 (EPA, 2016).
   b. An analysis to determine ~~-~~if there are different zones of indicator constituent concentration levels in each aquifer including~~-~~ a spatial analysis using techniques to different distributions of water quality (e.g., interpolated contours, box plots, bimodal distribution plots).
   c. The parametric or nonparametric~~-parametric~~ distribution of the selected indicator constituent concentration levels in each aquifer including:
      i. The appropriate parametric distribution if the population is parametric (e.g., normal, log normal) and the associated mean, standard deviation, skewness, median, minimum, and maximum is used for each indicator constituent.
      ii. The associated median, minimum, and maximum is used for each indicator constituent if the population distribution is nonparametric~~-parametric~~.
   d. An acceptable statistical outlier analysis to remove or retain any measured indicator constituent concentration levels.
7. The licensee has assigned the indicator constituent concentration levels to all ~~point of compliance~~point of compliance wells in each aquifer on a wellfield or well-by-well basis using acceptable statistical methods (e.g. EPA, 2009) or other standard (e.g., ASTM D6312) and provided:

a. The standard statistical parameter values (e.g., mean and variance; median) for each selected indicator constituent based on the applicable parametric or nonparametric ~~parametric~~ distribution of the indicator constituent for all measured values or a subset of measured values if different water quality zones are present for the selected indicator constituent in each aquifer.
b. The standard statistical parameter values (e.g., mean and variance; median) at each ~~point of compliance~~point of compliance well assigned from measured values within the well itself in each aquifer.

8. The licensee has determined and assigned upper control limits (UCLs) for each selected indicator constituent to detect an excursion in a timely fashion and to avoid false excursion detection by providing UCLs that meet the following criteria:
   a. The UCL for each indicator constituent falls within a range that is less than the lowest concentration that typically occurs in the lixiviant but greater than the assigned background concentration level.
   b. The UCL for each indicator constituent is determined as follows:
      i. In areas with good water quality (total dissolved solids less than 500 mg/L), the upper control limit is set at a value of 5 standard deviations above the mean of the measured background concentration.
      ii. In other areas, the UCL is established using either:
         1. methods provided by EPA (i.e., EPA, 2009); or
         2. another method if an acceptable technical basis is provided.
   c. The technical basis for assigning the UCL for each indicator constituent to all ~~point of compliance~~point of compliance wells within the immediately overlying, underlying, or adjacent aquifers to the production unit or at individual ~~point of compliance~~point of compliance wells in the aquifers immediately overlying, underlying, or adjacent to the production unit.

2.11.4.4 *Evaluation Findings*

If the staff review as described in this section results in the acceptance of selection of the three selected indicator constituents, the sampling and analysis of indicator constituent concentration levels in the immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations and the determination and assignment of the upper control limits for excursion detection, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the selection, sampling, analysis, of the indicator constituents and the assignment of the indicator constituent upper control limits at all ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations. This review included an evaluation using the review procedures in standard review plan Section 2.11.4.2 and the acceptance criteria outlined in standard review plan Section 2.11.4.3.

The licensee has selected at least three acceptable indicator constituents for excursion detection and the technical basis for their selection. The licensee has used acceptable locations for the ~~point of compliance~~point of compliance wells ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit to be used for excursion detection and for sampling of the indicator constituents. The licensee has demonstrated that an acceptable groundwater sampling and analysis plan was used to collect and analyze samples for indicator constituent concentration levels at each ~~point of compliance~~point of compliance well. The licensee has demonstrated that sample collection and

analysis methods were appropriate for each indicator constituent at each ~~point of compliance~~point of compliance well and that the timing between samples was sufficient to ensure independent samples were obtained to enable statistical evaluation of the indicator constituent concentration levels. The licensee conducted a satisfactory statistical evaluation of the sampling results including descriptive statistics of the measured indicator constituent concentration levels; provided an acceptable spatial analysis to determine if there were different water quality zones for specific indicator constituents; determined the data distribution of the indicator constituent (e.g., parametric or nonparametric); and conducted an acceptable outlier analysis to remove or retain any measured concentration levels for an indicator constituent. Finally, the licensee used an appropriate parametric or nonparametric ~~parametric~~ statistical analysis to assign the indicator constituent concentration level to all ~~point of compliance~~point of compliance wells on a wellfield or well-by-well basis in each aquifer. The licensee has used acceptable methods to determine and assign the upper control limits for each indicator constituent that will be used to detect an excursion at ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit based on the background indicator constituent concentration levels.

Based on the information provided and the detailed review conducted on the selection, sampling, analysis, of the indicator constituents and the assignment of the indicator constituent upper control limits at all ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit before wellfield operations at the _____ *in situ* recovery facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(4).

2.11.5 References

American Public Health Association(APHA). 2005. Standard methods for the examination of water and wastewater, 21st ed. Washington, DC, New York.

American Society for Testing and Materials Standards D 6312 (reapproved 2012), “Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs.”

Code of Federal Regulations (CFR), Title 10, Energy, Part 40, “Domestic Licensing of Source Material.”

EPA (United States Environmental Protection Agency). 2009. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Unified Guidance. Washington, DC: EPA. EPA 530/R-09-007.

EPA (United States Environmental Protection Agency). 2016. Statistical Software ProUCL 5.1.00 for Environmental Applications for Data Sets with and without Nondetect Observations. https://www.epa.gov/land-research/proucl-software.

3 DESCRIPTION OF PROPOSED FACILITY

The purpose of this review is to determine whether the information provided by an applicant or a licensee adequately describes the proposed new or expanded ISR facility that is the subject of either an initial license application or license amendment, respectively. This review is required for the NRC staff to make the findings in 10 CFR 40.32(c) that the applicant's or licensee's proposed equipment, facilities and procedures are adequate to protect health and minimize danger to life or property; and 10 CFR 40.32(d) 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. In this SRP section, the staff reviews the applicant's or licensee's proposed specifications relating to the operation of the ISR facility, wellfields, and associated infrastructure and the disposition of liquid wastes resulting from the ISR activities which address 10 CFR 40, Appendix A, Criteria 2 and 13, and Paragraphs 14(c), 14(d)(1), 14(d)(2), 14(d)(4), 14(d)(5), 14(e), and 14(g). SRP Section 5.7.8 contains the guidance for the review of operational monitoring of the ~~point of compliance~~point of compliance wells for excursion detection in the ISR wellfield, as required in Paragraph 14(d)(3).

3.1 *In situ* Recovery~~Leaching~~ Process and Equipment

3.1.1 Areas of Review

The staff should review the *in situ* recovery~~leaching~~ process as described in the application. This review should include, but not be limited to

1. A description of the production unit ~~mineralized zone(s)~~ and the feasibility of processing the defined well field areas.

2. A description of ~~W~~well design and construction methods~~techniques~~ in the ISR wellfield that meet specifications to ensure byproduct material does not leak into surrounding groundwater~~and integrity testing procedures~~ and to ensure the well installation~~s~~ will not result in hydraulic communication between the production unit~~zones~~ and ~~adjacent non-mineralized aquifers~~aquifers immediately overlying, underlying, and adjacent ~~aquifers~~ to the production unit.

3. A description of mechanical integrity testing procedures for all injection, production, and ~~point of compliance~~point of compliance wells in the ISR wellfield.

4. A description of the operation of the ISR wellfield that demonstrates that byproduct materials will be managed to prevent migration of hazardous constituents to groundwater in aquifers immediately overlying, underlying, and adjacent to the production unit in the ISR wellfield.

5. A description of the uppermost aquifer monitoring program for all surface and near surface operations having the potential to contaminate the uppermost aquifer to detect leaks or spills of byproduct material into the uppermost aquifer at the ISR facility.

6. A description of the methods for plugging and abandoning wells that demonstrates that vertical movement of fluids, including byproduct material, along the borehole is prevented.

~~3.~~7. A process description including injection/production rates and pressures; plant material balances and flow rates; lixiviant makeup; recovery efficiency; and gaseous, liquid, and solid wastes and effluents that will be generated

~~4.~~8. Proposed operating plans and schedules that include timetables and sequences for wellfield~~well field~~ operation, surface reclamation, and ~~ground-water~~groundwater restoration

~~5.~~9. Review of techniques for ensuring that a proliferation of small waste disposal sites is avoided.

The review should also include maps showing the facilities layout, descriptions of the process and/or circuit, water and material balances, and the chemical recycling system.

3.1.2 Review Procedures

The staff should determine whether the description of the *in situ* recovery~~leaching~~ process provided in the application is sufficient to permit evaluation of the operations and processes involved in conformance with the acceptance criteria contained in Section 3.1.3.

The ~~S~~staff review should ensure the following are included in this section: a map or maps showing the proposed sequence and schedules for uranium extraction and ~~ground-water~~groundwater quality restoration operations, a flow diagram of the process or circuit, a material balance diagram, a description of any chemical recycle systems, a water balance diagram for the entire system, and a map or maps showing the proposed sequence and schedules for land reclamation of the well field areas.

The staff reviews well design and construction methods to ensure~~If~~ wells ~~are not~~ will be properly completed, so that lixiviant will not~~can~~ flow through casing breaks and into overlying aquifers. Casing breaks can occur if the well is damaged during well construction activities. Casing breaks can also occur if water injection pressures exceed the strength of the well materials. Well completion techniques should be reviewed in sufficient detail to give the reviewer a clear understanding of how ~~recovery~~production, injection, and ~~point of compliance~~point of compliance ~~monitor~~ wells are drilled; how their location and spacing are selected; and what materials and methods are used in construction, casing installation, and abandonment. The ~~reviewer~~ staff should pay particular attention to the techniques employed to prevent hydraulic communication between immediately overlying or underlying aquifers through well boreholes and ensure that ~~secondary ground-water protection standards~~migration of by product material does not occur to surrounding groundwater. ~~are not violated (10 CFR Part 40, Appendix A, Criteria 5B, 5C, and 14~~3). Additionally, ~~the applicant~~the staff should review the ~~should describe~~ methods for well plugging and abandonment. The ~~reviewer~~staff should ensure that the well casing material used is appropriate for the depths to which the wells are drilled. The ~~reviewer~~staff should examine a description of the procedures used to conduct mechanical ~~test well~~ integrity testing of wells. The wells should be retested with sufficient frequency to ensure ~~the~~ mechanical integrity of ~~the~~ wells ~~construction~~. The ~~reviewer~~staff should examine in detail the justification provided by the licensee for the recommended time interval between successive mechanical~~well~~ integrity tests. The ~~reviewer~~staff may refer to a well handbook (e.g., Driscoll, 1989) to verify the appropriateness and expected performance of well installation, testing, and abandonment methods.

Description of Proposed Facility

To ensure that hydraulic communication between immediately overlying or underlying aquifers through well boreholes is promptly detectable, the ~~reviewer~~ staff should pay particular attention to the design and installation of vertical and horizontal ~~point of compliance~~point of compliance ~~excursion monitoring~~ wells. Additional review procedures for ~~excursion monitoring~~monitoring of point compliance wells for excursion detection ~~systems~~ are provided in Section 5.7.8.2 of this standard review plan.

The ~~reviewer~~staff should also pay particular attention to the uppermost aquifer monitoring program including the methods used for effective detection of leaks in surface and near-surface pipes carrying the lixiviant solutions to individual wells within a wellfield ~~well field~~ or between the wellfields~~well fields~~ and the processing facilities. Spills of pregnant lixiviant in particular can constitute a significant hazard to health and the environment if allowed to pond and dry on the ground surface, to run off into surface-water bodies, or to infiltrate and transport to ~~ground-water~~groundwater.

The ~~reviewer~~staff should determine that any lined impoundment to contain wastes is acceptably designed, constructed, and installed. Materials used to construct the liner should be reviewed to determine that they have acceptable chemical properties and sufficient strength for the design application. The ~~reviewer~~staff should determine that the liner will not be overtopped. The ~~reviewer~~staff should determine that a proper quality control program is in place. The review should be based on the concept that the site will be in compliance with 10 CFR Part 40, Appendix A, Criterion 2, which precludes long-term disposal of byproduct material onsite and ensures that the proliferation of small waste disposal sites is avoided. The ~~reviewer~~staff shall examine the terms of the approved waste disposal agreement.

For surface impoundments containing 11e.(2) byproduct material, the ~~reviewer~~staff should ensure that the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 5(A) have been met. If the waste water retention impoundments are located below grade, the ~~reviewer~~staff should determine that the surface impoundments have an acceptable liner and leak detection system in place to ensure protection of ground water. The location of a surface impoundment below grade will eliminate the likelihood of embankment failure that could result in any release of waste water. Should there be a proposal~~the applicant propose~~ to construct a surface impoundment to handle waste water, the ~~reviewer~~staff should determine that the design of associated dikes is such that they will not experience massive failure. The design of such dikes to resist erosion and protect against possible flooding events is evaluated in Section 2.7 of this standard review plan. In this section, the ~~reviewer~~staff should evaluate the stability of any dikes with respect to seismic events.

In addition, the ~~reviewer~~staff should evaluate any proposed surface impoundment to determine if it meets the definition of a dam as given in Regulatory Guide 3.11 (NRC, 1977). If this is the case, the surface impoundment should be included in the NRC Dam Safety Program, and be subject to Section 215, National Dam Safety Program of the Water Resources Development Act of 1996. If the ~~reviewer~~staff finds that the impoundment meets the definition of a dam, an evaluation of the dam ranking (low or high hazard) should be made. If the dam is considered a high hazard, an Emergency Action Plan is needed consistent with Federal Emergency Management Agency requirements. For low-hazard dams, no Emergency Action Plan is required. For either ranking of dam, the ~~reviewer~~staff should also determine that the licensee has an acceptable inspection program in place to ensure routine checks, and that performance is properly maintained (see Section 5.3 of this standard review plan).

In conducting these evaluations, the ~~reviewer~~staff shall consider the technical evaluations conducted by a state or another federal agency with authorities overlapping those of the NRC. ~~Ground-water~~Groundwater compliance and protection reviews are the primary technical areas impacted by overlapping authorities. 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~~staff 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~~staff 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.

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

3.1.3 Acceptance Criteria

The regulations applicable to the areas of review in this section are 10 CFR 40, Appendix A, Paragraphs 14(c), 14(d)(1), 14(d)(2), 14(d)(4), 14(d)(5), 14(e), and 14(g).

The *in situ* recovery~~leaching~~ process and equipment are acceptable if they meet the following criteria:

1. The description is sufficiently detailed to identify the production unit~~mineralized zone~~(s), their areal distribution, and their approximate thickness.

   If more than one production unit is proposed~~mineralized zone is to be leached~~, each production unit~~zone~~ should be defined separately. The estimated U_3O_8 grade should be specified.

2. Injection and production w~~W~~ell design, testing, and inspection reflect 10 CFR 40, Appendix A, Criterion 14 requirements~~accepted NRC practice~~ for *in situ* recovery~~leach~~ operations.

   a. Well Design and Construction—Injection and ~~recovery~~production wells have been constructed ~~should be constructed~~ from materials that are inert to lixiviants and are strong enough to withstand injection pressures. Polyvinyl Chloride, fiberglass, or acrylonitrile butadiene styrene plastic casings are ~~generally~~ used in wells less than 300-m [1,000-ft] deep. ~~Wells deeper than 300-m [1,000-ft], or those subjected to high-pressure cementing techniques, are subject to collapse.~~ For wells greater than 300 m [1,000 ft] deep, steel or fiberglass (or equivalent) casing is used to prevent casing collapse~~With appropriate design and installation techniques, however, Polyvinyl Chloride can be used for wells greater than 300 m [1,000 ft]. In these instances, steel or fiberglass casing is generally necessary~~. In injection and production wells~~In all wells (including monitor wells)~~, the applicant will case and cement the annular space between the side of the borehole and the casing ~~should be backfilled with a sealant~~ from the bottom of the casing to the surface in one continuous operation. This method is used to prevent the migration of byproduct material into or between aquifers. Injection between the outermost casing protecting adjacent aquifers and the well bore is prohibited.

The following factors have been considered in determining and specifying casing and cementing requirements:

i. Depth to the injection zone;
ii. Injection wellhead pressure;
iii. Hole size;
iv. Size and grade of all casing strings, including wall thickness, diameter, nominal weight, length, joint specification, and construction material;
v. Corrosiveness of lixiviant and byproduct material;
vi. Lithology of injection and confining units; and
vii. Type and grade of cement.

The applicant has justified its decision to not conduct cementing of injection and production wells when there is substantial evidence that no contamination of aquifers would result. Proper backfilling isolates the screened formation against vertical migration of water from the surface or from other formations, and ~~also~~ provides support for the casing. The applicant may propose alternate methods to cementing for NRC approval if the applicant can provide evidence that no contamination of aquifers would result. The casing and cement used in the construction of each newly drilled well must be designed for the life expectancy of the well. ~~Cement or cement-bentonite grout is generally acceptable as a sealant.~~

Appropriate well logs and other tests have been conducted during the drilling and construction of new injection and production wells. The well logs and tests appropriate to each well will be determined based on the intended function, depth, construction, and other characteristics of the well, availability of similar data in the area of the drilling site and the need for additional information that may arise from time to time as the construction of the well progresses.

Procedures in American Society for Testing and Materials D 5092 provide acceptable methods for design and construction of monitoring wells (American Society for Testing and Materials, 1995). Material normally used for monitor well casing is either metal or plastic. The possibility that chemical reactions may take place between the casing and the mineral constituents in the water affects the choice of casing material used for monitor wells. For example, iron oxide in steel-cased wells will adsorb trace and heavy metals dissolved in the ground water. Therefore, a baseline water sampling program should be used to determine concentrations of trace metals. The ~~applicant should use casing that is~~ casing should be inert to these metals, such as Polyvinyl Chloride or fiberglass. When any well is completed, it should be developed until production of essentially sediment-free water is assured for the life of the well. One acceptable development method is to use a swab in the well to create a vacuum on the upstroke and positive pressure on the downstroke. Air lifting is also an acceptable method for well development. Other state- or EPA-approved well development methods may also be used.

b. Well Mechanical Integrity Testing—Injection and production wells will~~recovery wells should~~ be tested for mechanical integrity before initial use, before reuse of wells that have been serviced with equipment or procedures that could damage the well casing, and at least once every five years thereafter. In cases where the

information would be repetitive and the wells are of similar age, type, and construction, the applicant or licensee, upon approval by the NRC, will submit data for a representative number of wells.

The mechanical integrity test method is acceptable if one of the following methods will be used: Following an initial pressure test, monitoring of the casing annulus pressure with sufficient frequency to be representative as approved by the NRC, while maintaining an annulus pressure different from atmospheric pressure measured at the surface; or a pressure test with liquid or gas.

If one of the two tests above are not used, a written description has been submitted of its alternative mechanical integrity test method, a description of how the proposed alternative mechanical integrity test method is at least as reliable as the methods described above, and all supporting technical data.

The following are examples of well integrity testing procedures that have been considered acceptable in previous applications. To inspect for casing leaks after a well has been completed and opened to the aquifer, a packer is set above the well screen, and each well casing is filled with water. At the surface, the well is pressurized with either air or water to 125 percent of the maximum operating pressure. The well pressure is then monitored for a period of 10 minutes to 20 minutes, with a pressure drop of no more than 10 percent, to ensure significant pressure drops do not occur through borehole leaks. Operating pressure varies with the depth of the well and should be less than formation fracture pressure. Well integrity tests should be performed on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, each well should be retested with sufficient frequency (once each five years or less) to ensure the integrity of the well construction if it is in use. Sole reliance on single-point resistance geophysical tools is not acceptable for determining the mechanical integrity at a well.

3. The number, location, and screened intervals of ~~excursion point of compliance~~point of compliance wells for excursion detection ~~monitoring wells~~ in each wellfield are constructed in the immediately overlying, underlying, and adjacent aquifers to the production unit using standard monitoring well installation, completion, and development methods. If the wellfield operation may be affected by subsidence or catastrophic collapse, the monitoring wells are located so that they will not be physically affected.~~described in sufficient detail, follow industry standard practice, and are adequate to ensure prompt detection of horizontal and vertical excursions, taking into account site specific parameters such as local geology and hydrology. Acceptance criteria for methods and calculations used to determine the placement of horizontal and vertical excursion monitoring wells are presented in Section 5.7.8.3 of this standard review plan.~~

The wellfield monitoring program includes monitoring injection pressures, production fluid volumes, and indicator constituent concentrations, as required by 10 CFR 40, Appendix A, Paragraph 14(d)(2). Monitoring of pressure and flow rate on injection wells is either on an individual well basis or by manifold monitoring.

4. The upper aquifer monitoring program provides m~~M~~ethods for timely detection and cleanup of leaks from surface and near-surface pipes within the wellfields~~well fields~~ and between the wellfields~~well field~~ and processing facilities are clearly described and included in the design. As required by 10 CFR Part 40, Appendix A, Paragraph 14(d)(4), the uppermost aquifer monitoring program must be approved by the NRC prior to wellfield operation for all surface and near-surface operations having the potential to contaminate the uppermost aquifer.

5. The ~~description~~ operation of the *in situ* recovery~~leaching~~ process in the ISR wellfield includes the following information and demonstrations:

   a. Projected down-hole injection pressures with the hydrostatic pressure of the fluid column should be demonstrated to be maintained below calculated casing (casing and cement) failure pressures and formation fracture pressures, to avoid hydrofracturing the aquifer and promoting leakage into the overlying units. Piping burst strength should be considered in deep well fields {greater than about 305 m [1,000 ft]}.

   b. Overall production rates or volumes ~~should be~~are higher than injection rates or volumes so that an inward hydraulic gradient that is sufficient to control wellfield fluids is maintained.

   c. Proposed plant material balances and flow rates should be acceptably described.

   d. Lixiviant makeup should be such that impact on the ~~ground-water~~groundwater quality and the prospects for long-term ~~ground-water~~groundwater restoration will be maintained at levels that ensure acceptable restoration goals can be achieved in a timely manner. Oxidants such as gaseous oxygen and hydrogen peroxide, and carbonates such as sodium bicarbonate or carbon dioxide gas have been demonstrated in a number of *in situ* recovery~~leach~~ facilities to be suitable lixiviants.

   e. The description should identify gaseous, liquid, and solid wastes and effluents that will be generated. Effluent monitoring and control measures are discussed in Section 4.0 of this standard review plan.

   f. An analysis of the effects that *in situ* recovery~~leach~~ operations are likely to have on surrounding water users has been provided. An acceptable impact analysis should be based on results of numerical or analytical modeling calculations that are used to estimate ~~ground-water~~groundwater travel times from the proposed production units~~extraction areas~~ to the nearby points of ~~ground-water~~groundwater or surface-water usage, estimate the amount of process bleed necessary to maintain an inward gradient to prevent migration of lixiviant from the well field, and describe the ~~applicant's~~ mitigative measures to recover lixiviant excursions. If ~~the applicant chooses to use~~ nominal parameter estimates are used, parameter uncertainties should be considered to ensure that the selected values represent expected conditions. An acceptable impact analysis should describe the following:

      i. The ability to control the migration of lixiviant from the production units~~zones~~ to the surrounding environs

ii. ~~Ground-water~~Groundwater and surface-water pathways that might transport lixiviant~~extraction solutions~~ off~~site~~~~site~~ in the event of an uncontrolled excursion, surface piping leak, or incomplete restoration

iii. The impact of *in situ* recovery~~leach~~ operations on ~~ground-water~~groundwater flow patterns and aquifer levels

iv. The expected post-extraction impact on geochemical properties and water quality

6. The applicant commits to providing NRC a wellfield operating plan before it begins wellfield operation that contains the elements in 10 CFR Part 40, Appendix A, Paragraph 14(d)(1)(iv).

~~6.~~7. Proposed operating plans and schedules include timetables for wellfield~~well field~~ operation, surface reclamation, and ~~ground-water~~groundwater restoration. Water balance calculations should be provided that demonstrate that the liquid waste disposal facilities (surface impoundments, land application, deep-~~-~~well injection) are adequate to process the proposed production and restoration efforts at any time.

~~7.~~8. The staff should verify the ~~applicant~~ analyses or perform independent review analyses of floods and flood velocities. If the design assumptions and calculations are reasonable, accurate, and compare favorably with independent staff estimates, the designs are acceptable.

~~8.~~9. The staff should evaluate the design of diversion channels in several critical areas using the criteria and guidance presented in NUREG–1623 (NRC, 1998). For the main channel area, the staff should verify that appropriate models and input parameters have been used to design the erosion protection. The staff should assure that flow rates, flow depths, and shear stresses have been correctly computed. The diversion channels should be sized and protected to pass a probable maximum flood with minimal, if any, damage to the diversion channel. No release of contained materials should occur during a probable maximum flood. The staff should determine that the depth of burial of any disposed of material is sufficient to preclude bottom scouring, if an existing or constructed channel is located in or near a pit or impoundment. Where practical, the use of diversion channels at new facilities should be avoided to lessen costs of reclamation and future maintenance.

~~9.~~10. The staff should review the plans, specifications, inspection programs, and quality assurance/quality control programs to assure that acceptable measures are being taken to construct the facility according to accepted engineering practices. The staff will compare the information provided with typical programs used in the construction industry.

~~10.~~11. Results from research and development or other production operations are used to support the description of the *in situ* recovery~~leaching~~ process, where appropriate.

~~11.~~12. 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 onsite. The applicant has committed to notify NRC in writing within seven

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 lixiviantlixivient injection).

~~12.~~13. The applicant has described its program for providing the following reports to the NRC in accordance with 10 CFR 40, Appendix A, Paragraph 14(d)(5): semi-annual reports required by 10 CFR 40.65 and; reports of confirmed excursions; and reports of surface or near surface leaks or spills.

~~13.~~14. The applicant has described its methods for plugging and abandoning wells in accordance with 10 CFR 40, Appendix A, Paragraph 14(g).

3.1.4 Evaluation Findings

If the staff review as described in this section results in the acceptance of the *in situ* recovery~~leaching~~ process and equipment, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the *in situ* recovery~~leaching~~ process and equipment proposed for use at the _____ *in situ* recovery~~leach~~ facility. This review included an evaluation using the review procedures in standard review plan Section 3.1.2 and the acceptance criteria in standard review plan Section 3.1.3.

The applicant ~~has~~ has acceptably described the production unit ~~mineralized zone~~(s) and the well design and construction methods in the ISR wellfield to ensure that they meet certain specifications and to ensure the well installation will not result in hydraulic communication between the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit. The licensee has provided acceptable mechanical integrity testing procedures for all injection, production and ~~point of compliance~~point of compliance wells in the ISR wellfield~~demonstrated protection~~ to protect against leaks and vertical migration of water~~, proposed tests for mechanical well integrity of wells,~~. The applicant has demonstrated that operation of the ISR wellfield will be conducted to ensure that byproduct materials will be managed to prevent migration of hazardous constituents to groundwater in immediately overlying, underlying, and adjacent aquifers to the production by demonstrating~~and demonstrated that the *in situ* recoveryleaching process will meet the following criteria:~~ (i) down hole injection pressures are less than formation fracture pressures; (ii) overall production rates are higher than injection rates to create and maintain an inward hydraulic gradient; (iii) plant material balances and flow rates are appropriate; (iv) lixiviant makeup is such that restoration goals can be achieved in a timely manner; (v) recovery efficiency is assessed through mass balance calculations; and (vi) reasonable estimates of gaseous, liquid, and solid wastes and effluents are provided (used in evaluation of effluent monitoring and control measures in standard review plan Section 4.0). The applicant has used the results from research and development or other production operations to support the evaluation of the *in situ* recovery~~leaching~~ process. The applicant has provided an uppermost aquifer monitoring program for all surface and near surface operations having the potential to contaminate the uppermost aquifer to detect leaks or spills of byproduct material into the uppermost aquifer at the ISR facility. The applicant has provided acceptable methods for plugging and abandoning wells to ensure that vertical movement of fluids, including byproduct material, along the borehole after abandonment is prevented. The ~~applicant~~applicant ~~has~~ has provided acceptable operating plans, schedules, and timetables for well field operation, surface reclamation, and ~~ground-water~~groundwater restoration.

Based on the information provided in the application and the detailed review conducted of the *in situ* recoveryleaching process and equipment for the _____*in situ* recoveryleach facility, the staff concludes that the proposed *in situ* recoveryleaching process and equipment are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant or licensee'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 or licensee to confine source or byproduct material to the location and purposes authorized in the license; and 10 CFR Part 40, Appendix A, Criteria 2 for non-proliferation of small disposal sites; 5(A) for ground-water protection; 5B for secondary ground-water protection; 5C for maximum values for ground-water protection; and 13 for hazardous constituents, Paragraph 14(c) for well design and construction requirements, Paragraphs 14(d)(1)-(d)(2), 14(d)(4), and 14(d)(5) for ISR wellfield operation requirements, and Paragraph 14(e) for mechanical integrity of injection and production wells, and Paragraph 14(g) for plugging and abandonment of wells. The related reviews of the 10 CFR Part 20 radiological aspects of the *in situ* leaching process and equipment in accordance with standard review plan Sections 4.0, "Effluent Control Systems;" 5.0, "Operations;" and 7.0, "Environmental Effects;" are addressed elsewhere in this technical evaluation report.

3.1.5 References

American Society for Testing and Materials. "Standard Practice for Design and Installaiton of Ground Water Monitoring Wells in Aquifers." Designation D5092-90. Philadelphia, Pennsylvania: American Society for Testing and Materials. 1995.

Driscoll, F.G. "Groundwater and Wells." St. Paul, Minnesota: Johnson Filtration Systems, Inc. 1989.

NRC. "Recommendation on Ways to Improve the Efficiency of NRC Regulation at *In situ* Leach Uranium Recovery Facilities." SECY-99-0013. Washington, DC: NRC. 2000.

———. NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization." Washington, DC: NRC. 1998.

———. Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Washington, DC: NRC, Office of Standards Development. 1977.

5 OPERATIONS

5.2 Management Control Program

5.2.1 Areas of Review

The staff should review the management control program and administrative procedures proposed to ensure that activities affecting health, safety, and the environment will be conducted in accordance with written standard operating procedures, including records keeping and reporting. The reviewer should evaluate the management control and decision bases to be used by the Safety and Environmental Review Panel in deciding when it is necessary to apply for a license amendment. Procedures governing non-routine work or maintenance that is not covered by a standard operating procedure, such as use of radiation work permits, should be reviewed.

The staff should examine the applicant's program for cultural resources protection.

The staff should review the applicant's record keeping and retention plans for the materials control and tracking program; the radiation protection program; the sampling, survey and calibration programs; for planned special exposures; to track doses to workers and members of the public; for the disposal of source, and byproduct materials made under 10 CFR 20.2002 and 20.2003; and for the records important to decommissioning the facility, including records of spills or unusual occurrences involving the spread of contamination, cleanup actions taken, and the location of remaining contamination. The staff should also review the licensee's plans and arrangements to identify and maintain the records that must be retained for the life of the facility and ultimately be transferred to NRC at the termination of the license.

While occupational and safety concerns are important and need to be included in the development of standard operating procedures, NRC regulatory authority is limited to those instances where occupational safety concerns may affect radiological operations or accidents.

5.2.2 Review Procedures

The reviewer should determine that the proposed management control program and administrative procedures are sufficient to assure that any activities affecting health, safety, and the environment, including compliance with any license commitments or conditions, will be conducted in accordance with written operating procedures. The review should include the process for identifying and developing standard operating procedures for routine work, and the review and approval process to be used by the radiation safety staff to modify standard operating procedures when appropriate. Methods for review and approval of non-routine work or maintenance activity by the radiation safety staff should be examined.

The reviewer should determine whether the licensee has agreed to administer a cultural resources inventory before engaging in any development activity not previously assessed by NRC. The reviewer should verify that any disturbances to be associated with such development will be completed in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. Additionally, the reviewer should evaluate if the licensee has committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. The reviewer

should confirm that any such artifacts will be inventoried and evaluated, and no further disturbance will occur until the licensee has received authorization from the NRC to proceed.

The reviewer should determine whether the proposed record keeping and retention programs are adequate to ensure that the licensee will be able to track, control, and demonstrate control of, the source and byproduct material at the site, such that on-site and off-site dose limits will not be exceeded. The reviewer should determine whether records important to decommissioning, such as descriptions of spills and other unusual occurrences, will be maintained by the licensee, and will be in an identifiable or, preferably, separate file. The reviewer should also determine whether the licensee has a plan to maintain the records that will be turned over to NRC at license termination.

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.

5.2.3 Acceptance Criteria

The management control program is acceptable if:

(1) The proposed management control program is sufficient to assure that all proposed activities that may affect health, safety, and the environment, including compliance with any license commitments or conditions, will be conducted in accordance with written operating procedures. These shall include procedures that evaluate the consequences of a spill or incident/event against 10 CFR Part 20, Subpart M and 10 CFR 40.60 reporting criteria.

(2) The applicant provides a process that will be used to identify and prepare operating procedures for routine work.

There is an adequate mechanism for the development, approval, and review (on an annual basis) of standard operating procedures by the radiation safety staff. Subsequent inspections will ensure that standard operating procedures are adequate and applied correctly.

The process includes procedures covering all aspects of radiation safety, routine maintenance activities (especially in radiation areas), and Safety and Environmental Review Panel reviews and activities.

For standard operating procedures for radiation safety, refer to Regulatory Guide 8.31, Section 2 (NRC, 2002).

(3) The applicant presents methods for review and approval of non-routine work or maintenance activity by the radiation safety staff. The methods include the preparation and issuance of radiation work permits for activities where standard operating procedures do not apply.

(4) The applicant provides for the establishment of a Safety and Environmental Review Panel. (A detailed review of Safety and Environmental Review Panel composition is addressed in Section 5.1 of this standard review plan.) Procedures governing the functioning of the Safety and Environmental Review Panel ensure that approvals of any

changes in the facility, the operating procedures, or the conduct of tests or experiments are appropriately documented and reported. These changes, tests, or experiments may be ~~effected~~ affected without obtaining a license amendment pursuant to 10 CFR 40.44, so long as the change, test, or experiment does not

(a) Create a possibility for an accident of a different type than previously evaluated in the license application (as updated)

(b) Create a possibility for a malfunction of a structure, system, or control with a different result than previously evaluated in the license application (as updated)

(c) Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report or the environmental assessment or technical evaluation reports or other analyses and evaluations for license amendments

Quantitative likelihood and consequence analyses may not be required for changes at uranium *in situ* ~~leach~~recovery facilities.

The Safety and Environmental Review Panel records will include written safety and environmental evaluations made by the Safety and Environmental Review Panel that provide the basis for determining whether changes, tests, or experiments were implemented in accordance with the bases described in Section 5.2.3. Changes pages should have both a change indicator for the area changed (e.g., a bold line vertically drawn in the right margin adjacent to the portion actually changed) and a page change indication (date of change or change number, or both).

The annual Safety and Environmental Review Panel report and page changes may be furnished along with reports normally submitted to satisfy 10 CFR 40.65 reporting requirements.

(5) The licensee is exempted from the requirements of 20 CFR 1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted with the words “ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL.”

(6) The licensee has agreed to administer a cultural resources inventory before engaging in any development activity not previously assessed by NRC. Any disturbances to be associated with such development will be completed in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their implementing regulations. The licensee has committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. Any such artifacts will be inventoried and evaluated, and no further disturbance will occur until the licensee has received authorization from the NRC to proceed.

(7) The record keeping and retention plans demonstrate that the licensee will maintain and retain records of the receipt, transfer, and disposal of any source or byproduct material processed or produced at the licensed facility, for the period set out in the license conditions, or until the Commission terminates the license.

(8) The following will be permanently maintained and retained until license termination:

(a) Records of on-site radioactive waste disposal such as by deep~~-~~well injection, land application, or burial under 10 CFR 20.2002 and 20.2007.

(b) Records required by 10 CFR 20.2103(b)(4).

(c) Records required by 10 CFR Part 40, Appendix A, Criteria 8 and 8A and included in Regulatory Guide 3.11.1 (NRC, 1980).

(d) Records containing information important to decommissioning and reclamation, including:

(i) Descriptions of any spills, excursions, contamination events or unusual occurrences, including the dates, locations, areas, or facilities affected; assessments of hazards; corrective and cleanup actions taken; assessment of cleanup effectiveness, and the location of any remaining contamination; nuclides involved; quantities, forms and concentrations, and descriptions of hazardous constituents; descriptions of inaccessible areas that cannot be cleaned up; and sketches, diagrams, or drawings marked to show areas of contamination and places where measurements were made. Significant spills that should be included are any radiological spills that have the potential to exceed site cleanup standards and any radiological spill that leaves the site. ~~A license condition will be established to this effect.~~ Records requirements for spills that impact the uppermost aquifer are addressed in acceptance criteria 5.2.3(12).

(ii) Information related to site characterization; residual soil contamination levels; on-site locations used for burials of radioactive materials; hydrology and geology, with particular emphasis on conditions that could contribute to ground-water or surface-water contamination; and locations of surface impoundments, waste water ponds, lagoons, and ~~well field~~wellfield aquifer anomalies.

(iii) As-built drawings or photographs of structures, equipment, restricted areas, ~~well field~~wellfields, areas where radioactive materials are stored, and any modifications showing the locations of these structures and systems through time.

(iv) Drawings of areas of possible inaccessible contamination, including features such as buried pipes or pipelines.

(v) Pre-operational background radiation levels at and near the site.

These records will be maintained with adequate safeguards against tampering and loss.

(9) The licensee demonstrates that records can be provided to a new owner or new licensee in the event that the property or license is transferred, or to NRC, after license termination.

(10) New licensees or owners demonstrate that any such records received from a previous owner or licensee will be retained, along with their own records, to be turned over to NRC after license termination.

(11) Records will be maintained as hard copy originals, as copies on microfiche, or will be electronically protected, and will be readily retrievable for NRC inspection.

(12) Reports of spills~~;~~ and evaporation pond leaks~~; excursions of source, 11e.(2) byproduct material, or process chemicals;~~ will be made to the NRC Headquarters Project Manager by telephone or electronic mail (email) within 48 hours of the event. This notification shall be followed, within thirty (30) days of the notification, by submittal of a written report to the NRC Headquarters Project Manager, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved. A license condition will be established to this effect. As required by 10 CFR 40, Appendix A, Paragraph 14(d)(5)(ii), when an excursion is confirmed under paragraph 14(d)(2)(ii), a report must be made to the NRC within one business day, followed by submission of a written report to the NRC within seven calendar days from when the excursion is confirmed. As required by 10 CFR 40, Appendix A, Paragraph 14(d)(5)(iii), if surface or near surface leaks or spills of byproduct material are detected in the uppermost aquifer, a report will be made to the NRC within one business day, followed by submission of a written report to the NRC within seven calendar days from when the leak is detected in the uppermost aquifer.

(13) An annual report will be submitted to the NRC that includes the as low as is reasonably achievable audit report, land use survey, monitoring data, corrective action program report, one of the semiannual effluent and environmental monitoring reports, and the Safety and Environmental Review Panel information. A license condition will be established to this effect.

5.2.4 Evaluation Findings

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

NRC has completed its review of the management control program proposed for use at the _____ *in situ* ~~leach~~recovery facility. This review included an evaluation using the review procedures in standard review plan Section 5.2.2 and the acceptance criteria outlined in standard review plan Section 5.2.3.

The applicant has an acceptable management control program that assures that all safety-related operating activities can be conducted according to written operating procedures. The applicant has provided acceptable operating procedures or a process that will be used to develop standard operating procedures. The applicant has acceptably identified radiation protection, maintenance activities (especially in radiation areas), development of ~~well field~~wellfields, and Safety and Environmental Review Panel reviews as areas where standard operating procedures are acceptable and correctly applied. The applicant has demonstrated that non-routine work or maintenance activity will comply with radiation safety requirements and that radiation work permits will be issued for activities where standard operating procedures do not apply.

The applicant will administer a cultural resources protection program in compliance with the National Historic Preservation Act, the Archeological Resources Protection Act, and their

implementing regulations. The applicant will cease any work resulting in the discovery of previously unknown cultural artifacts until such artifacts are inventoried and evaluated and authorization has been obtained from the NRC to proceed.

The applicant has acceptable record keeping and retention and reporting programs that will be adequate to ensure that the licensee is able to track, control, and demonstrate control over the source and byproduct materials that are processed, produced, or stored at the facility during its operating life, through decommissioning, and to license termination. The record keeping and retention plans will assist in ensuring that both on-site and off-site exposures are kept within regulatory limits and in documenting compliance with NRC regulations. The applicant has demonstrated an acceptable program to maintain records on spills, likely contamination events, and unusual occurrences for use in calculating annual surety amounts and to ensure acceptable decommissioning. The applicant will maintain records for decommissioning, on-site and off-site disposal, personnel exposure, and off-site releases of radioactivity, as permanent records for the facility that will be transferred to any new owner or licensee, and ultimately to NRC, before license termination. Reports will be made to the NRC as required by regulations.

Based on the information provided in the application and the detailed review conducted of the management control program for the _____ *in situ* ~~leach~~recovery facility, the staff concludes that the proposed management control program is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criteria 8 and 8A, which specify documentation requirements for airborne effluents and waste retention systems; 10 CFR Part 40, Appendix A, Paragraph 14(d)(4)(iv), which specifies requirements for spill reporting to NRC of surface or near surface leakage or spills of byproduct material detected in the uppermost aquifer; 10 CFR 20.1101, which defines radiation protection program requirements; the National Historic Preservation Act and the Archeological Resources Protection Act, which define requirements for the protection of cultural resources; 10 CFR Part 20, Subpart L and Subpart M, which define requirements for record keeping and reporting; and 10 CFR 40.61(d) and (e), which also define requirements for record keeping.

5.2.5 References

NRC. Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills will be as low as is Reasonably Achievable.” Rev. 1. Washington, DC: NRC, Office of Nuclear Regulatory Research. 2002.

—— Regulatory Guide 3.11.1, Revision 1, “Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mills.” Washington, DC: NRC, Office of Standards Development. 1980.

5.7.8 Operational Groundwater, Uppermost Aquifer, and Surface Water Monitoring Programs

The applicant, in the case of an initial application for a new ISR facility, or licensee, in the case of an amendment requesting an expansion of an existing ISR facility, must provide descriptions of the operational groundwater, uppermost aquifer, and surface water monitoring programs, which will be reviewed and approved by the NRC staff using the guidance in this section. The applicable requirements for these programs are contained in the following regulations:

Operational Groundwater Monitoring Program

- 10 CFR Part 40, Appendix A, Paragraph 14(b)(4), which requires the determination of numerical upper control limits on indicator constituents at all ~~point of compliance~~point of compliance wells and in the aquifers immediately overlying, underlying, and adjacent to the production unit. The licensee's proposed numerical upper control limits, which are included in the post-licensing wellfield package, are reviewed by the NRC staff using the guidance in SRP Section 2.11.4.

- 10 CFR Part 40, Appendix A, Paragraph 14(d)(2)(ii), which requires samples to be taken for approved indicator constituents in the ~~point of compliance~~point of compliance wells in aquifers immediately overlying, underlying, and adjacent to the production unit. The licensee's proposed indicator constituents, which are included in the post-licensing wellfield package, are reviewed by the NRC staff using the guidance in SRP Section 2.11.4.

- 10 CFR Part 40, Appendix A, Paragraph 14(h)(1), which requires certain corrective actions if an excursion is not eliminated within 60 days.

Uppermost Aquifer Monitoring Program

- 10 CFR Part 40, Appendix A, Paragraph 14(d)(4), which requires establishment of an uppermost aquifer monitoring program if surface and near surface operations have the potential to contaminate the uppermost aquifer.

- 10 CFR Part 40, Appendix A, Paragraph 14(h)(3), which requires certain corrective actions if a leak or spill of licensed material is detected in the uppermost aquifer.

Surface Water Monitoring Program

- 10 CFR Part 40, Appendix A, Criterion 7, which requires an operational monitoring program, which may include surface water monitoring, to measure or evaluate compliance with applicable standards and regulations; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects.

5.7.8.1 *Areas of Review*

The areas of review are the operational groundwater, uppermost aquifer, and surface water monitoring programs. For the operational groundwater program, this review includes a description of: (1) excursion indicator constituents and adequate methods to assign their upper control limits; (2) the program to detect, confirm, report and take action to eliminate excursions; and (3) corrective action to be taken for confirmed excursions lasting more than 60 days. For the uppermost aquifer monitoring program, this review includes a description of: (1) the program for detection and reporting of leaks or spills in the uppermost aquifer; and (2) corrective action to be taken for spills or leaks in the uppermost aquifer. For the surface water monitoring program, this review includes, if surface water is present at the site, a description of the monitoring program for detecting contamination of surface water bodies.

5.7.8.2 *Review Procedures*

The staff should review the descriptions of the operational groundwater monitoring program for excursion detection at ~~point of compliance~~point of compliance wells in the ISR wellfield, the uppermost aquifer monitoring program to detect leaks or spills in the uppermost aquifer, and the surface water monitoring program (if required). To this end, the reviewer should:

1. Verify the applicant (for a license application) or licensee (for a license amendment) will provide in the wellfield package at least three acceptable indicator constituents for excursion detection and has provided an acceptable technical basis for their selection.
2. Verify the applicant or licensee will provide in the wellfield package the background indicator constituent concentration levels for excursion detection at ~~point of compliance~~point of compliance wells in the aquifers overlying, underlying, and immediately adjacent to the production unit prior to wellfield operations using acceptable sample collection and analysis methods (e.g., APHA, 2005) based on at least 4 independent samples.
3. Verify that the applicant or licensee will determine and provide in the wellfield package the upper control limits for each indicator constituent using acceptable statistical methods to ensure timely detection of excursions due to unplanned lixiviant migration from a production unit.
4. Verify the applicant or licensee has provided an acceptable technical basis for establishing the location of ~~point of compliance~~point of compliance wells and screen intervals to detect vertical excursions in the immediately overlying and underlying aquifers and horizontal excursions in the immediately adjacent aquifers to the production unit.
5. Verify that the operational groundwater monitoring program for excursion detection includes frequency of sampling, sample collection, and analysis procedures, criteria for placing a ~~point of compliance~~point of compliance well on excursion status, actions to eliminate the excursion, and notification procedures to be followed if an excursion is confirmed.
   Verify that the applicant or licensee has described its program of corrective action in the event that any contamination is detected for an excursion that lasts more than 60 days and will report the results of the corrective action.
6. Verify that the licensee or applicant described an acceptable uppermost aquifer monitoring program to detect leaks or spills into the uppermost aquifer.
7. Verify that the licensee or applicant has described corrective actions it will take to remediate any contamination in the uppermost aquifer from leaks or spills and that it will provide a report describing the corrective action results.
8. Verify that the licensee or applicant has determined whether a surface water monitoring program is necessary at the site and, if so, that the surface water monitoring program will detect contamination of surface water bodies from the ISR facility.

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.

5.7.8.3 *Acceptance Criteria*

The operational groundwater, uppermost aquifer, and surface water monitoring programs are acceptable if they meet the following criteria:

Operations

1. The description of the operational groundwater monitoring program includes at least three indicator constituents for excursion detection and the technical basis for selecting those constituents, including:
    a. The choice of indicator constituents will be based on the lixiviant composition and groundwater geochemistry. Ideal indicator constituents are measurable parameters that are found in significantly higher concentrations in the lixiviant than in the groundwater background constituent concentrations.
    b. Indicator constituents for excursion detection will be conservative (i.e., not significantly attenuated by geochemical reactions in the aquifers). For example, for an alkaline lixiviant, chloride, conductivity and alkalinity are considered acceptable indicator constituents because they act as conservative tracers, are easily measured, and their concentrations are significantly increased during *in situ* recovery. Uranium is not considered a good indicator constituent because, although it is mobilized by *in situ* recovery, it may be retarded by reducing conditions in the aquifer (Staub et. al,1986).
2. The description of the operational groundwater monitoring program for excursion detection includes sampling of all ~~point of compliance~~point of compliance wells in the aquifers immediately overlying, underlying, and adjacent to the production unit before wellfield operations begin to measure background concentration levels of selected indicator constituents for excursion detection including:
    a. Acceptable methods are proposed to collect samples and analyze indicator constituents at ~~point of compliance~~point of compliance wells (e.g. APHA, 2005).
    b. At least four independent sets of samples, spaced adequately to account for any temporal variation, will be collected to determine the background indicator constituent concentrations.
3. The description of the operational groundwater monitoring program for excursion detection will include a method to determine individual upper control limits for each indicator constituent at all ~~point of compliance~~point of compliance wells such that:
    a. Upper control limits for the indicator constituents will be calculated to detect excursions in timely fashion and to avoid false detections:
        i. The upper control limit for each indicator constituent will fall within a range that is less than the lowest concentration that typically occurs in the lixiviant but greater than the background concentration level.
        ii. The upper control limit for each indicator constituent will be determined using:
            1. Appropriate statistical methods to establish upper control limits will be using acceptable guidance (e.g., EPA, 2009.)
            2. In areas with good water quality (total dissolved solids less than 500 mg/L), the upper control limit will be set at a value of 5 standard deviations above the mean of the measured background concentration.
            3. Any other method if an acceptable technical basis is provided by the applicant or licensee.
    b. Upper control limits for each indicator constituent are assigned to all ~~point of compliance~~point of compliance wells as a single value in each aquifer (immediately overlying, underlying, or adjacent aquifers to the production unit) ~~-~~if it can be shown that there is no significant variation of the indicator constituent across the aquifer (~~-~~e.g., mean and variation of indicator constituent is not significantly different between ~~point of compliance~~point of compliance wells in the aquifer).

c. Upper control limits for each indicator constituent are ~~-~~assigned to individual ~~point of compliance~~point of compliance wells in each aquifer (immediately overlying, underlying, or adjacent aquifers to the production unit) if there is significant variation of the indicator constituent across the aquifer (e.g. mean and variation of same indicator constituent is significantly different between ~~point of compliance~~point of compliance wells in same aquifer).

4. The description of the operational groundwater monitoring program includes the use of appropriate spacing and density for ~~point of compliance~~point of compliance well locations in the immediately overlying, underlying, and adjacent aquifers to the production unit in the ISR wellfield in which:
   a. ~~Point of compliance~~Point of compliance wells to detect horizontal excursions in the adjacent aquifer to the production unit will be located on a perimeter that surrounds the entire wellfield and are screened over the entire production unit.
   b. ~~Point of compliance~~Point of compliance wells to detect horizontal excursions in the aquifer adjacent to the production unit will be located close enough to the wellfield to provide timely detection of excursions, but far enough away from the wellfield to avoid false excursion detections (e.g., within a distance of 180 m [600 ft] to 75 m [250 ft] from boundary of the production unit (NRC, 2001, Table 4-6) and a technical justification is provided for distances greater than about 150 m [500 ft]).
5. The description of the operational groundwater monitoring program may exclude the requirement to monitor ~~point of compliance~~point of compliance wells for excursion detection in the underlying aquifer if one or more of the following conditions exists:
   a. The underlying aquifer is a poor producer of water;
   b. The underlying aquifer is of poor water quality;
   c. There is a large aquitard between the production unit and the underlying aquifer and few boreholes have penetrated the aquitard; or
   d. The installation of ~~point of compliance~~point of compliance wells would significantly increase the risk of a vertical excursion into the underlying aquifer.
6. The description of the operational groundwater monitoring program includes additional ~~point of compliance~~point of compliance wells for excursion detection in the immediately overlying and underlying aquifer in the following situations:
   a. In areas where the production unit confining layers are particularly thin, missing, or of questionable continuity.
   b. In areas where the production unit may be hydraulically connected to the immediately overlying and underlying confining layers through folds, faults, or fractures.
   c. On the hydraulically downgradient side of a wellfield when the direction of groundwater flow in an overlying or underlying aquifer is well known.
   d. In areas where injection pressure may be highest (i.e., closer to injection wells than to production wells).
7. The description of the operational groundwater monitoring program includes the ~~point of compliance~~point of compliance well monitoring frequency, and the criteria for determining when an excursion is detected and confirmed, including:
   a. All ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifer to the production unit will be sampled for indicator constituents at least once every two weeks.
   b. An excursion is deemed to be detected if two or more indicator constituents in any ~~point of compliance~~point of compliance well exceed their upper control limits.
   c. A verification sample is taken within 48 hours after results of the first analyses were received.

d. If the second sample does not indicate that upper control limits were exceeded, a third sample is taken within 48 hours after the second set of sampling data was acquired.
e. If neither the second nor the third sample indicates that upper control limits were exceeded, the first sample is considered in error, and the ~~point of compliance~~point of compliance well is removed from excursion status.
f. If either the second or third sample contains indicators above upper control limits, an excursion is confirmed, and the ~~point of compliance~~point of compliance well is placed in excursion status, the sampling is increased to weekly, and actions to eliminate the excursion are taken.

8. The description of the operational groundwater monitoring program includes excursion detection notification procedures, including:
   a. Notification of NRC within 24 hours by telephone and within seven days in writing from the time an excursion is confirmed.
   b. A written report describing the excursion event, actions taken to eliminate the excursion, and results of those actions within 60 days of the excursion confirmation.
9. The description of the operational groundwater monitoring program includes actions to be taken to eliminate excursions lasting less than 60 days and sampling to confirm the excursion is eliminated, including:
   a. Methods to eliminate horizontal excursions from the production unit to the immediately adjacent aquifer (e.g., adjusting the production/injection well flow rates to increase the inward gradient in the area of the excursion).
   b. Vertical and horizontal excursions can be considered eliminated when weekly sampling of all indicator constituents shows they are below their respective upper control limits as demonstrated by measurements over a suitable time period.
10. The description of the operational groundwater monitoring program describes corrective actions taken if an excursion is not eliminated within 60 days of confirmation, including:
   a. Terminating injection of lixiviant into the production unit.
   b. Sampling to determine whether any hazardous constituent has exceeded their approved concentration limits at the ~~point of compliance~~point of compliance well with the confirmed excursion.
   c. If any hazardous constituent has exceeded its approved concentration limits, characterization of the extent of the contamination and corrective action taken to the extent necessary to achieve compliance with the approved concentration limits.
   d. A provision to increase the financial surety for corrective action in accordance with 10 CFR Part 40, Appendix A, Paragraph 9(f)(4).
   e. Continuance of the corrective action until the hazardous constituent concentration levels meet their approved concentration limits.
   f. A report for NRC approval describing the corrective action taken, the corrective action results, and monitoring data that demonstrates that the hazardous constituents meet their approved concentration limits.
11. The description of the operational groundwater monitoring program addresses the approach to calculating and revising the wellfield restoration surety if contamination is detected from an excursion lasting more than 60 days, including:
   a. An assumption that the entire thickness of the aquifer between the production unit and the ~~point of compliance~~point of compliance well on excursion has been contaminated to calculate the increase in surety for horizontal excursions. The width of the excursion is assumed to be the distance between the ~~point of compliance~~point of compliance well on excursion status plus one ~~point of~~

~~compliance~~point of compliance well spacing distance on either side of the excursion.

b. An assumption that that the entire thickness of the aquifer is contaminated for a vertical excursion into the immediately overlying or underlying aquifer. As characterization of the extent of contamination proceeds, the surety may be increased or decreased, as appropriate. Once the extent of contamination is determined, the area contaminated above background is used to calculate the level of surety.

c. In calculating the increase in surety bonding for horizontal and vertical excursions, the same formula used to calculate the number of pore volumes required to restore the production unit is applied to the assumed areas of contamination, consistent with 10 CFR Part 40, Appendix A, Criterion 9. The surety can be adjusted downward once cleanup is complete.

d. In calculating the area affected by an excursion and the volume of water required to effect restoration, a conservative estimate is taken to ensure that adequate funds are available to clean up the groundwater should the applicant or licensee fail to do so.

12. The description of the uppermost aquifer monitoring program includes:

a. A description of how the applicant or licensee will detect leaks or spills of byproduct material for all surface and near surface operations having the potential to contaminate the uppermost aquifer, including, but not limited to:

i. Leak detection monitoring at wellheads of production and injection wells.

ii. Procedures to test and inspect pipelines, wellfield header houses, and other related wellfield infrastructure to detect leaks or other conditions that could lead to leaks or spills of byproduct material.

iii. Monitoring wells downgradient of surface waste impoundments to detect leakage of byproduct material.

b. Methods to characterize and evaluate the extent of contamination of the uppermost aquifer if any leak or spill of source, lixiviant, or byproduct material has been detected in the uppermost aquifer.

13. The description of the uppermost aquifer monitoring program includes a description of the corrective actions if contamination from leaks or spills of byproduct material are detected in the uppermost aquifer, including:

a. A report to the NRC within seven days of detection of any contamination in the uppermost aquifer.

b. The corrective actions taken to the extent necessary to achieve compliance with the approved concentration limits for all hazardous constituents in the uppermost aquifer.

c. Once corrective action is completed and the hazardous constituent concentration levels meet their approved concentration limits, the submittal of a written report for NRC approval describing the corrective actions taken and monitoring data that demonstrates that the hazardous constituents meet their approved concentration limits.

14. If surface water is present at the site, the description of the surface water monitoring program includes:

a. The pre-operational and operational water quality sampling locations for any surface water body that lies within the proposed license boundary, and upstream and downstream locations on any perennial drainage features that are within the license boundary.

b. The pre-operational surface water quality results from sampling conducted at all sampling locations on a seasonal basis (e.g., quarterly) for a minimum of one

year before *in situ* recovery operations begin, including probable hazardous constituents (e.g., As, Se, U, Ra 226, etc.) and any additional constituents (e.g., Cl and alkalinity).

c. The operational surface water quality monitoring to be conducted at all locations during operations, including a monitoring schedule and a list of probable hazardous constituents (e.g., As, Se, U, Ra-226, etc.) and any additional constituents (e.g., Cl, alkalinity) to be evaluated.

5.7.8.4 *Evaluation Findings*

If the staff review, as described in this section, results in the acceptance of the operational groundwater, uppermost aquifer, and surface water monitoring programs, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the groundwater and surface water monitoring programs at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.8.2 and the acceptance criteria outlined in standard review plan Section 5.7.8.3.

The applicant or licensee has established acceptable operational groundwater, uppermost aquifer, and surface water monitoring programs at the _____ *in situ* recovery site. For the operational groundwater monitoring program, the applicant or licensee has: proposed at least three acceptable indicator constituents for excursion detection and the technical basis for their selection; proposed acceptable locations for the ~~point of compliance~~point of compliance wells to be used for excursion detection and for sampling of the indicator constituents; proposed an acceptable sampling program to measure background indicator constituent concentration levels for excursion detection at the ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit; proposed acceptable methods to determine and assign the upper control limits for each indicator constituent that will be used to detect an excursion at ~~point of compliance~~point of compliance wells in the immediately overlying, underlying, and adjacent aquifers to the production unit based on the background indicator constituent concentration levels; demonstrated that the operational groundwater monitoring program includes the sampling and analysis of the indicator constituents all ~~point of compliance~~point of compliance wells for excursion detection, at least every two weeks, in the immediately overlying, underlying and adjacent aquifers to the production unit; and established acceptable criteria for detecting and confirming an excursion at a ~~point of compliance~~point of compliance well. The applicant or licensee has committed to notify NRC if an excursion is confirmed and take action to eliminate the excursion within 60 days. The applicant or licensee has committed to characterize the type and extent of contamination and take corrective action in the event of excursion that lasts more than 60 days. The applicant or licensee has committed to provide a report describing the results of the corrective action to remediate any contamination from the excursion. For the uppermost aquifer monitoring program, the applicant or licensee has provided an acceptable uppermost aquifer monitoring program to detect leaks and spills byproduct material and characterize any contamination and committed to notify NRC and undertake corrective action to remediate any contamination detected from leaks or spills into the uppermost aquifer and provide a written report of the corrective action results. The applicant or licensee has provided an acceptable surface water monitoring program for detection of contamination to surface water bodies at the ISR facility.

Based on the information provided in the application or license amendment request and the detailed review conducted of the groundwater and surface water monitoring programs at the _____ *in situ* recovery facility, the staff concludes that the groundwater, uppermost aquifer, and surface water monitoring programs are acceptable and are in compliance with 10 CFR Part 40, Appendix A, Paragraphs 14(b)(4), 14(d)(2), and 14(d)(4). The groundwater monitoring program is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(h)(1), which requires corrective action if an excursion is not eliminated within 60 days of confirmation and is determined to have contaminated groundwater in the immediately overlying, underlying, and adjacent aquifers to the production unit. The uppermost aquifer monitoring program is also in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(h)(3), which requires corrective action if contamination from leaks or spills is detected in the uppermost aquifer. The operational groundwater, uppermost aquifer and surface water monitoring program are also in compliance with 10 CFR 40.32(c), which requires the applicant's or licensee'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; and 10 CFR 40.31, which defines requirements for applications for specific licenses. The groundwater, uppermost aquifer and surface water monitoring programs are also in compliance with 10 CFR Part 40, Appendix A, Criteria 5B(1), 5B(5), and 5C, which provide hazardous constituent concentration limits; 10 CFR Part 40, Appendix A, Criterion 5D, which requires a groundwater corrective action program; and 10 CFR Part 40, Appendix A, Criteria 7 and 7A, which requires surface water and groundwater detection monitoring programs.

5.7.8.5 References

American Public Health Association(APHA). 2005. Standard methods for the examination of water and wastewater, 21st ed. Washington, DC, New York.

American Society for Testing and Materials. "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring." Designation D6312–98. West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1998.

EPA (United States Environmental Protection Agency). 2009. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Unified Guidance. Washington, DC: EPA. EPA 530/R-09-007.

NRC. NUREG/CR–6733, "A Baseline Risk-Informed, Performance-Based Approach for In situ Leach Uranium Extraction Licensees." Washington, DC: NRC. 2001.

Staub, W.P., et al. NUREG/CR–3967, "An Analysis of Excursions at Selected In situ Uranium Mines in Wyoming and Texas." Washington, DC: NRC. 1986.

~~**5.7.8 Ground-Water and Surface-Water Monitoring Programs**~~

~~5.7.8.1 *Areas of Review*~~

~~There are three distinct phases of ground-water and surface-water monitoring: pre-operational, operational, and restoration. Pre-operational monitoring is conducted as a part of site characterization, and review procedures are in Section 2 of this standard review plan.~~

Restoration monitoring is conducted during the ground-water restoration phase of operations, and review procedures are in Section 6. This standard review plan section deals specifically with monitoring ground-water and surface-water quality during the production or operational phase of *in situ* leach activities.

The staff should review the technical bases and procedures for the following components of an effective ground-water and surface-water operational monitoring program:

(1) Well field baseline water quality monitoring programs (ground-water and surface-water)

(2) Selection of excursion indicators and their respective upper control limits

(3) The placement of excursion monitoring wells

(4) Well field testing to verify horizontal continuity between the production zone and perimeter wells and vertical isolation between the production zone and vertical excursion monitor wells

(5) The excursion monitoring program, including well sampling schedules, criteria for placing well fields on excursion status, and corrective actions to be taken in the event of an excursion

(6) The surface-water monitoring program

For all of the preceding aspects of ground-water and surface-water monitoring programs that involve analysis of water samples, procedures for sample collection and analysis should be reviewed.

5.7.8.2 *Review Procedures*

Well field hydrologic and water chemistry data are collected before *in situ* leach operations to establish a basis for comparing operational monitoring data. Hydrologic data are used to (i) evaluate whether the well field can be operated safely, (ii) confirm monitor wells have been located correctly, and (iii) design aquifer restoration activities. Water chemistry data are used to establish a set of water quality indicators, and the concentrations of these indicators in monitoring wells are used to determine whether the well field is being operated safely. Water chemistry data are also used to set the water quality standard for restoring the production zones and adjacent aquifers after *in situ* leach extraction ceases. The reviewer should determine whether these objectives of the operational monitoring program have been met. To this end, the reviewer should

(1) Verify that procedures for establishing baseline water quality include acceptable sample collection methods, a set of sampled parameters that is appropriate for the site and *in situ* leach extraction method, and collection of sample sets that are sufficient to represent any natural spatial and temporal variations in water quality.

(2) Review the applicant's selection (or procedure for selecting) the set of water quality parameters and their respective upper control limits that will be used as indicators to ensure timely detection and reporting of unplanned lixiviant migration (excursions) from production zones.

(3) Review the applicant's technical basis or procedures for establishing the appropriate monitor well spacing for vertical and horizontal excursion monitoring.

(4) Evaluate whether well field testing is sufficient to show a horizontal hydraulic connection between the production zones and the perimeter monitor well network, and vertical hydraulic separation between the production zones and the shallow and deep monitor wells.

(5) Evaluate whether procedures describing the operational excursion monitoring program include sampling schedules, sampling and analytical procedures, criteria for placing well fields on excursion status, and corrective action and notification procedures to be followed if an excursion is detected.

(6) Evaluate whether a surface-water monitoring program is necessary at the site and, if so, whether the monitoring program will be effective to detect migration of contaminants into surface-water bodies.

In conducting these evaluations, the reviewer should consider the review of ground-water activities conducted by state and other federal agencies to identify any areas where dual reviews can be eliminated. Although the staff must make the necessary findings of compliance with applicable regulations, if a state or other federal agency asks questions in a particular area, the reviewer need not duplicate those questions. Instead, the reviewer can rely on the answers to the state or federal agency questions if they are acceptable, and if the applicant submits them as part of the NRC application. 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.

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.

5.7.8.3 *Acceptance Criteria*

The ground-water and surface-water monitoring program should ensure that an excursion is detected long before *in situ* leach solutions could seriously degrade the quality of ground-water outside the well field area. Early detection of excursions by a monitor well is influenced by the thickness of the aquifer monitored, the distance that monitor wells are placed from the well field and from each other, the frequency that the monitor wells are sampled, the water quality parameters that are sampled, and the concentrations of parameters that will be used to declare that an excursion has been detected.

The ground-water and surface-water monitoring programs are acceptable if they will allow the early detection and timely restoration of excursions. The following criteria must be met by *in situ* leach operational monitoring programs:

(1) For each new well field, the applicant's approach for establishing baseline water quality data is sufficient to (i) define the primary restoration goal of returning each well field to its pre-operational water quality conditions and (ii) provide a standard for determining when an excursion has occurred. The reviewer should verify that acceptable procedures were used to collect water samples, such as American Society for Testing and Materials D4448 (American Society for Testing and Materials, 1992). The reviewer should also

ensure that acceptable statistical methods are used to meet these three objectives, such as American Society for Testing and Materials D6312 (American Society for Testing and Materials, 1998).

Baseline sampling programs should provide enough data to adequately evaluate natural spatial and temporal variations in pre-operational water quality. At least four independent sets of samples should be collected, with adequate time between sets to represent any pre-operational temporal variations. A set of samples is defined as a group of at least one sample at each of the designated baseline monitor wells and analyzed for the water quality conditions of the sampled aquifer at a specific time.

An acceptable set of samples should include all well field perimeter monitor wells, all upper and lower aquifer monitor wells, and at least one production/injection well per acre in each well field. For large well fields, it may not be practical to sample one production/injection well per acre. Consequently, enough production/injection wells must be sampled to provide an adequate statistical population if fewer than one well per acre is used. As a general guideline, for normally and log-normally distributed populations, at least six samples are required to achieve 90 percent confidence that any random sample will lie within two standard deviations from the sample mean. In no case should the baseline sampling density for production/injection wells be less than one per 4 acres.

The applicant should identify the list of constituents sampled for baseline concentrations. Table 2.7.3-1 provides a list of acceptable constituents for monitoring at in situ leach facilities. Alternatively, applicants may propose a list of constituents that is tailored to a particular location. In such cases, sufficient technical bases must be provided to demonstrate the acceptability of the selected constituent list. For example, many licensees have decided not to sample for Th-230; Th-230 is a daughter product from the decay of uranium-238, and studies have shown that it is mobilized by bicarbonate-laden leaching solutions. However, studies have also shown that after restoration, thorium in the ground-water will not remain in solution, because the chemistry of thorium causes it to precipitate and chemically react with the rock matrix (Hem, 1985). As a result of its low solubility in natural waters, thorium is found in only trace concentrations. Additionally, chemical tests for thorium are expensive, and are not commonly included in water analyses at *in situ* leach facilities. This example concerning Th-230 demonstrates an acceptable technical basis for excluding Th-230 from the list of sampled constituents. For all constituents that are sampled, laboratory reports documenting the measurements should be maintained by the applicant.

An outlier is a single non-repeating value that lies far above or below the rest of the sample values for a single well. Dealing with outliers in the sample sets should be done using proper statistical methods. The outlier may represent a sampling, analytical, or other unknown source of error or an unidentified randomness in the data. Its inclusion within the sample could significantly change the baseline data, since the outlier is not typical of the bulk of the samples. All calculations, assumptions, and conclusions made by the applicant in evaluating outliers should be fully explained. When an outlier is suspected, perhaps the easiest solution is to take another sample from the source well; if the repeat sample yields the same results, then the outlier should not be discarded. If the repeat sample is more consistent with the statistical population, the outlier can be replaced with the new sample. Another acceptable method for dealing with potential outliers is to accept any value within three standard deviations of the mean (the standard deviation should be calculated without using the suspected outliers). It is often

necessary to perform log transformations on data to better approximate a normal distribution before calculating sample statistics. Care should be taken not to exclude suspected outliers that ultimately may represent bimodal distributions. Methods in American Society for Testing and Materials E178 (American Society for Testing and Materials, 1994), NUREG/CR–4604 (NRC, 1988) and NUREG–1475 (NRC, 1994) are acceptable methods for outlier calculation. Other documented and technically justified methods used by applicants will be considered in the evaluation of outliers (e.g., EPA, 1989).

(2) The applicant selects excursion indicator constituents and upper control limits. Upper control limits are concentrations for excursion indicator constituents that provide early warning that leaching solutions are moving away from the well fields and that ground-water outside the monitor well ring may be threatened. Excursion indicator constituents should be parameters that are strong indicators of the *in situ* leach process and that are not significantly attenuated by geochemical reactions in the aquifers. If possible, the chosen parameters should be easily analyzed to allow timely data reporting. The upper control limit concentrations of the chosen excursion indicators should be set high enough that false positives (false alarms from natural fluctuations in water chemistry) are not a frequent problem, but not so high that significant ground-water quality degradation could occur by the time an excursion is identified. A minimum of three excursion indicators should be proposed. The choice of excursion indicators is based on lixiviant content and ground-water geochemistry. Ideal excursion indicators are measurable parameters that are found in significantly higher concentrations during *in situ* leach operations than in the natural waters. At most uranium *in situ* leach operations, chloride is an excellent excursion indicator because it acts as a conservative tracer, it is easily measured, and chloride concentrations are significantly increased during *in situ* leaching. Conductivity, which is correlated to total dissolved solids, is also considered to be a good excursion indicator (Staub, 1986; Deutsch, 1985). Total alkalinity (carbonate plus bicarbonate plus hydroxide) is an excellent indicator in well fields where sodium bicarbonate or carbon dioxide is used in the lixiviant. If conductivity is used to estimate total dissolved solids, measurements will be normalized to a reference temperature, usually 25 °C, because of the temperature dependence of conductivity.

Calcium, sodium, and sulfate are usually found at significantly higher levels in *in situ* solutions than in natural ground-water concentrations. The use of cations (e.g., calcium2+, sodium+) as excursion indicators is generally not appropriate because they are subject to ion exchange with the host rock. The use of sulfate may give false alarms because of induced oxidation around a monitor well (Staub, 1986; Deutsch, 1985). However, this should only be a problem if upper control limit values are set too conservatively. Uranium is not considered a good excursion indicator because, although it is mobilized by *in situ* leaching, it may be retarded by reducing conditions in the aquifer. Although water level changes in artesian aquifers are quickly transmitted, water levels are generally not considered good indicators, because water levels tend to have significant natural variability. The applicant may choose to add a non-reactive, conservative tracer to *in situ* leach solutions to act as an excursion indicator. The applicant is required to provide the technical bases for the selection of excursion indicators.

Upper control limit concentrations must be set to easily identify excursions. An excursion is defined to occur whenever two or more excursion indicators in a monitoring well exceed their upper control limits. The upper control limit for each excursion

indicator must generally be less than the lowest concentration that typically occurs in the lixiviant while the well field is in operation. Each upper control limit must also be greater than the baseline concentration for its respective excursion indicator. Applicant site-specific experience is often valuable in determining appropriate upper control limits that provide timely detection and avoid false alarms. Guidance for appropriate statistical methods that can be used to establish upper control limits can be found in American Society for Testing and Materials D6312 (American Society for Testing and Materials, 1998).

Upper control limits for a specific excursion indicator should be determined on a statistical basis to account for likely spatial and temporal concentration variations within the mineralized zone. Statistical techniques, such as the student's t-test, are acceptable for setting upper control limits. In some cases, the use of a simple percentage increase above baseline values is acceptable. The staff has decided that in areas with good water quality (a total dissolved solids less than 500 mg/L), setting the upper control limit at a value of 5 standard deviations above the mean of the measured concentrations is an acceptable approach. However, in some aquifers of good water quality, low chloride concentrations have been found to have such a narrow statistical distribution that a specified concentration (e.g., 15 mg/L) above the mean or the mean plus 5 standard deviations approach, which ever is greater, has been used to establish the chloride upper control limit.

The same upper control limits may be assigned to all monitor wells within a particular hydrogeologic unit in a given well field if baseline data indicate little chemical heterogeneity. Alternatively, if individual monitor wells in a given unit exhibit unique baseline water quality, upper control limits may be assigned on a well-by-well basis. If upper control limits vary from well to well, a table should be included listing all monitor wells and their respective upper control limits.

(3) The applicant establishes criteria for determining monitor well locations. Production zone perimeter monitor wells are used to detect horizontal excursions outside the well field boundary. They generally surround the entire well field and are screened over the entire production zone hydrogeologic unit. Perimeter monitor wells should be placed close enough to the well field to provide timely detection, yet they should be far enough away from the well field to avoid numerous false alarms. Previously approved *in situ* leach excursion monitoring systems used monitor wells as far as 180 m [600 ft] and as near as 75 m [250 ft] from the well field edge (NRC, 2001, Table 4-6). The licensee should be afforded some discretion in determining the appropriate distance of horizontal excursion monitor wells from the well field, but should provide justification for distances greater than about 150 m [500 ft]. For example, a rigorous modeling demonstration that a theoretical excursion can be controlled at the monitor well locations within 60 days of detection is an acceptable technical basis. The horizontal excursion monitor wells must be spaced close enough to one another so that the likelihood of missing an excursion plume is low. In determining the appropriate spacing between perimeter monitoring wells, the applicant must consider such factors as the distance of the monitoring wells from the edge of the well field, the minimum likely size of an excursion source zone, ground-water flow directions and velocities outside of the well field, and the potential for mixing and dispersion. Staff should consult NUREG/CR–6733 (NRC, 2001, Section 4.3.3) for an analysis and discussion of acceptable approaches for establishing the appropriate monitor well spacing.

NUREG/CR–6733 (NRC, 2001, Section 4.3.3) established that significant risks for vertical excursions may exist if monitor wells are randomly located, given the typical criteria for spacing of vertical excursion monitor wells at licensed *in situ* leach facilities {e.g., one well per 1.6 ha [4 acres] for overlying aquifers; one well per 3.2 ha [8 acres] for underlying aquifers}. Thus, location of vertical excursion monitor wells within the well field should be such that the likelihood of detecting a vertical excursion is maximized. The appropriate number of these monitor wells may vary from site to site. It may be appropriate to exclude the requirement to monitor water quality in the underlying aquifer if (i) the underlying aquifer is a poor producer of water, (ii) the underlying aquifer is of poor water quality, (iii) there is a large aquitard between the production zone and the underlying aquifer and few boreholes have penetrated the aquitard, or (iv) deep monitor wells would significantly increase the risk of a vertical excursion into the underlying aquifer. Monitor wells completed in aquifers above the first overlying aquifer may not be required when (i) the aquifers are separated from the production zone by thick aquitards, (ii) a high quality mechanical integrity well testing program will be implemented, or (iii) the aquifers are unsubstantial producers of water or of poor water quality. In well fields where the production zone confining layers are particularly thin, or of questionable continuity, a greater number of monitor wells is appropriate. In general, when the direction of ground-water flow in an upper or lower aquifer is well known, the applicant should consider locating these wells on the hydraulically down gradient side of a well field, in areas where production zone confining layers may be thin or incompetent, and in areas where injection pressure may be highest (i.e., closer to injection wells than to production wells).

The process for determining the screened interval of the monitor wells should be described. Fully screened monitor wells sample the entire thickness of the aquifer. Therefore, excursions could not pass above or below the well screens. However, the concentration of the indicator parameters might be diluted and therefore may not provide timely warning that an excursion is occurring. Partially screened monitor wells only sample the zone of extraction within an aquifer. These wells might miss some excursions, but would suffer less from dilution effects than fully screened wells. For most situations the staff favors fully screened monitor wells. Fully screened monitor wells would assure that excursions will eventually be detected, have the advantage of more accurately representing the water quality that a ground-water user is likely to experience, and do not suffer from the uncertainty of predicting the completion intervals of injection and production wells that have not yet been drilled.

(4) The applicant establishes well field test procedures. Once a well field is installed, it should be tested to establish that the production and injection wells are hydraulically connected to the perimeter horizontal excursion monitor wells and are hydraulically isolated from the vertical excursion monitor wells. Such testing will serve to confirm the performance of the monitoring system and will verify the validity of the site conceptual model reviewed in Section 2 of this standard review plan. The reviewer should verify that well field test approaches have sound technical bases. Test approaches typically consist of a pumping test that subjects the well field to a sustained maximum withdrawal rate while monitoring the perimeter and vertical excursion wells for drawdown. The test should continue until the effects of pumping can be clearly seen via drawdown in the perimeter monitor wells. Typically, about 0.3 m [1 ft] of drawdown in the perimeter monitor wells will verify hydraulic connection, but the amount may vary because of the distance from the pumping wells, pumping rates, and hydraulic conductivity. To investigate vertical confinement or hydraulic isolation between the production zone and

upper and lower aquifers, water levels in upper or lower aquifers may also be monitored during the pumping tests.

(5) The applicant defines operational approaches for the monitoring program. The monitoring program must indicate which wells will be monitored for excursion indicators, the monitoring frequency, and the criteria for determining when an excursion has occurred. An acceptable excursion monitoring program should indicate that all monitor wells will be sampled for excursion indicators at least every 2 weeks during *in situ* leach operations.

An excursion is deemed to have occurred if two or more excursion indicators in any monitor well exceed their upper control limits. A verification sample must be taken within 48 hours after results of the first analyses were received. If the second sample does not indicate that upper control limits were exceeded, a third sample must be taken within 48 hours after the second set of sampling data was acquired. If neither the second nor the third sample indicates that upper control limits are exceeded, the first sample is considered in error, and the well is removed from excursion status. If either the second or third sample contains indicators above upper control limits, an excursion is confirmed, the well is placed in excursion status, and corrective action must be initiated.

Generally, the risk of contamination to surface-water bodies from *in situ* leach operations is low when proper operational procedures are followed. Any surface-water body that lies within the proposed license boundary should be sampled at upstream and downstream locations, both before and during operations. The reviewer should ensure that pre-operational water quality sampling locations for applicable surface-waters are indicated in the application. The pre-operational data should be collected on a seasonal basis for a minimum of 1 year before *in situ* leach operations. Procedures for monitoring surface-water quality during operations should be discussed in the application: this discussion must include a monitoring schedule, monitor locations, and a list of sampled constituents. The applicant may be exempted from monitoring during operations if the site characterization demonstrates that no significant flow of ground water to surface water occurs near the site (e.g., if surface-water bodies are perched and ephemeral).

The excursion monitoring operational procedures must also include corrective action and notification plans in the event of an excursion. NRC must be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions, and the corrective action results must be submitted to NRC within 60 days of the excursion confirmation. If wells are still on excursion status when the report is submitted, the report must also contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the case of a vertical excursion, the report must contain a projected date when characterization of the extent of the vertical excursion would be completed.

Corrective action to retrieve horizontal excursions within the production-zone aquifer is generally accomplished by adjusting the flow rates of the pumping/injection wells to increase process bleed in the area of the excursion. Vertical excursions have proven more difficult to retrieve: at some *in situ* leach facilities, vertical excursions have persisted for years. If an excursion is not corrected within 60 days of confirmation, applicants must either terminate injection of lixiviant into the well field until the excursion

is retrieved, or provide an increase to the reclamation surety in an amount that is agreeable to NRC and that would cover the expected full cost of correcting and cleaning up the excursion. The surety increase must remain in force until the excursion is corrected. The written 60-day excursion report should state and justify which course of action will be followed.

If wells are still on excursion status at the time the 60-day report is submitted to NRC, and the surety option is chosen, the well field restoration surety will be adjusted upward. To calculate the increase in surety for horizontal excursions, it is assumed that the entire thickness of the aquifer between the well field and the monitor wells on excursion has been contaminated with lixiviant. The width of the excursion is assumed to be the distance between the monitor wells on excursion status plus one monitor well spacing distance on either side of the excursion. When the excursion is corrected, the additional surety requirements resulting from the excursion will be removed.

To calculate the increase in surety for vertical excursions, an initial estimate of the area contaminated is made. All estimates assume that the entire thickness of the aquifer is contaminated. As characterization of the extent of contamination proceeds, the surety may be increased or decreased, as appropriate. Once the extent of contamination is determined, the area contaminated above background is used to calculate the level of surety. When the vertical excursion is cleaned up, the additional surety requirements resulting from the excursion are removed.

In calculating the increase in surety bonding for horizontal and vertical excursions, the same formula used to calculate the number of pore volumes required to restore a well field is applied to the assumed areas of contamination. This approach is consistent with 10 CFR Part 40, Appendix A, Criterion 9. Increased surety provides assurance that cleanup will be accomplished in the event of licensee default, and surety can be adjusted downward once cleanup is complete. In calculating the area affected by an excursion and the volume of water required to effect restoration, a conservative estimate is taken to ensure that adequate funds are available to clean up the ground water should the licensee fail to do so.

Corrective action for vertical and horizontal excursions can be determined complete when all excursion indicators are below their respective upper control limits, or if only one excursion indicator exceeds its respective upper control limit by less than 20 percent. Stability in the excursion indicator concentrations must be demonstrated by measurements over a suitable time period before the corrective action measures can be discontinued.

(6) If an *in situ* leach facility is located adjacent to bodies of surface-water, the applicant must establish a surface-water monitoring program that will be effective to detect migration of contaminants into surface-water bodies . Alternatively, the applicant may demonstrate that the risk of contamination from *in situ* leach activities is negligible or that potential releases are within limits set by the Safe Drinking Water Act.

5.7.8.4 *Evaluation FIndings*

If the staff review, as described in this section, results in the acceptance of the ground-water and surface-water monitoring programs, the following conclusions may be presented in the technical evaluation report and environmental assessment.

NRC has completed its review of the ground-water and surface-water monitoring programs at the _____*in situ* leach facility. This review included an evaluation using the review procedures in standard review plan Section 5.7.8.2 and the acceptance criteria outlined in standard review plan Section 5.7.8.3.

The applicant has established acceptable ground-water and surface-water monitoring programs at the _____*in situ* leach site. The applicant has established acceptable well field baseline sampling programs including the number and timing of samples, constituents sampled, and appropriate statistical methods to remove outliers. The applicant has selected acceptable excursion indicator constituents and an approach for establishing upper control limits. Appropriate criteria are used to establish monitor well locations for all aquifers likely to be affected. Appropriate well field test procedures are established. The applicant has defined acceptable operational approaches for the ground-water and surface-water monitoring programs, including identifying appropriate wells for monitoring for excursion indicators, monitoring frequency, and criteria for determining the presence of an excursion. The applicant has defined an acceptable sampling program for any surface-water body that lies within the facility boundary, including downstream sampling locations and standard approaches for monitoring with a schedule and a list of analyzed constituents. The applicant has prepared an acceptable ground-water and surface-water corrective action plan, including notification of NRC and subsequent reporting in the event of an excursion.

Based on the information provided in the application and the detailed review conducted of the ground-water and surface-water monitoring programs at the _____*in situ* leach facility, the staff concludes that the ground-water and surface-water monitoring programs 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; and 10 CFR 40.31, which defines requirements for applications for specific licenses. The ground-water and surface-water monitoring programs are also in compliance with 10 CFR Part 40, Appendix A, Criteria 5B(1), 5B(5), and 5C, which provide concentration limits for contaminants; 10 CFR Part 40, Appendix A, Criterion 5D, which requires a ground-water corrective action program; and 10 CFR Part 40, Appendix A, Criteria 7 and 7A, which require ground-water monitoring programs.

Pre-operational monitoring is conducted as part of site characterization and is addressed in Section 2 of this technical evaluation report, whereas restoration monitoring is conducted during ground-water restoration and is addressed in Section 6 of this technical evaluation report.

5.7.8.5 *References*

American Society for Testing and Materials. "Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring." Designation D6312–98. West Conshohocken, Pennsylvania: American Society for Testing and Materials. 1998.

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6 ~~GROUND-WATER~~GROUNDWATER ~~QUALITY~~ RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 ~~Plans and Schedules for Ground-Water Quality~~Wellfield Groundwater Restoration

10 CFR Part 40, Appendix A, Criterion 14(f) requires the licensee to restore the groundwater in the production unit to the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5). The groundwater restoration of the production unit begins after the licensee terminates uranium recovery in the production unit (permanently ceases lixiviant injection).

In the application for an ISR facility, the applicant must provide a general description of the wellfield restoration plan that is to be reviewed by staff using guidance in Section 3.2. After licensing and before beginning operations in each wellfield, the licensee must provide a wellfield restoration plan describing the groundwater restoration of the production unit in the wellfield pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(b)(5) for NRC review and approval as part of the wellfield package described in the guidance in Section 2.11. The wellfield restoration plan must demonstrate that the hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5) will be met at the points of compliance after restoration of the production unit in the ISR wellfield. The licensee is expected to follow the approved restoration plan to achieve the hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b), for all hazardous constituents at all points of compliance in the production unit in the wellfield.

The Commission has determined that the hazardous constituent concentration limits in Paragraphs 5B(5)(a) or (b) are inherently protective of surrounding groundwater, as stated in 10 CFR Part 40, Appendix A, Paragraph 5B(6). However, after conducting groundwater restoration in accordance with the approved wellfield restoration plan, if the licensee determines the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b), cannot be practically achieved for a specific hazardous constituent, the licensee may propose an alternate concentration limit (ACL) pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f) for that hazardous constituent. The guidance for staff to review a proposed ACL for a hazardous constituent pursuant to the requirements in Criterion 14(f) is provided separately in Appendix F.

After the licensee has demonstrated that all approved hazardous constituent concentration limits (including an ACL) have been met at all ~~point of compliance~~point of compliance wells, the licensee is required to conduct post-restoration monitoring in the ISR production unit pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f)(1). During post-restoration monitoring the licensee must demonstrate there has been no statistically significant exceedance of the approved hazardous constituent concentration limits during quarterly monitoring at all ~~point of compliance~~point of compliance wells in the production unit for three consecutive years. If a statistically significant exceedance of the approved hazardous constituent concentration limit is detected in a ~~point of compliance~~point of compliance well in the production unit during post-restoration monitoring, the licensee must undertake corrective action pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(h)(2).

Finally, after the licensee completes post-restoration monitoring, the licensee must provide a wellfield restoration report to the NRC for approval pursuant to 10 CFR Part 40, Appendix A,

Paragraph 14(f)(2). The wellfield restoration report must describe the wellfield restoration activities and results, including compliance with the NRC approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5), and the post-restoration monitoring data demonstrating no statistically significant exceedance of the approved concentration limits for three consecutive years.

The guidance in this SRP is for staff review of the information provided by the licensee to determine if it is acceptable to demonstrate compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(5), Criterion 14(f), Paragraphs 14(f)(1)-(2), and Paragraph 14(h)(2). The guidance in Section 6.1.1 addresses the information needed for the staff to review and approve the wellfield restoration plan to achieve the hazardous constituent concentration levels in the production unit in an ISR wellfield ~~-~~and to conduct post-restoration monitoring. The guidance in Section 6.1.2 addresses the information that staff should review on the corrective action if an exceedance of the approved hazardous constituent concentration limits is detected. Finally, the guidance in Section 6.1.3 addresses the information that staff should review to determine if the wellfield restoration report demonstrates that there is reasonable assurance that the hazardous constituent concentration limits will not be exceeded after the groundwater restoration of the production unit is approved. The guidance for staff to review and approve a proposed ACL for a hazardous constituent is provided in Appendix F.

It is important to note that the acceptance criteria laid out in this standard review plan are for the guidance of NRC staff responsible for the review of applications to operate *in situ* ~~leach~~recovery facilities. Review plans are not substitutes for the Commission's regulations, and compliance with a particular standard review plan is not required. This standard review plan provides descriptions of methodologies that have been found acceptable for demonstrating regulatory compliance. Alternative methods and solutions different from those set out in the standard review plan will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a license by NRC.

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~~groundwater restoration plans and the sureties associated with them.

Technical assessment of the selected ~~ground-water~~groundwater restoration methods, restoration time and pore volume displacements, and sureties may entail use of 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 Wellfield Restoration Plan

10 CFR Part 40, Appendix A, Paragraph 14(b)(5), requires the licensee to provide a wellfield restoration plan to demonstrate that the wellfield restoration will meet the requirements in Criterion 14(f) and Paragraph 14(f)(1).

6.1.1.1 *Areas of Review*

The area of review is the licensee's wellfield restoration plan for restoration of hazardous constituents in groundwater. This includes the licensee's proposed groundwater restoration method, its technical bases, and any groundwater flow or contaminant transport models, if they are used to support the predicted performance of the groundwater restoration in the production unit. This also includes the licensee's approach to assessing the performance of each restoration method and how the licensee will conduct monitoring to demonstrate the success of each groundwater restoration method in the ISR wellfield. The staff reviews the licensee's plan to conduct post-restoration monitoring and take corrective action if the approved hazardous constituent concentration limits are exceeded during post-restoration monitoring. The areas of review also include the schedule for the wellfield restoration plan that addresses the expected time for application of each restoration method and the duration of post-restoration monitoring in the production unit. Finally, the staff should review the plans and methods for disposal of liquid wastes from groundwater restoration, such as deep-well injection, discharge to surface water, or land application.

6.1.1.2 *Review Procedures*

The staff should review and approve the wellfield restoration plan proposed by the licensee for the production unit in the ISR wellfield before a new wellfield begins operation. The staff should evaluate the wellfield restoration plan is sufficient to meet the NRC approved hazardous constituent concentration limits after restoration in the production unit is completed. The staff will review the following elements of the wellfield restoration plan:

1. An estimate of the hazardous constituent concentration levels that will be present when uranium extraction ceases in the production unit.
2. An estimate of the volume of byproduct material that will require groundwater restoration of the production unit, including a description of the method used to estimate the pore volume and the associated horizontal and vertical flare factors in the production unit.
3. For each hazardous constituent identified pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(b)(2), the wellfield restoration plan must specify a targeted hazardous constituent concentration limit, expressed in terms of a numerical limit, and include an analysis or demonstration that the wellfield can be restored to meet these limits.

4. The proposed restoration methods to be used and the technical bases for the predicted success of the restoration methods to meet the hazardous constituent concentration limits in the production unit.
5. Identification of the hazardous constituents and any other groundwater constituents to be monitored, the existing ~~point of compliance~~point of compliance wells to be sampled, and sampling frequency of these ~~point of compliance~~point of compliance wells.
6. Wellfield restoration performance assessment measures, including groundwater monitoring, to evaluate the performance of the proposed restoration over time.
7. A post-restoration monitoring program pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f)(1), that includes quarterly sampling of hazardous constituent concentration levels at all existing ~~point of compliance~~point of compliance wells in the production unit for three years, and requires the licensee to report to the NRC and take corrective action for any statistically significant exceedance of an approved hazardous constituent concentration limit ~~-~~pursuant to Paragraph 14(h)(2).
8. A schedule for the wellfield restoration plan that addresses the expected time for application of each restoration method and the duration of post-restoration monitoring in the production unit.
9. Plans and methods for disposal of liquid wastes from groundwater restoration, such as deep-well injection, discharge to surface water, or land application.
10. A comprehensive description of any groundwater or contaminant transport modeling, if it is used to support the predicted performance of the groundwater restoration in the production unit, including estimates of restoration time and a description of the uncertainties in the input parameters and modeling methods. Specifically, any groundwater flow and contaminant transport modeling should include:
    a. Techniques used to collect data on the geology, hydrology, geochemistry, processes, plume geometry and ~~/~~extent.
    b. Technical bases for evaluating effects of the geology, hydrology, geochemistry, processes, and physical properties on groundwater flow and contaminant transport pathways.
    c. Consistency and adequacy of model assumptions.
    d. Technical bases for the concentrations of contaminants.
    e. Sufficiency of data and selection of model parameters and simplifications.
    f. Evaluation of uncertainty associated with model parameters.
    g. Model results compared to more detailed model results or site data (i.e., model validation).

6.1.1.3 *Acceptance Criteria*

The staff will find the wellfield restoration plan acceptable if the licensee has submitted a wellfield restoration plan containing the following elements:

1. An estimate of hazardous constituent concentration levels in the production unit and the volume of fluids that will require groundwater restoration that includes:
    a. The estimated hazardous constituent concentration levels at each ~~point of compliance~~point of compliance well in the production unit.

b. An estimate of the pore volume[3] using the associated horizontal and vertical flare[4] factors in the production unit that includes the calculations and a demonstration that the method for estimating the affected pore volume is valid (e.g., consistent with the methods used at any ISR research and development site or historical ISR sites upon which pore volume estimates may be based).

2. For each hazardous constituent, a targeted hazardous constituent concentration limit for the groundwater restoration, expressed in terms of a numerical limit, and an analysis or demonstration that the production unit can be restored to meet these limits that includes:
   a. Estimates of post-extraction hazardous constituent concentration levels that consider the lixiviant composition and host rock geochemistry.
   b. Target hazardous constituent concentration limits that are based on a realistic assessment of the expected post-restoration hazardous constituent concentration levels by comparing the target limit with previous restorations at similarly situated ISR research and development sites or other previously restored ISR wellfields.
   c. Target hazardous constituent concentration limits that are established at points of compliance that adequately represent the production unit.
3. For each proposed restoration method and its application in the production unit, a description -that includes:
   a. The physical, chemical, or biological process involved.
   b. The process flow balance and associated infrastructure.
   c. The aquifer pore volumes to be treated.
   d. A discussion of chemical additives used in the restoration process, anticipated effects of chemical additives, and alternate techniques that may be employed.
   e. The estimated length of time the method will be applied.
   f. The description of methods for disposal or treatment of wastes and effluents from each method.
   g. The technical bases that support the anticipated success of the proposed restoration method in the wellfield restoration plan to meet the approved hazardous constituent concentration limits in the production unit that includes:
      i. Evidence from ISR site-specific lab studies, pilot studies or field studies that have been shown to be, or are applicable to, the hazardous constituents in the site-specific conditions of the production unit in the ISR wellfield.
      ii. Projected performance from groundwater flow and contaminant transport or geochemical models using site-specific technical information from the production unit in the ISR wellfield.

[3] Pore volume is a term of convenience used by the *in situ* recovery 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 in recovery of 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 wellfield scales.

[4] 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.

iii. Historical performance from well--documented and successful restoration of hazardous constituents in a similarly -situated production unit in an ISR wellfield. Sources of information can include research and development and production sites that are located in similar hydrogeologic environments and have used similar restoration techniques. The proposed restoration methods should be appropriate for the host rock and lixiviant chemistry.

4. The licensee has provided a description of how the performance of each restoration method will be assessed over time, including:
   a. The identification of the hazardous constituents and any other radiological or non-radiological constituents to be monitored, the well locations to be used as points of compliance, and sampling frequency of those points of compliance wells.
   b. A description of how groundwater monitoring results at ~~point of compliance~~point of compliance wells in the production unit will be used to provide the spatial and temporal concentration levels of hazardous constituents during the application of each restoration method (e.g., concentration contours over time) and to demonstrate the success of each groundwater restoration method to reduce hazardous constituent concentration levels of hazardous constituents (e.g., time series analysis).
   c. A description of how other constituents (e.g., chloride) and indicators (e.g., oxidation reduction potential) will be monitored to assess the performance of each restoration method.
   d. A description of how the wellfield restoration plan may be modified as necessary to improve restoration performance, as needed.
5. The licensee has provided a description of a post-restoration monitoring program that will be implemented after the wellfield restoration has been completed and all hazardous constituents meet their approved limits at all ~~point of compliance~~point of compliance wells that includes:
   a. Quarterly sampling at each ~~point of compliance~~point of compliance well for three years to analyze whether any hazardous constituent exceeds its approved concentration limits on a well-by-well basis.
   b. Acceptable statistical tests to evaluate if the measured concentration level of a hazardous constituent has shown a statistically significant exceedance of the approved concentration limit during the post-restoration monitoring period including:
      i. Listed statistical tests for detection and compliance monitoring in 40 CFR 264.97(h)(1)-(4).
      ii. Another statistical test method from the EPA statistical guidance, "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance," (EPA, 2009) to be approved by the NRC.
   c. Notifying the NRC in writing within seven days if, during the post-restoration monitoring period, the collected samples show that concentrations of any of the monitored hazardous constituents at a ~~point of compliance~~point of compliance well has shown a statistically significant exceedance of its approved concentration limit.
   d. The corrective action the licensee will take to achieve compliance with the approved hazardous constituent concentration limits if any hazardous constituent concentration level at a ~~point of compliance~~point of compliance well in the

restored production unit shows a statistically significant exceedance of any approved hazardous constituent concentration limits during post-restoration monitoring and following the seven day report.

6. The licensee has provided the plans and schedules for groundwater restoration and post-restoration monitoring of the production unit that includes:
   a. The time expected to conduct and complete each restoration method in the production unit
   b. The time expected for the post-restoration monitoring period of the production unit
   c. For purposes of surety bonding, the estimates of the level of effort (typically in terms of pore volume displacements) necessary to achieve the approved hazardous constituent concentration limits. These estimations may be based on historical results obtained from a research and development site or experience in other wellfields having similar hydrologic and geochemical characteristics.
7. The licensee has provided plans and methods of liquid waste disposal during groundwater restoration, such as deep-well injection, discharge to surface water, and land application that are consistent with generally-accepted techniques.
8. If numerical groundwater flow or contaminant transport modeling is used to support or develop the groundwater restoration plans, the licensee has provided:
   a. The descriptions of features, physical properties, and the geological, hydrologic, 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.
   b. An evaluation of the sufficiency of data used to support model input 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.
   c. An evaluation of the technical bases for parameter ranges, probability distributions, or bounding values. 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 realistic.
   d. An examination of the initial conditions and boundary conditions used in any numerical modeling for consistency with available data, including the potential importance of temporal and spatial variations in boundary conditions and source terms used to support the groundwater restoration plan.
   e. An evaluation the licensee's assessment of uncertainty and variability in model parameters, including whether uncertainty in both temporal and spatial parameter variability is incorporated into or bounded by parameter values.
   f. An examination of the technical bases for the identification of post-extraction changes to groundwater quality, including how it has been incorporated into estimates of restoration time or attain restoration goals.
   g. An examination of 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 reduce concentrations of, or retard, contaminants. The modeling considers available data about the native groundwater downgradient of the production areas, the geochemical environment, hydraulic and transport properties, and the spatial variations of aquifer properties and groundwater volumetric fluxes along the flow paths.

h. An evaluation of the estimated restoration time or required number of pore volume displacements for consistency with the output from any numerical model of groundwater restoration.
i. An evaluation of whether the licensee 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 sensitivity analyses support the model of the groundwater restoration and the estimation of restoration time and pore volume displacements.
j. An evaluation of the estimated restoration time or required number of pore volume displacements for consistency with the output from any numerical model of groundwater restoration.

9. The licensee has justified the use of numerical or analytical contaminant transport modeling to support the predicted success of the wellfield restoration plan. When flow and contaminant transport modeling is used, the licensee provided the data and model justification to demonstrate that conclusions used to develop the wellfield restoration plan are reasonable. Data and model justification meet the following criteria:
    a. Important design features, physical properties, and consistent and appropriate assumptions are identified and described sufficiently for incorporation into the modeling that supports the wellfield restoration plan.
    b. The licensee provided sufficient data to justify the selection of models used to develop the wellfield restoration plan and to adequately define model parameters, initial and boundary conditions, and any simplifying assumptions.
    c. Parameter values, assumed ranges, probability distributions, and/or bounding assumptions used in modeling groundwater 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 groundwater restoration are provided.
    d. In the case of sparse data and/or low confidence in the quality of available data or parameter estimates, the licensee demonstrates by sensitivity analyses or other methods that the proposed groundwater restoration approach is appropriate, and the contingency built into the surety is consistent with the uncertainties.
    e. For reactive transport models, adequate site geochemical data are provided to support the wellfield restoration plan and models. The model describes changes over time in the geochemical parameters pH, Eh, dissolved oxygen, temperature, major cation and anion concentrations, contaminant concentrations, and host-rock mineralogy.
    f. 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. The model includes sensitivity analyses that demonstrates contaminant concentrations will not be underestimated. The effect of model limitations on uncertainty is described. The types of model limitations include: the assumption of local equilibrium; not modeling changes in porosity caused by precipitation or dissolution of the solid phase; omitting colloidal transport; neglecting density effects due to varying total dissolved solids; simplifying the mineralogical suite; and neglecting surface reactions such as ion exchange.

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

10. The licensee has described the management of liquid waste and solid wastes (e.g., sludge) in surface impoundments. The licensee demonstrated that surface impoundments will be 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. The licensee also demonstrated that monitoring would detect any migration of contaminants to the ground water. Solid waste material will be disposed of in an existing tailings impoundment or 11e.(2) disposal cell in accordance with 10 CFR Part 40, Appendix A, Criterion 2. 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.
11. The licensee has described the management of liquid effluents to surface waters. The licensee complies with new source performance standards in 40 CFR 440.34, which requires that there shall be no discharge of process wastewater to navigable waters from mills using the acid leach, alkaline leach or combined acid and alkaline leach process for the extraction of uranium or from mines and mills using *in situ* leach methods. Liquid effluents not prohibited by 40 CFR 440.34 meet the requirements in 10 CFR 20.1302 for radioactive material and the appropriate state limits for non-radioactive material.
12. The licensee meets 10 CFR 20.2002 for liquid waste disposal by land application, as appropriate. Applications for alternative disposal by land application include provisions for periodic soil surveys to verify that concentrations of radionuclides in soil do not exceed those projected.
13. The licensee meets 10 CFR 20.2002 for liquid waste disposal by deep-well ~~well~~ injection, as appropriate.

6.1.1.4 *Evaluation Findings*

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

NRC has completed its review of the wellfield restoration plan for groundwater restoration of the production unit in the ISR wellfield at the *in situ* recovery facility. This review included an evaluation of the methods that will be used in wellfield restoration plan and using the review procedures in standard review plan Section 6.1.1.2 and the acceptance criteria outlined in standard review plan Section 6.1.1.3.

The staff concludes that the licensee has provided an acceptable wellfield restoration plan that is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(b)(5), that requires the licensee to provide a wellfield restoration plan to demonstrate that the wellfield restoration will meet the required regulations in Criterion 14(f) and Paragraph 14(f)(1).
Specifically, the wellfield restoration plan proposed by the licensee for restoration of hazardous constituents in groundwater commits to meet the approved hazardous constituent concentration limits in production unit in the ISR wellfield. The groundwater restoration methods proposed by the licensee in the wellfield restoration plan are reasonable and have an acceptable technical bases which support their selection. If applicable, the licensee has provided groundwater flow or contaminant transport modeling that supports the predicted performance of the groundwater

restoration in the production unit. The licensee has provided an acceptable plan for how the performance of each restoration method will be assessed including how monitoring of the ~~point of compliance~~point of compliance wells in the production unit will be evaluated to determine the performance of each groundwater restoration method in the ISR wellfield. The licensee has committed to conduct post-restoration monitoring and take corrective action if the approved hazardous constituent concentration limits show a statistically significant exceedance during post-restoration monitoring. The licensee has provided the schedule for the wellfield restoration plan that addresses the expected time for application of each restoration method and the length of post-restoration monitoring in the production unit. The licensee has provided the plans and methods for disposal of liquid wastes from groundwater restoration, such as deep-well injection, discharge to surface water, and land application.

Based on the information provided by the licensee and the detailed review conducted of the wellfield restoration plan for groundwater restoration of the production unit in the ISR wellfield *in situ* recovery facility, the staff concludes that the proposed wellfield restoration plan is acceptable and is in compliance with 10 CFR Part 40 Appendix A, Paragraph 14(b)(5), that requires the licensee to provide a wellfield restoration plan to demonstrate that the wellfield restoration will meet the required regulations in Criterion 14(f) and Paragraph 14(f)(1). The proposed wellfield restoration plan is also in compliance with 10 CFR 51.45(c), which requires the licensee 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 groundwater restoration in accordance with standard review plan Sections 5.0, “Operations;” and 7.0, “Environmental Effects;” are addressed elsewhere in this safety evaluation report.

~~6.1.1 Areas of Review~~

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

~~(1) Ground-water modeling used to estimate 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~~

~~(b) Technical bases for evaluating effects of the geology, hydrology, geochemistry, processes, and physical phenomena on flow and transport pathways~~

~~(c) Consistency and adequacy of model assumptions~~

~~(d) Technical bases for the concentrations of contaminants~~

~~(e) Sufficiency of data and selection of model parameters and simplifications~~

~~(f) Evaluation of uncertainty associated with model parameters~~

~~(g) Model results compared to more detailed model results or site data (i.e., model validation)~~

~~(2) Estimates of the concentrations and lateral and vertical dispersion 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 restore ground-water quality, including identification of *in situ* chemical reactions that may hinder or enhance restoration.~~

~~(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 water quality characteristics, and any prior experience restoring ground water at the site.~~

~~(6) Adverse effects of the proposed water quality restoration operations on ground waters outside production zones.~~

~~(7) Procedures to be used for plugging, sealing, capping, and abandoning wells.~~

~~(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 input 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 reduce concentrations of, or retard, contaminants. The modeling should consider available data about the native ground-water downgradient of the production areas, the geochemical environment, hydraulic and transport properties, and the spatial variations of aquifer properties 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, 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.

(8) Assess whether plans for methods of effluent disposal, such as deep-well injection, discharge to surface water, and land application 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 may impose ground-water restoration requirements that are more stringent than the delegated federal program. 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 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 selection of 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 approach 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[5] and the associated horizontal and vertical flare.[6]

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 production 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. 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

[5] 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.

[6] 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.

~~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, 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 indicator 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 monitored 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 production 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 production zone and any affected aquifers to pre-operational (baseline) water quality conditions. Recognizing that *in situ* leach operations fundamentally alter ground-water geochemistry, restoration activities are not likely to return ground-water quality to 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 monitored water quality indicator constituents to within the baseline range of statistical variability for each constituent. 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—*In situ* leach operations may cause permanent changes in water quality within the exploited production zone, because the *in situ* leach extraction process relies on changing the chemistry in the production zone to remove the uranium. The applicant may therefore propose returning the water quality 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 restoration standards before falling back on secondary restoration 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 commit to use reasonable efforts to reach primary restoration standards.~~

~~It is acceptable to establish secondary restoration standards on a constituent-by-constituent basis, with the numerical limits established to ensure state or EPA primary or secondary drinking water standards will not be exceeded in any potential source of drinking water. 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 production 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, 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 is completed, all designated monitor wells must be sampled for all monitored constituents. Well fields may be decommissioned when all constituent concentrations meet approved restoration standards and no post-restoration degradation in ground-water quality occurs outside of the aquifer exemption boundary.~~

~~(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 production 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 production zone should not, as a result of *in situ* leach operations, exceed EPA primary or secondary drinking water standards for ground 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 proposed by the applicant 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 may 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 production 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 adjacent ground-water resources. As an example, if an applicant proposes no ground-water restoration activities within the exploited production zone, the applicant would be required to show that adequate institutional control provisions are in place to assure potential water supplies adjacent to the exploited production zone would not be accessed for a use that would harm human health or the environment. 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 that monitoring results are contrary to model predictions and ground-water restoration must be initiated.~~

~~Ground-Water Quality Restoration, Surface Reclamation, and Plant Decommissioning~~

~~(10) Onsite Evaporation~~

~~Liquid waste and solid wastes (sludge) from surface impoundments resulting from *in situ* leach operations are 11 e.(2) byproduct material. Licensees must demonstrate that surface impoundments are 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. Solid waste 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.~~

~~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.~~

~~(11) Release In Surface Waters~~

~~Process waste water resulting from *in situ* leach operations is 11e.(2) byproduct material. The U.S. Environmental Protection Agency (EPA), in accordance with 40 CFR 440.34, does not allow new ISL facilities to discharge process waste water to navigable waters. For release of this waste to surface waters, existing licensees must meet the requirements of 10 CFR 20.1302(b)(2), and should demonstrate that doses are maintained as low as is reasonably achievable (ALARA). NRC has no specific requirements for non-radiological constituents, and may adopt the appropriate State limits. Anticipated discharge must be described in enough detail to evaluate environmental impacts. Appropriate State and Federal agency permits should be obtained in accordance with 10 CFR 20.2007.~~

~~(12) Land Applications~~

~~For the land application of process waste water, the applicant must meet the regulatory provisions in 10 CFR 20.2002 and demonstrate that doses are maintained ALARA within the dose limits in 10 CFR 20.1301. Proposed land application activities should 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 ALARA. 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 10 CFR 20.2007. The applicant must also comply with NRC regulatory provisions for decommissioning. The applicant should also address whether the proposed land applications methodologies will comply with 10 CFR Part 40, Appendix A, Criterion 6(6), at the time of decommissioning.~~

~~(13) Deep-Well Injection~~

~~Proposals for disposal of liquid waste from process water by injection in deep wells must meet the regulatory provisions in 10 CFR 20.2002 and demonstrate that doses are~~

ALARA and within the dose limits in 10 CFR 20.1301. The injection facility should 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 ALARA, and within the dose limits in 10 CFR 20.1301.

In addition, pursuant to the provisions of 10 CFR 20.200, proposals for disposal by injection in deep wells should 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 EPA regulatory provisions in 40 CFR Part 146: Underground Injection Control (UIC) Program: Criteria and Standards, and applicants must obtain necessary permits from EPA and/or States authorized by EPA to enforce these provisions. In general, applications that satisfy EPA regulations under the UIC Program, which are approved by the EPA or an EPA-authorized State issuing the UIC permit and the applicable provisions of 10 CFR Part 20, will also be approved by the staff. Licensees and applicants disposing of liquid waste from process water by injection in deep wells are further required to comply with NRC regulatory provisions for decommissioning.

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 committed to adopt well field ground-water restoration standards that are representative of the pre-operational baseline ground-water conditions. As a secondary restoration goal, the applicant has identified and committed to ensure federal or state drinking water standards will not be exceeded outside of the aquifer exemption boundary as a result of operations.

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 approach that includes a 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 proposed 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 indicator 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 adopted a primary restoration program that will return the water quality of the production 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's post-restoration stability monitoring program is 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.~~

6.1.2 Post-Restoration Monitoring Exceedance of Approved Hazardous Constituent Concentration Limit and Corrective Action

The regulations in 10 CFR Part 40, Appendix A, Paragraph 14(f)(1), require that after groundwater restoration in the production unit to the approved hazardous constituent concentration limits at all ~~point of compliance~~point of compliance wells (including an ACL), the licensee is required to conduct post-restoration monitoring in the ISR production unit pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f)(1). During post-restoration monitoring, the licensee must demonstrate there has been no statistically significant exceedance of the approved hazardous constituent concentration limits during quarterly monitoring at all ~~point of compliance~~point of compliance wells in the production unit for three consecutive years. If a statistically significant exceedance of the approved hazardous constituent concentration limit is

detected in a ~~point of compliance~~point of compliance well in the production unit during post-restoration monitoring, the licensee must report it under requirements in Paragraph 10 CFR Part 40, Appendix A, Paragraph 14(f)(1) and undertake corrective action pursuant to Paragraph 14(h)(2).

6.1.2.1 *Areas of Review*

The areas of review includes whether the licensee has taken the required actions and made the required reports if the approved post-restoration monitoring program in the restored production unit has detected a statistically significant exceedance of any approved hazardous constituent concentration limit at any ~~point of compliance~~point of compliance well. The staff also reviews whether the exceedance was reported within seven days to the NRC. The areas of review also include whether the licensee took corrective action to the extent necessary to achieve compliance with the approved concentration limit for the hazardous constituent at the ~~point of compliance~~point of compliance well, and whether, once the corrective action was completed, the licensee provided a written report for NRC review and approval describing the corrective action taken, the corrective action results, and monitoring data that demonstrates that the hazardous constituent was returned to its approved concentration limit at the ~~point of compliance~~point of compliance well in the production unit. The staff also reviews the report to determine if the licensee has undertaken the appropriate corrective action as necessary to address the nature and extent of the exceedance. The staff will also determine whether the licensee has provided reasonable assurance that the corrective action for the exceedance was successful and if not, whether the staff should impose additional requirements for corrective action, operation, monitoring, or reporting, as necessary. The staff will also determine whether the licensee should restart the post-restoration monitoring at the affected ~~point of compliance~~point of compliance wells in the restored production unit by collecting quarterly samples that demonstrate no statistically significant exceedance of the approved concentration limits for any hazardous constituent for three consecutive years.

6.1.2.2 *Review Procedures*

The staff should review the reports and any corrective action taken by the license in response to a statistically significant exceedance of a hazardous constituent concentration limit during the post-restoration monitoring of the production unit in the ISR wellfield. The staff should determine:

1. If the licensee notified the NRC in writing within seven days if, during the post-restoration monitoring period, the collected samples show that concentrations of any of the monitored hazardous constituent at a ~~point of compliance~~point of compliance well has shown a statistically significant exceedance of its approved limit.
2. If the licensee took corrective action in a timely fashion and to the extent necessary to achieve compliance with the approved concentration limits for all hazardous constituents.
3. Once corrective action was completed such that the hazardous constituent concentration level at the ~~point of compliance~~point of compliance well met its approved concentration limit, the licensee provided a written report for NRC approval describing the corrective action taken, the corrective action results, and monitoring data that demonstrates that the hazardous constituents meet their approved concentration limits at the affected ~~point of compliance~~point of compliance wells in the production unit.

4. If the licensee has not provided reasonable assurance that the corrective action for the exceedance was successful, the staff will consider additional requirements for corrective action, operation, monitoring, or reporting, as necessary.
5. If the licensee has not provided reasonable assurance that the corrective action for the exceedance was successful, the staff will consider requiring the licensee to restart the post-restoration monitoring at the affected ~~point of compliance~~point of compliance wells in the restored production unit by collecting quarterly samples which demonstrate no statistically significant exceedance of the approved concentration limits for any hazardous constituent for three consecutive years.

6.1.2.3 *Acceptance Criteria*

The staff will find the post-restoration monitoring that detects a statistically significant exceedance and any associated corrective action acceptable if the licensee provides information that meets the following acceptance criteria:

1. If the licensee conducted post-restoration monitoring following the approved wellfield restoration plan and detected a statistically significant exceedance of an approved hazardous constituent concentration limit using:
    a. Listed statistical tests for detection and compliance monitoring in 40 CFR 264.97(h)(1)-(4).
    b. Another statistical test method from the EPA statistical guidance "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance," (EPA, 2009) as approved by the NRC.
2. The licensee notified the NRC in writing within seven days that there was a statistically significant exceedance at a ~~point of compliance~~point of compliance well and provided:
    a. The location of the ~~point of compliance~~point of compliance well in the production unit and the name of the hazardous constituent that showed the exceedance.
    b. The concentration level of all hazardous constituents that triggered the exceedance and the concentration of all other identified hazardous constituents and any other available indicator constituent (e.g., chloride, etc.) concentration levels at the ~~point of compliance~~point of compliance well.
    c. The statistical analysis that shows the exceedance was statistically significant.
3. The licensee took corrective action in a timely fashion and to the extent necessary to achieve compliance with the approved concentration limit for the hazardous constituent at the ~~point of compliance~~point of compliance well and provided a written report for NRC approval describing:
    a. The corrective action taken to address the nature and extent of the exceedance including:
        i. The treatment method and process used.
        ii. The ~~time period~~duration of the treatment and the pore volumes treated.
    b. The corrective action results and monitoring data that demonstrates with reasonable assurance that the hazardous constituent met its approved concentration limit at the ~~point of compliance~~point of compliance well in the production unit.
4. If the licensee has not provided reasonable assurance that the corrective action for the exceedance was successful, the staff will consider imposing additional requirements for corrective action, operation, monitoring, or reporting, as necessary, and may require the licensee to restart the post-restoration monitoring at the affected ~~point of~~

~~compliance~~point of compliance wells in the restored production unit considering but not limited to:

a. The time within the three-year post-monitoring period when the exceedance of the hazardous constituent limit occurred.
b. The number and location of wells associated with the exceedance of the hazardous constituent limit.
c. Other mitigating factors including geochemical (e.g. oxidation and reduction) conditions at the ~~point of compliance~~point of compliance well where the hazardous constituent exceedance occurred, the presence of a downward trend or no trend in the hazardous constituent prior to the exceedance, etc.
d. The relative size of the exceedance in terms of expected variance of the hazardous constituent distribution after corrective action.

6.1.2.4 *Evaluation Findings*

If the staff review, as described in this section, concludes that the licensee has made the required reports and taken the required corrective action if the approved post-restoration monitoring program has detected a statistically significant exceedance of any approved hazardous constituent concentration limits at any ~~point of compliance~~point of compliance well in the restored production unit, the following conclusions may be presented in the safety evaluation report on the corrective action report.

NRC has completed its review of the corrective action report for the statistically significant exceedance detected in the production unit during post-restoration monitoring in the ISR wellfield at the _____ in situ recovery facility. This review included the required reporting for the exceedance and the correction action that was taken using the review procedures in standard review plan Section 6.1.2.2 and the acceptance criteria outlined in standard review plan Section 6.1.2.3.

The staff concludes that the licensee has made the required reports and taken the required corrective action in response to the detection of a statistically significant exceedance of the approved hazardous constituent concentration limit at a ~~point of compliance~~point of compliance well in the restored production unit during the approved post-restoration monitoring program pursuant to the requirements in 10 CFR Part 40, Appendix A, Paragraphs 14(f)(1) and 14(h)(2). Specifically, during post-restoration monitoring, the licensee appropriately detected a statistically significant exceedance of an approved hazardous constituent concentration limit at a ~~point of compliance~~point of compliance well using an acceptable statistical analysis. The exceedance was reported within 7 days to the NRC. The licensee took corrective action to the extent necessary to achieve compliance with the approved hazardous constituent concentration limit at the ~~point of compliance~~point of compliance well. Once the corrective action was completed, the licensee provided a written report for NRC review and approval describing the corrective action taken, the corrective action results, and monitoring data that demonstrates that the hazardous constituent met its approved concentration limits at the ~~point of compliance~~point of compliance well in the production unit.

Based on the information provided by the licensee to report a statistically significant exceedance of a hazardous constituent limit during post-restoration monitoring in the production unit and take corrective action in the ISR wellfield at the _____ *in situ* recovery facility, the staff concludes that the licensee has demonstrated compliance with 10 CFR Part 40, Appendix A,

Paragraph 14(f)(1), that requires the licensee to conduct post-restoration monitoring and 10 CFR Part 40, Appendix A, Paragraph 14(h)(2), that requires the licensee to take corrective action.

6.1.3 Wellfield Restoration Report

The regulations in 10 CFR Part 40, Appendix A, Paragraph 14(f)(2), require the licensee to provide a wellfield restoration report to demonstrate that the wellfield restoration has successfully met the required regulations in Criterion 14(f) and Paragraph 14(f)(1).

6.1.3.1 *Areas of Review*

Following completion of the post-restoration monitoring program for the production unit in the ISR wellfield, the licensee submits a wellfield restoration report for NRC review and approval. The wellfield restoration report describes the wellfield restoration and results, including compliance with the NRC approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5) and the post-restoration monitoring data demonstrating no statistically significant exceedance of the approved concentration limits at all ~~point of compliance~~point of compliance wells in the production unit for three consecutive years. The staff reviews if the licensee has provided the necessary information for the staff to determine when the licensee has completed wellfield restoration based on data from the performance assessment groundwater monitoring program and post-restoration monitoring. The staff also determines if the restoration has been undertaken to achieve the lowest possible concentration level of each hazardous constituent in the production unit. The areas of review also include how groundwater monitoring data at ~~point of compliance~~point of compliance wells in the production unit were used by the licensee to assess the spatial and temporal concentration levels of hazardous constituents to demonstrate the success of each groundwater restoration method in the ISR wellfield. The staff will review the evidence provided by the license to determine if the approved hazardous constituent concentration levels have been met at the end of restoration, the licensee acceptably conducted post-restoration monitoring, and has demonstrated the hazardous constituent concentration levels at the ~~point of compliance~~point of compliance wells in the production unit have not shown a statistically significant exceedance for three consecutive years.

6.1.3.2 *Review Procedures*

The staff should review if the wellfield restoration report to determine if restoration of the production unit was conducted by licensee following the approved wellfield restoration plan required by 10 CFR Part 40, Appendix A, Paragraph 14(b)(5) and has met the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5), in the production unit in the ISR wellfield. The staff should review if the wellfield restoration has been implemented in accordance with the wellfield restoration plan, has demonstrated compliance with the approved hazardous constituent concentration limits based on performance monitoring program and other information that demonstrate that the restoration was applied to meet the hazardous constituent concentration levels for hazardous constituents at the points of compliance in the production unit. The staff should review how the groundwater monitoring data was applied to demonstrate the success of each groundwater restoration method in the ISR wellfield. The staff should review how groundwater monitoring data at ~~point of compliance~~point of compliance wells in the production unit was used to assess the spatial and temporal reduction in the hazardous constituent concentration level in the production unit. The staff

should determine if the licensee acceptably conducted post-restoration monitoring and has demonstrated the hazardous constituent concentration levels at the ~~point of compliance~~point of compliance wells in in the production unit have not shown a statistically significant exceedance of the approved limits for three consecutive years.

6.1.3.3 *Acceptance Criteria*

The staff should review the wellfield restoration report to determine if it meets the acceptance criteria listed below. Specifically, the reviewer should find that:

1. The licensee has demonstrated that the approved wellfield restoration plan has been applied have applied to the extent practicable in the production unit by providing:
    a. A description of the application of each proposed restoration method and its effect on the concentration level of each hazardous constituent in the production unit during restoration including:
        i. A description of the application of each groundwater restoration method in the production unit that includes:
            1. The physical, chemical, and biological treatment process and implementation;
            2. The pore volumes treated;
            3. The length of time each restoration method was applied;
            4. Any variation in the restoration method to improve performance.
        ii. Contour plots that show the spatial distribution of the hazardous constituent concentration levels in the production unit during the restoration.
        iii. Time series plots that show the reduction in hazardous constituent concentration levels in the production unit during the restoration.
        iv. A demonstration of asymptotic behavior in the hazardous constituent concentration levels at all ~~point of compliance~~point of compliance wells at the end of restoration.
2. The licensee has demonstrated the post-restoration monitoring program and other information provided by the licensee demonstrates that the hazardous constituent concentration levels have met, and not shown a statistically significant exceedance of, the approved limits at the ~~point of compliance~~point of compliance wells in the restored production unit for three consecutive years by providing:
    a. The quarterly monitoring data for all hazardous constituents at all ~~point of compliance~~point of compliance wells that demonstrates no statistically significant exceedance using acceptable statistical tests for exceedance detection including:
        i. Descriptive spatial and temporal plots (e.g., contour and time series) of the quarterly monitoring data for each hazardous constituent concentration at each ~~point of compliance~~point of compliance well.
        ii. Evidence from statistical tests as listed in 40 CFR 264.97(h)(1)-(4) or other statistical tests approved by NRC that show no statistically significant exceedance in the three years of quarterly monitoring data for any hazardous constituent at any ~~point of compliance~~point of compliance well.
        iii. Any additional technical analysis to support that the hazardous constituent concentration levels of hazardous constituents, such as groundwater flow and contaminant transport modeling that shows

hazardous constituent concentration levels have met, and will continue to meet, approved limits at points of compliance (See acceptance criteria 8 and 9 for groundwater flow and contaminant transport modeling in Section 6.1.1.3)

6.1.3.4 *Evaluation Findings*

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

NRC has completed its review of the wellfield restoration report for groundwater restoration of the production unit in the ISR wellfield at the *in situ* recovery facility. This review included an evaluation of the methods that will be used in wellfield restoration plan and using the review procedures in standard review plan Section 6.1.3.2 and the acceptance criteria outlined in standard review plan Section 6.1.3.3.

The staff concludes that the licensee has provided an acceptable wellfield restoration report that is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(f)(2), that requires the licensee to provide a wellfield restoration report to demonstrate that the wellfield restoration has successfully met Paragraphs 14(f) and 14(f)(1). The licensee has completed restoration of the production unit following the approved wellfield restoration plan required by 10 CFR Part 40, Appendix A, Paragraph 14(b)(5), and has met the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraph 5B(5), in the production unit in the ISR wellfield. The licensee has implemented the wellfield restoration in accordance with the wellfield restoration plan, has demonstrated compliance with the approved hazardous constituent concentration limits based on the performance monitoring program and other information that demonstrate that the restoration was applied to meet the hazardous constituent concentration levels for hazardous constituents at the points of compliance in the production unit. The licensee has provided groundwater monitoring data and other information as needed to demonstrate the success of each groundwater restoration method in the production unit to meet the approved hazardous concentration limits at all ~~point of compliance~~point of compliance wells. The licensee has acceptably conducted post-restoration monitoring and has demonstrated the hazardous constituent concentration levels at the ~~point of compliance~~point of compliance wells in in the production unit have not shown a statistically significant exceedance of the approved limits for three consecutive years.

Based on the information provided by the licensee and the detailed review conducted of the wellfield restoration report for groundwater restoration of the production unit in the ISR wellfield at the *in situ* recovery facility, the staff concludes that the wellfield restoration report is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Paragraph 14(f)(2), that requires the licensee to provide a wellfield restoration report to demonstrate that the wellfield restoration has successfully met the required regulations in Paragraphs 14(f) and 14(f)(1).

6.1.4 References

Uranium Mill Tailings Radiation Control Act of 1978, as amended, Pub. L. 95-604, 92 Stat. 3021.

Atomic Energy Act of 1954, as amended, Pub. L. 83-703, 68 Stat. 919.

~~Ground-water Quality~~Groundwater Restoration, Surface Reclamation, and Plant Decommissioning

Code of Federal Regulations (CFR) *Title 40*, *Protection of the Environment*, Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings."

Code of Federal Regulations (CFR) *Title 40*, *Protection of the Environment*, Part 144, "Underground Injection Control Program."

Code of Federal Regulations (CFR) *Title 40*, *Protection of the Environment*, Part 440, "Ore Mining And Dressing Point Source Category, Subpart C, Uranium, Radium and Vanadium Ores Subcategory."

Environmental Protection Agency (EPA), "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance," EPA-530-R-09-007, 2009

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 recovery facilities. 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
(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~~point of compliance.	2.11.4, 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 constituents at the ~~point of compliance~~point of compliance do not exceed the background concentration, the value in Paragraph 5C, or an approved alternate concentration limit.	2.11.4, 3.1.4, 5.7.8.4, 6.1.1.4, 6.1.3.4 3.1.4
(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.	

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.	
(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.
(6) Cleanup residual contamination from byproduct material consistent with the radium benchmark dose.	4.2.4, 6.2.4, 6.4.4
(7) Prevent threats to human health and the environment from non-radiological hazards.	2.11.4, 6.2.4
Criterion 6A: Ensure expeditious completion of the final radon barrier.	Not applicable.
(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.	
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	5.7.8.4, 5.7.9.4

	with a corrective action program.	
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.	Partially applicable: 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.	Not applicable
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 or~~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 constituents reasonably expected to be in or derived from byproduct materials and detected in ground water.	3.1.4

Criterion 14(a): Site characterization and suitability demonstration	2.1.4, 2.2.4, 2.6.4, 2.7.4
Criterion 14(b): Wellfield pre-operational requirements	2.11.4, 5.7.8.4, 6.1.1.4, 6.1.3.4
Criterion 14(c): Well design and construction requirements	3.1.4
Criterion 14(d): Operating, monitoring, and reporting requirements	3.1.4, 5.2.4, 5.7.4, 5.7.8
Criterion 14(e): Mechanical integrity	3.1.4
Criterion 14(f): Wellfield restoration	6.1.4
Criterion 14(g): Plugging and Abandonment	3.1.4
Criterion 14(h): Corrective Action	5.7.8.4, 6.1.2.4

APPENDIX F
ALTERNATE CONCENTRATION LIMITS

The regulations in 10 CFR Part 40, Appendix A, Paragraph 5B(5) specify the hazardous constituent concentration limits that must be met at ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in an ISR wellfield. Specifically, these regulations state:

5B(5)—At the ~~point of compliance~~point of compliance, the concentration of a hazardous constituent must not exceed—

(a) The Commission approved background concentration of that constituent in the ground water;

(b) The maximum contaminant level for that constituent as set forth in paragraph 5C, provided that the background level is below the value listed; or

(c) An alternate concentration limit established by the Commission.

The licensee is required to provide the background hazardous constituent concentration levels that are used to establish the approved limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b) at ~~point of compliance~~point of compliance wells in accordance with Criterion 14(b). Specifically, the licensee is required to meet 10 CFR Part 40, Appendix A, Paragraphs 14(b)(2) and 14(b)(3) prior to operation of the ISR wellfield, which require the licensee to identify the hazardous constituents, select ~~point of compliance~~point of compliance wells, measure and evaluate background hazardous constituent concentration levels and propose background hazardous constituent concentration levels in the production unit and in immediately overlying, underlying, and adjacent aquifers to the production unit in an ISR wellfield. The licensee is required to provide this information ~~to~~ so the NRC ~~so it~~ can establish the hazardous constituent concentration limits at ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit pursuant to 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b).

Following completion of uranium recovery operations, the licensee must restore the hazardous constituent concentration levels in the production unit pursuant to Criterion 14(f). The licensee must conduct groundwater restoration, using the approved wellfield restoration plan required in 10 CFR Part 40, Appendix A, Paragraph 14(b)(5), to achieve and maintain compliance with the approved hazardous constituent concentration limits at all ~~point of compliance~~point of compliance wells in the production unit in the ISR wellfield. If the licensee determines that the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b) cannot be practically achieved for a specific hazardous constituent after performing restoration according to the approved wellfield restoration plan, the licensee may propose an alternate concentration limit (ACL) under Paragraph 5B(5)(c) for that hazardous constituent pursuant to Paragraph 5B(6), which states:

5B(6)—Conceptually, background concentrations pose no incremental hazards and the drinking water limits in paragraph 5C state acceptable hazards but these two options may not be practically achievable at a specific site. Alternate concentration limits that present no significant hazard may be proposed by licensees for Commission consideration. Licensees must provide the basis for any proposed limits including consideration of practicable corrective actions, that limits are as low as reasonably achievable, and information on the factors the Commission must consider. The Commission will establish a site specific alternate concentration limit for a hazardous constituent as provided in paragraph 5B(5) of this criterion if it finds that the

proposed limit is as low as reasonably achievable, after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded.

In addition, Paragraph 5B(6)(a) lists nine factors related to potential adverse effects on groundwater quality that must be considered by the Commission to make the finding that a hazardous constituent will not pose a present and potential hazard as long as the ACL is not exceeded. These factors are:

(i) The physical and chemical characteristics of the waste in the licensed site including its potential for migration;
(ii) The hydrogeological characteristics of the facility and surrounding land;
(iii) The quantity of ground water and the direction of groundwater flow;
(iv) The proximity and withdrawal rates of groundwater users;
(v) The current and future uses of ground water in the area;
(vi) The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality;
(vii) The potential for health risks caused by human exposure to waste constituents;
(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;
(ix) The persistence and permanence of the potential adverse effects.

Furthermore, 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b) also sets out ten factors related to potential adverse effects on hydraulically-connected surface water quality that must be considered by the Commission to make the finding that a hazardous constituent will not pose a present and potential hazard as long as the ACL is not exceeded. These factors are:

(i) The volume and physical and chemical characteristics of the waste in the licensed site;
(ii) The hydrogeological characteristics of the facility and surrounding land;
(ii) The quantity and quality of ground water, and the direction of ground-water flow;
(iv) The patterns of rainfall in the region;
(v) The proximity of the licensed site to surface waters;
(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;
(vii) The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality;
(viii) The potential for health risks caused by human exposure to waste constituents;
(iv) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and
(x) The persistence and permanence of the potential adverse effects.

For the Commission to establish an ACL for a hazardous constituent in the production unit, ~~T~~the licensee must provide site-specific information for Commission review, addressing each of the above factors, to demonstrate that the proposed ACL for the hazardous constituent poses no substantial present or potential hazard. These factors can only be addressed for the groundwater and surface water on a site-specific basis after restoration is completed. For this reason, the licensee cannot provide this information prior to operations in the production unit in an ISR wellfield.

An ACL is a risk-informed hazardous constituent concentration limit that may be established in the production unit if restoration of groundwater using the approved wellfield restoration plan

required in 10 CFR Part 40, Appendix A, Paragraph 14(b)(5) does not result in achieving the hazardous constituent concentration limits in 5B(5)(a) and (b). This appendix provides guidance on how the staff should review a licensee's application for a proposed ACL. Appendix F Sections F.1 and F.2 address the staff's review of whether the proposed ACL meets the requirements in 10 CFR Part 40, Appendix A, Paragraph 5B(6). Appendix F Sections F.3 and F.4, address how staff should review the information provided by the licensee to address the required factors listed in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a) and (b), respectively, to evaluate the present and potential hazard from adverse effects on groundwater and hydraulically-connected surface water.

After the staff completes its review of the information addressed in Appendix F, Sections F.1 through F.4., the staff may make the overall finding presented in Appendix F, Section F.5, that the licensee's proposed ACL is as low as reasonably achievable, that the licensee has considered practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the proposed ACL is not exceeded.

F.1 Technical Basis for Proposing an Alternate Concentration Limit for a Hazardous Constituent

If a licensee determines that the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b) cannot be practically achieved for a specific hazardous constituent in the production unit after performing restoration according to the approved wellfield restoration plan, the licensee may propose an ACL for that hazardous constituent under Paragraph 5B(5)(c).

This section provides guidance on how the staff should review the information provided by the licensee for the proposed ACL for a hazardous constituent to demonstrate that the licensee implemented the approved wellfield restoration plan and was not able to practically achieve the approved hazardous constituent concentration limit in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or 5B(5)(b).

F.1.1 Areas of Review

The areas of review include the technical bases provided by the licensee for the proposed ACL that demonstrate the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b), could not be practically achieved in ~~point of compliance~~point of compliance wells in the production unit. The staff will first evaluate the information provided by the licensee to demonstrate that the restoration methods in the approved wellfield restoration plan pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(b)(5), were applied but were unable to meet the approved hazardous constituent concentration limits. The staff will then review the information provided by the licensee demonstrating that the licensee's wellfield restoration efforts achieved the lowest possible level for the concentration of the hazardous constituent at ~~point of compliance~~point of compliance wells in the production unit after implementing each restoration method in the approved wellfield restoration plan.

The areas of review also include the licensee's technical bases for assigning the proposed ACL for a hazardous constituent at each ~~point of compliance~~point of compliance well. Specifically, the staff reviews the technical bases used to justify the numerical value of each proposed ACL compared with the final field measured values, and any associated statistical evaluation~~,~~ or

analytical or numerical modeling used to support the proposed ACL. The staff also reviews the methods used to assign the proposed ACL to the ~~point of compliance~~point of compliance wells, whether on a well-by-well basis or as a single value for all wells or groups of wells.

F.1.1.1 *Review Procedures*

The staff should use the following review procedures to determine if the licensee has demonstrated the basis for proposing an ACL after its restoration efforts could not practically achieve the hazardous constituent concentration limits in 5B(5)(a) or (b) compliance with 10 CFR Part 40, Appendix A, Criterion 5B(6) for the proposed ACL for a hazardous constituent in the production unit in the ISR wellfield:

1. Verify that the licensee demonstrated that it applied each restoration method in accordance with the approved wellfield restoration plan and could not practically achieve the approved hazardous constituent concentration limit in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) and (b).
2. Verify that the licensee has proposed the lowest concentration level for the ACL for a hazardous constituent in the production unit in the ISR wellfield based on the field measured values at ~~point of compliance~~point of compliance wells at the end of restoration.
3. Verify that the licensee has provided a satisfactory technical basis for assigning the proposed ACL to all ~~point of compliance~~point of compliance wells in the production unit using acceptable statistical methods or analytical or numerical groundwater flow and contaminant modeling.

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F.1.1.2 *Acceptance Criteria*

The description and consideration of the basis for proposing an ACL is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has demonstrated that it applied each restoration method in the approved groundwater restoration plan and found that it could not practically achieve the approved concentration limit for the hazardous constituent in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) and (b) by providing:
    a. A description of the application of each restoration method and its effect on the concentration level of the hazardous constituent in the production unit including:
        i. The number of aquifer pore volumes that were used for each restoration method based on field-measured restoration flow rates.
        ii. Time series data showing concentration levels of the hazardous constituent or other surrogate constituents at ~~point of compliance~~point of compliance wells during application of each restoration method.
        iii. Evidence of asymptotic behavior in the concentration levels of the hazardous constituent or surrogate constituents at each ~~point of compliance~~point of compliance well at the end of restoration.
    b. An assessment of each restoration method that demonstrates that the restoration methods in the approved wellfield restoration plan could not practically achieve the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) and (b) including:
        i. An explanation of the reason(s) why the chemical, physical or biological treatment processes used in the restoration method in the approved

wellfield restoration plan did not have the predicted outcome of reducing the concentration of the hazardous constituent to the level expected.

ii. An explanation of the reason(s) why continued efforts using the approved restoration methods would not provide sufficient reductions in the concentration level of the hazardous constituent to achieve the approved concentration limit for the constituent.

2. The licensee has demonstrated that it has selected the lowest concentration level for the proposed ACL for a hazardous constituent at all ~~point of compliance~~point of compliance wells by providing:
   a. The spatial distribution of the concentration of the hazardous constituent in the production unit at the end of restoration derived from field measured values at all ~~point of compliance~~point of compliance wells.
   b. The temporal behavior (e.g. time series) of the concentration of the hazardous constituent in each ~~point of compliance~~point of compliance well during restoration that supports the selected concentration level for the proposed ACL.
3. The licensee has provided the technical basis for assigning the proposed ACL to all ~~point of compliance~~point of compliance wells in the production unit using widely-accepted statistical methods or groundwater flow and transport modeling.
   a. The licensee has assigned the proposed ACL to the ~~point of compliance~~point of compliance wells using acceptable statistical methods provided in Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Unified Guidance (EPA, 2009) or other acceptable statistical guidance.
   b. Any groundwater flow and contaminant transport modeling used to assign the proposed ACL for the hazardous constituent was conducted using available site field data and accepted groundwater flow and contaminant transport modeling techniques (see SRP Sections 6.1.1.2 and 6.1.1.3).

F.1.1.3 *Evaluation Findings*

If the staff review results in the acceptance of the basis for the proposed ACL, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate its basis for the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F Section F.1.2 and the acceptance criteria outlined in standard review plan Appendix F Section F.1.3.

The licensee has demonstrated that it implemented each restoration method in the approved wellfield restoration plan and could not practically achieve the approved hazardous constituent concentration limit in 10 CFR Part 40, Appendix A, Paragraphs 5B5(a) and (b). The licensee has proposed the concentration level for the ACL for [INSERT NAME OF CONSTITUENT] in the production unit in the ISR wellfield based on the field-measured values at ~~point of compliance~~point of compliance wells at the end of restoration. The licensee has provided a satisfactory technical basis for assigning the proposed ACL to all ~~point of compliance~~point of compliance wells in the production unit using acceptable statistical methods or analytical or numerical groundwater flow and contaminant modeling.

Based on the information provided in the application and the detailed review of the basis for the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the

in situ recovery facility, the staff concludes the basis for the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6).

F.1.1.4 *References*

EPA (United States Environmental Protection Agency). 2009. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Unified Guidance. Washington, DC: EPA. EPA 530/R-09-007.

F.2 Proposed Alternate Concentration Limits are As Low As Reasonably Achievable

A licensee may propose an ACL for a hazardous constituent after groundwater restoration in a production unit in an ISR wellfield pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f), if it can demonstrate that the ACL presents no significant hazard pursuant to Paragraph 5B(6). For each proposed ACL for a hazardous constituent, the licensee "*must provide the basis for any proposed limits including consideration of practicable corrective actions, that limits are as low as reasonably achievable, and information on the factors the Commission must consider.*" Therefore, the licensee must first demonstrate the basis for the proposed ACL as described in Appendix F, Section F.1. Next, the licensee must show that the proposed ACL for the hazardous constituent, is "as low as reasonably achievable, after considering practicable corrective actions." For a proposed ACL to be found "as low as is reasonably achievable," for a hazardous constituent, the licensee must provide a separate evaluation that considers: (1) the implementation of any additional or alternative corrective actions to achieve the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b); and (2) the cost and benefits of implementing the additional or alternative corrective actions.

This section provides guidance on how the staff should review the information provided by the licensee to demonstrate that the proposed ACL is as low as reasonably achievable (ALARA) for a hazardous constituent in the production unit in an ISR wellfield pursuant to 10 CFR Part 40, Appendix A, Paragraph 5B(6).

F.2.1 Areas of Review

The areas of review include the licensee's technical bases for concluding that the hazardous constituent concentration level for the proposed ACL is ALARA after restoration of the production unit in the ISR wellfield. The staff reviews the licensee's consideration of any additional or alternative corrective actions that could be used to reduce the proposed ACL for the hazardous constituent in the production unit. Specifically, the staff reviews other practicable corrective actions identified by the licensee that could be used in the production unit to attempt to reduce the proposed ACL further to approach or reach the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b). The staff also reviews whether the licensee conducted a comprehensive evaluation of costs and benefits of any additional or alternative corrective actions.

F.2.2 Review Procedures

Staff should use the following review procedures to determine if the licensee has demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 5B(6) for the proposed ACL for a hazardous constituent in the production unit in the ISR wellfield:

1. Verify the licensee has provided a complete range of practicable corrective action alternatives for achieving compliance with the approved hazardous constituent concentration levels under 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b).
2. Verify the licensee has provided the costs and direct and indirect benefits associated with implementing corrective action alternatives to achieve the approved hazardous constituent limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b).
3. Verify the licensee has appropriately made the ALARA finding based on the evaluation of the corrective action alternatives and cost and benefits.

F.2.3 Acceptance Criteria

The description and evaluation of a proposed ACL for a hazardous constituent in the production unit as ALARA is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided an evaluation of practicable corrective action alternatives for achieving compliance with the approved hazardous constituent concentration levels under 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b) including:
    a. The licensee has comprehensively described and assessed the potential applicability of the corrective action alternatives including:
        i. A description of all corrective action alternatives, both passive and active, or any appropriate sequential combination of alternatives that contains sufficient detail to verify the technical feasibility of each corrective action, including the suitability of a corrective action based on the technical and engineering information needed to design and implement a particular measure in the production unit.
        ii. A description of all corrective action alternatives that is sufficient for completing the cost and benefit analysis for implementing a particular corrective action.
    b. The licensee has provided the site-specific operational and monitoring data that can be used to predict the effectiveness of any additional corrective actions including:
        i. Information from literature sources or documented results from other ISR recovery or similar groundwater remediation sites for those corrective actions that have not been implemented at the site but appear to be practicable.
        ii. Projections of the hazardous constituent concentration levels that each corrective action would likely produce at the ~~point of compliance~~point of compliance wells in the production unit as the actions are applied.

2. The licensee has provided the costs and direct and indirect benefits associated with implementing corrective action alternatives to achieve the approved hazardous constituent concentration limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b) including:
    a. The capital costs to design and construct the alternatives.
    b. The operation and maintenance costs.
    c. The licensee has determined the direct and indirect benefits of implementing further corrective actions by providing:
        i. Estimates of the value of the current and projected groundwater resource if the approved hazardous constituent concentration limits were met

based on the cost of a domestic or municipal drinking water supply or the cost of water supplied from an alternate source, including the water yields; costs for developing alternate water supply sources; and legal, statutory, or other administrative constraints on the use and development of the water resources.

ii. Estimates of the indirect benefits by assessing the avoidance of the establishment of an ACL, including the prevention of land value depreciation, institutional controls to prevent access, etc.

iii. Any other qualitative factors that could affect the cost and benefits analysis, such as environmental degradation or enhancement.

3. The licensee has completed the ALARA evaluation of the corrective action alternatives and cost and benefits for the proposed ACL for a hazardous constituent and concluded the proposed ACL is ALARA based on the following findings:

a. If the proposed ACL is for a radiological constituent:

i. It is technically infeasible or unreasonable to undertake additional corrective action for the reduction in hazardous constituent concentration level below the proposed ACL.

ii. The comparison of the costs to achieve the target concentrations lower than the proposed ACL are far in excess of the value of the resource and the benefits associated with performing the corrective action alternative.

iii. The "dollar per person-rem avoided" cost analysis for the proposed ACL exceeds the dollar per person-rem conversion factor of $2,000 (NRC 1995).[7]

iv. The alternative corrective actions to reduce radiation risks from a radiological hazardous constituent could result in a significantly larger risk from non-radiological constituents (NRC Regulatory Guide 8.8, Revision 3 (1978)).

b. If the proposed ACL is for a non-radiological constituent:

i. It is technically infeasible or unreasonable to undertake additional corrective actions for the reduction in hazardous constituent concentration level below the proposed ACL.

ii. The comparison of the costs to achieve the target concentrations lower than the proposed ACL are far in excess of the value of the resource and the benefits associated with performing the corrective action alternatives.

F.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the licensee's demonstration that the proposed ACL for the hazardous constituent in the production unit is ALARA, the following conclusions may be presented in the technical evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit is ALARA at the _____ *in situ* recovery facility. This review included an evaluation using the review

[7] The staff is evaluating whether this value should increase based on changes in both the value of a statistical life and the cancer mortality risk coefficient, as described in SECY-17-0017 (NRC, 2017).

procedures in standard review plan Appendix F, Section F.2.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.2.3.

The licensee has established, considering practicable corrective action alternatives and their costs and benefits, that the proposed ACL for [INSERT NAME OF CONSTITUENT] is ALARA pursuant to 10 CFR Part 40, Appendix A, Paragraph 5B(6). The licensee has provided a complete range of practicable corrective action alternatives for achieving compliance with the approved hazardous constituent concentration levels under 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or (b). The licensee has provided the costs and direct and indirect benefits associated with implementing corrective action alternatives to achieve the approved hazardous constituent limits in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a) or 5B(5)(b). The licensee has appropriately made the ALARA finding based on the evaluation of the corrective action alternatives and cost/benefits.

Based on the information provided in the application and the detailed review conducted of the demonstration that the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit is ALARA at the *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6).

F.2.5 References

NRC. "Proposed Revision to NUREG-1530 - Reassessment of NRCs Dollar Per Person-Rem Conversion Factor Policy." SECY-17-0017. Washington, DC: NRC, 2017.

NRC. NUREG-1530, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy." Washington, DC: NRC, 1995.

NRC. Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," Revision 3. 1978.

F.3 Present or Potential Hazard to Groundwater

A licensee may propose an ACL for a hazardous constituent after groundwater restoration in a production unit in an ISR wellfield pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f). These regulations state that a proposed ACL may be established for a hazardous constituent if it will not pose a substantial present or potential hazard to human health or the environment as long as the ACL is not exceeded. Furthermore, Paragraph 5B(6)(a), which states that the Commission will consider potential adverse effects on groundwater quality in its present and potential hazard review, lists nine factors the Commission will consider in its review.

For the staff to make this present or potential hazard finding for groundwater, the licensee must provide an evaluation of the factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a). For ISRs, the factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a) are used to assess the risk of the potential or present hazard to groundwater from the proposed ACL for the hazardous constituent in the production unit in the ISR wellfield. These factors can only be addressed to assess the risk to groundwater on a site-~~specific specific~~ basis after the approved wellfield restoration plan pursuant to 14(b)(5) is implemented to achieve the approved hazardous constituent concentration limits in the production unit in the ISR wellfield. This section provides guidance on how the staff should review the information provided by the licensee for the proposed ACL for a hazardous constituent to address all of the listed factors in

5B(6)(a) that the staff must consider to make a finding on the present or potential hazard to groundwater from the hazardous constituent at the proposed ACL. Specifically, Appendix F, Section F.3 provides guidance for the staff review of the information needed to evaluate the present and potential hazard by addressing the factors that may contribute to an adverse effect on groundwater quality if the proposed ACL was established. The staff should review and may establish an ACL for the hazardous constituent based on its independent evaluation of the licensee's assessment of this present and potential hazard to groundwater.

F.3.1 The physical and chemical characteristics of the waste in the licensed site including its potential for migration

The first factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(i) is the physical and chemical characteristics of the waste in the licensed site including its potential for migration. For an ISR wellfield, "waste in the licensed site" is the hazardous constituent at the proposed ACL in the production unit at the end of restoration. Therefore, to address this factor, the licensee will evaluate the physical and chemical characteristics of the hazardous constituent at the proposed ACL in the production unit. In addition, the licensee must address the potential for migration of the hazardous constituent at the proposed ACL from the production unit based on these physical and chemical characteristics. This physical and chemical characterization is required to support a risk assessment of the potential migration of the hazardous constituent at the proposed ACL in the production unit through groundwater to potential points of exposure to human or other receptors as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.1.1 *Areas of review*

The area of review in this section is information on the chemical and physical characteristics of the hazardous constituent at the proposed ACL in the production unit. This includes the chemical and physical parameters that describe the expected state and behavior of the hazardous constituent at the proposed ACL at the ~~point of compliance~~point of compliance wells and the supporting technical basis. The area of review also includes: information describing the potential migration behavior of the hazardous constituent based on its chemical and physical characteristics at the proposed ACL under the prevailing and anticipated conditions; and any analytical or numerical model of groundwater flow and contaminant transport or geochemical modeling presented by the licensee to determine the ACL's potential for health risks caused by human exposure as described in Appendix F, Section F.3.7 for the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii).

F.3.1.2 *Review procedures*

The staff should review the licensee's evaluation of the physical and chemical characteristics of the hazardous constituent at the proposed ACL at all ~~point of compliance~~point of compliance wells in the production unit and in immediately overlying, underlying, and adjacent aquifers to the production unit. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee has provided the chemical and physical characteristics of the hazardous constituent at the proposed ACL under the field conditions at all ~~point of compliance~~point of compliance wells in the production unit.
2. Verify the licensee has provided sufficient field-based evidence to support the description of the chemical and physical characteristics of the hazardous constituent at

the proposed ACL as a function of the prevailing and anticipated conditions in the production unit.

3. Verify that the licensee has described the parameters that will affect the potential migration of the hazardous constituent at the proposed ACL based on its chemical and physical characteristics under the prevailing and anticipated groundwater flow and geochemical conditions in the production unit.
4. Verify that the licensee has provided and justified the values of the parameters needed for the licensee to conduct a migration evaluation of the hazardous constituent at the proposed ACL using analytical evaluation or numerical groundwater flow and contaminant transport modeling.

F.3.1.3 *Acceptance criteria*

The licensee's evaluation of the physical and chemical characteristics and potential for migration of the hazardous constituent at the proposed ACL at ~~point of compliance~~point of compliance wells in the ISR production unit in an ISR wellfield as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(i) is acceptable if it meets the acceptance criteria listed below:

1. The licensee has evaluated the chemical and physical characteristics of the hazardous constituent at the proposed ACL under the field conditions at ~~point of compliance~~point of compliance wells in the production unit in an ISR wellfield by providing:
    a. Characterization of the chemical and physical properties within the production unit setting, including:
        i. Chemical characteristics of the groundwater within the production unit that are described by measurements or appropriate estimates of pH, temperature, redox potential, buffering capacity, and the concentrations of major anions/cations at each ~~point of compliance~~point of compliance in the production unit.
        ii. Characterization of the production unit minera~~o~~logy that includes measurements or appropriate estimates of buffering capacity, total organic carbon, cation exchange capacity, cation/anion balance, and the clay mineralogy.
    b. Descriptions, supporting measurements, or appropriate estimates of the chemical and physical state of the hazardous constituent at the proposed ACL at the ~~point of compliance~~point of compliance wells within the geochemical and aquifer matrix including:
        i. The chemical speciation of the hazardous constituent, if appropriate, including its oxidation state and likely complexation with anions or cations in the production unit setting.
        ii. The physical state each species of the hazardous constituent (e.g., dissolved, adsorbed, precipitated, complexed with carbonate, etc.) in the production unit setting.
        iii. Any field tests (e.g., core evaluation, gas sampling) and geochemical characterization conducted by the licensee to support these findings.
2. The licensee has evaluated the major attenuation mechanisms that affect migration of the hazardous constituent at the proposed ACL based on its chemical and physical characteristics under the prevailing and anticipated flow, transport, and geochemical conditions in the production unit by considering:
    a. Dilution and mixing of the hazardous constituent from the production unit by surrounding groundwater including:

i. An analysis of dispersion (i.e., the process in which the hazardous constituent spreads out and become less concentrated as it moves away from the source) using field-estimated or relevant literature values.
ii. An analysis of mixing from water being added to the groundwater system (e.g., natural recharge, aquifer leakage, etc.) based on field measurements, or through use of conservative assumptions from similar sites or literature values.

b. Sorption or ion exchange of the hazardous constituent within the production unit including:
   i. An evaluation of sorption including estimates of the distribution coefficient, Kd, if a linear sorption model is used, from batch or column equilibria experiments, or representative literature values.
   ii. An evaluation of cation exchange that considers the affinity of each hazardous constituent for the production unit minerology (e.g., clay and oxide surfaces).
   iii. An evaluation of impacts of potentiometric surface rebound characterized in Section F.3.3.3, Criterion (2)(c), on sorption and desorption processes related to the hazardous constituent.

c. Precipitation of the hazardous constituent or any other geochemical or biochemical process that may affect migration of the hazardous constituent under production unit conditions including but not limited to:
   i. An evaluation of surface complexation processes that may impact mobility of the hazardous constituent.
   ii. An evaluation of complexation processes in solution that may increase the mobility of a hazardous species or impact the hazardous species ability to be removed from solution.

F.3.1.4 *Evaluation findings*

If the staff review, as described in this section, results in the finding that the licensee has acceptably evaluated the physical and chemical characteristics of the waste in the licensed site including its potential for migration for the proposed ACL for the hazardous constituent in the production unit, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptably evaluated the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(i) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.1.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.1.3.

The staff finds the licensee has provided the chemical and physical characteristics of [INSERT NAME OF CONSTITUENT] at the proposed ACL under the field conditions at all ~~point of compliance~~point of compliance wells in the production unit in an ISR wellfield. The licensee has provided sufficient field-based evidence to support the description of the chemical and physical characteristics of [INSERT NAME OF CONSTITUENT] at the proposed ACL as a function of the prevailing and anticipated conditions in the production unit. The licensee has described the parameters that will affect the potential migration of [INSERT NAME OF CONSTITUENT] at the proposed ACL based on its chemical and physical characteristics under the prevailing and anticipated flow, transport, and geochemical conditions in the production unit. The licensee has

provided and justified the values of the parameters needed for the licensee to conduct a migration evaluation of the hazardous constituent at the proposed ACL using analytical evaluation or numerical groundwater flow or contaminant transport modeling.

Based on the information provided in the application and the detailed review conducted of the physical and chemical characteristics of the waste in the licensed site including its potential for migration for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(i).

F.3.2 The hydrogeological characteristics of the facility and surrounding land

The second factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ii) to be considered in the risk assessment of the present or potential hazard to groundwater from a proposed ACL is the hydrogeological characteristics of the facility and the surrounding land. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. Therefore, this factor requires the licensee to evaluate the hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after restoration in the ISR wellfield. This hydrogeological characterization is needed to conduct the assessment of the potential migration of the hazardous constituent at the proposed ACL in the production unit through groundwater to humans or other receptors as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.2.1 *Areas of review*

The areas of review include information on the current hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after restoration of the aquifer following the guidance in SRP Section 2.11.1. This includes any revisions to the hydrogeological characteristics for these aquifers compared to those provided before wellfield operations and whether the pre-operational hydrogeologic characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit have changed. The areas of review also include any field data that support revisions to the hydrogeological characteristics that was collected during operation and restoration and after restoration of the production unit.

F.3.2.2 *Review procedures*

The staff should review if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the hydrogeological characteristics of the facility and surrounding land. For an ISR wellfield, the “facility and surrounding land” in this factor is the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit and any hydraulically-connected surface water. Staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee has provided the current hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration.

2. Verify that the licensee has provided the technical bases for any revisions of the hydrogeologic characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

F.3.2.3 *Acceptance criteria*

The evaluation of the hydrogeological characteristics of the facility and the surrounding land as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ii) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided the current hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration of the production unit including:
    a. The current hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after restoration of the aquifer based on aquifer testing or other tests (e.g., hydraulic conductivity, storage coefficient, etc.).
    b. Any additional information to update subsurface geology and lithology descriptions and any field data used as the technical bases for these revisions, including drilling mud logs, electrical logs, or coring obtained during well installation and other field investigations during operation and restoration.
    c. Any revisions to the hydrogeological characteristics for these aquifers compared to those provided before wellfield operations.
    d. Any existing, new, or potential hydraulic connection to surface water from the production unit in the ISR wellfield.
2. The licensee has provided the technical bases for any revisions of the hydrogeologic characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit including:
    a. All information the licensee collected and provided during operation and restoration of the production unit that specifically address ~~if~~whether the original hydrogeologic characteristics have changed (e.g., potentiometric surfaces, injection, and production well performance).
    b. The identification of any preferential flow pathways in an aquifer which were not previously detected, whether natural (e.g., faults) or artificial (e.g., mine workings).
    c. Any changes in hydraulic conductivity in the aquifer and/or well performance such as reduced injectivity in wells caused by operation or restoration.
    d. Any additional aquifer tests that were conducted to quantify changes in the hydraulic parameters of these aquifers (e.g., hydraulic conductivity, storage coefficient).
    e. Any update or revisions to the hydrologic characteristics and hydrologic conceptual site model based on other field data, field observations, and further aquifer testing (e.g., confined vs. unconfined aquifer behavior).
    f. The hydrologic data that support the any existing, new, or potential hydraulic connection to surface water from the production unit in the ISR wellfield (e.g., potentiometric surfaces, water chemistry, etc.)

F.3.2.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee has acceptably evaluated the hydrogeological characteristics of the facility and surrounding land, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptably evaluated the hydrogeological characteristics of the facility and surrounding land for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.2.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.2.3.

The staff finds the licensee has provided the current hydrogeological characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration. The licensee has also provided the technical bases for any revisions of the hydrogeologic characteristics of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ii) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ii).

F.3.3 The quantity of groundwater and direction of groundwater flow

The third factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iii) to be considered in the risk assessment of the present or potential hazard to groundwater from a proposed ACL is the quantity of groundwater and the direction of groundwater flow. For an ISR wellfield, it is the hazardous constituent at the proposed ACL in the production unit at the end of restoration that can act as the potential source of contamination to surrounding groundwater. Therefore, this factor requires the licensee to describe the current quantity of groundwater and direction of groundwater flow in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield after operation and restoration. The evaluation of this factor provides information required to conduct the assessment of the potential migration of the hazardous constituent at the proposed ACL in the production unit through groundwater to humans or other potential receptors as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.3.1 *Areas of review*

The areas of review include information provided by the licensee on the current groundwater quantity and direction of groundwater flow in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operations and restoration. This includes any revisions to the groundwater quantity and direction of groundwater flow in these aquifers compared to that provided as part of the pre-operational wellfield characterization of the ISR wellfield, and whether the revised information demonstrates that the groundwater quantity and direction of groundwater flow in these aquifers has been significantly changed by extraction and injection operations and restoration and may continue to be altered. Finally, this review

area includes the technical basis for these revisions, including all field data and any groundwater flow modeling to evaluate the groundwater flow quantity and direction in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operations and restoration.

F.3.3.2 *Review procedures*

The staff should review if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the quantity of groundwater and direction of groundwater flow. For an ISR wellfield, "the groundwater" in this factor is the groundwater in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit that may be potentially hydraulically-connected. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee has provided the current estimates of groundwater quantity and flow direction in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operations and restoration.
2. Verify that the licensee has provided the technical basis for the current and future estimates of groundwater quantity and groundwater flow direction in the production unit and immediately overlying and underlying aquifers based on the impact of operation and restoration.

F.3.3.3 *Acceptance criteria*

The evaluation of the quantity of groundwater and direction of groundwater flow in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iii) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided the current estimates of groundwater quantity and flow direction in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operations and restoration including:
    a. The pre-operational and current potentiometric surface in the production unit and immediately overlying and underlying aquifers in the wellfield.
    b. An estimate of pre-operational and current groundwater quantity based on any change (e.g., drawdown) of the potentiometric surface caused by operation and restoration in the production unit and any associated effect on immediately overlying and underlying aquifers in the wellfield.
    c. Revised maps of current groundwater flow direction in the production unit and immediately overlying and underlying aquifers in the wellfield based on the current potentiometric surfaces in these aquifers.
    d. An estimate of the expected extent of any further recovery of the potentiometric surface in the production unit and immediately overlying and underlying aquifer on groundwater quantity or direction over time (e.g., time for full recovery of potentiometric surface).
2. The licensee has provided the technical basis for the current and future estimates of the groundwater quantity and groundwater direction in the production unit and immediately overlying and underlying aquifers to the production unit including:
    a. A comparison of the current estimated groundwater quantity in the production unit to any change expected due to groundwater consumption from maintaining

an inward hydraulic gradient during operations and restoration, to provide an objective confirmation of the estimated change.

b. The analytical or groundwater flow modeling used to support any estimates of current groundwater quantity and flow direction (see SRP section 6.1.1).

c. The analytical or groundwater flow modeling used to support any estimate of the expected time and extent of further recovery of the potentiometric surface from this drawdown in the production unit and immediately overlying and underlying aquifers.

d. An assessment if any changes in groundwater direction are a result of preferential flow pathways in an aquifer that were not previously identified or known, whether natural (e.g., faults) or artificial (e.g., mine workings).

e. Any additional aquifer tests that were conducted to quantify any changes in hydraulic conductivity of these aquifers that are used to support revisions to groundwater direction.

F.3.3.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee the has acceptably evaluated the quantity of groundwater and direction of groundwater flow, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptably evaluated the quantity of groundwater and direction of groundwater flow for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.3.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.3.3.

The staff finds the licensee has provided the quantity of groundwater and direction of groundwater flow of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration. The licensee has also provided the technical bases for any estimates of quantity of groundwater and direction of groundwater flow in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iii) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iii).

F.3.4 The proximity and withdrawal rates of groundwater users

The fourth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iv) to be considered in the risk assessment of the present or potential hazard to groundwater from a proposed ACL is the proximity and withdrawal rates of groundwater users. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. Therefore, this factor requires the licensee to describe the proximity and withdrawal rates of groundwater wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR

wellfield. This factor also requires the licensee to provide the information needed to assess if any existing wells are in the production unit or immediately overlying, underlying, and adjacent aquifers to the production unit. The location and withdrawal rates of these wells will influence the groundwater flow system and potentially expose receptors to the hazardous constituent. This information is needed to evaluate the effect of these wells on the groundwater flow to evaluate the migration of the hazardous constituent at the proposed ACL from the production unit to receptors as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.4.1 *Areas of review*

This area of review includes the current proximity and withdrawal rates of groundwater users in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration as compared to the pre-licensing well and user information. This area of review also includes a comparison of this new information to the prior information to determine if the use and withdrawal rates of existing wells were revised, and if any private or industrial wells were added and within a distance where they are hydraulically-connected the production unit in the ISR wellfield. The areas of review also includes the licensee's analysis of how the proximity and withdrawal rates of the existing and any added wells influence the groundwater flow system in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in or near the ISR wellfield, including any analytical or numerical groundwater flow modeling used to determine the capture zones of the wells. The review of capture zones of wells in the production unit and adjacent, overlying, and underlying aquifers consider whether the proximity and withdrawal rates will lead to migration to potential receptors.

F.3.4.2 *Review procedures*

The staff should review if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the proximity and withdrawal rates of groundwater users. For an ISR wellfield, "the groundwater user" in this factor are those public and private entities using groundwater from the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit in or near the ISR wellfield that may be potentially hydraulically connected. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee has provided the current proximity, uses, and withdrawal rates of groundwater wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit, and has compared the information on all wells in these aquifers to the information provided to license the ISR facility.
2. Verify the licensee has determined if the rate or use of an existing well was revised or if any public or private wells were added.
3. Verify that the licensee has provided an analysis of how the proximity and withdrawal rates of all wells influence the groundwater flow system in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit and the technical bases and analysis used in this analysis, including any analytical or numerical groundwater flow modeling.

F.3.4.3 *Acceptance criteria*

The evaluation of the proximity and withdrawal rates of groundwater users as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iv) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided the current proximity and withdrawal rates of groundwater users in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within a three-mile radius of the ISR wellfield including:
    a. A comprehensive description of all private and public wells that includes location, screened interval, completion type, use, and withdrawal rates within the overlying, underlying, and adjacent aquifers to the production unit.
    b. Any change to an existing public or private well location, screened interval, completion type, use, or approved rate of all wells that were identified and described in the license application and records for plugging and abandonment of any existing wells within the overlying, underlying, and adjacent aquifers to the production unit.
    c. Any revisions to EPA or state declarations on the current and future uses groundwater in these aquifers, including new class of use assignments, wellhead protection areas, or sole source aquifer declarations.
    d. Any new or revised court-ordered restrictions on groundwater use in these aquifers within three miles (e.g., restriction in river basins where groundwater is hydrologically connected to surface water or groundwater limits in an irrigation area).
2. The licensee has provided an evaluation of how the current well locations, use, and rates influence the groundwater flow system in and near the production unit and the technical bases and analysis to support this evaluation, including:
    a. Any analytical or numerical groundwater flow modeling (see SRP Section 6.1.1)
    b. Any analytical or numerical groundwater flow modeling to determine the capture zones of the existing wells, which describe:
        i. whether the capture zone of any wells in the production unit and adjacent, overlying, and underlying aquifer based on the proximity and withdrawals rates will lead to migration to potential receptors.
        ii. whether any well identified by the licensee is likely to capture groundwater from the production unit based on their proximity and rate.

F.3.4.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee has acceptably evaluated the proximity and withdrawal rates of groundwater users, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review the information provided by the licensee to demonstrate it has acceptably evaluated the proximity and withdrawal rates of groundwater users for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.4.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.4.3.

The staff finds the licensee has provided the proximity and withdrawal rates of groundwater users of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration. The licensee has also provided the technical bases for any revisions of the proximity and withdrawal rates of groundwater users of the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iv) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iv).

F.3.5 The current and future uses of groundwater in the area

The fifth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(v) to be considered in the risk assessment of the present or potential hazard to groundwater from a proposed ACL is the current and future uses of groundwater in the area. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. Therefore, to meet this factor, a licensee describes the current and future uses of groundwater in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield, including whether current and future uses of groundwater will pose a health risk to human or other receptors from the migration of the hazardous constituent at the proposed ACL in the production unit as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.5.1 *Areas of review*

The areas of review include the current and future uses of groundwater in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within a three-mile radius of the ISR wellfield. This includes any information provided by the licensee on EPA or state declarations that define or protect the current and future uses of groundwater, including public water supplies that use groundwater, wellhead protection areas, or sole source aquifer definitions. The areas of review include whether EPA has determined that the production unit aquifer is an Underground Source of Drinking Water (USDW) or an aquifer exemption declaration for the production unit was made by EPA under the Safe Drinking Water Act (SDWA), if the production unit is a USDW, including the description of the location, extent and boundary of the aquifer exemption. The staff's review in this area includes information provided by the licensee on any state declaration on the current and future uses of groundwater for domestic, livestock, irrigation, and industrial applications, typically known as Class of Use[8]. Finally, the areas of review include any information provided by the licensee on relevant court-ordered restrictions on groundwater or hydraulically connected surface water use (e.g., restriction in river basins where groundwater is hydrologically connected to surface water or groundwater limits in an irrigation area).

[8] Class of Use is a groundwater quality standard for radiological and non-radiological hazardous and non-hazardous constituents issued by a state for specific groundwater uses.

F.3.5.2 *Review procedures*

The staff should review if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the current and future uses of groundwater in the area. For an ISR wellfield, "the groundwater in the area" in this factor is the groundwater in all aquifers within and near the ISR wellfield, including the uppermost aquifer, the production unit, and immediately overlying, underlying, and adjacent aquifers to the production unit in and near the ISR wellfield. Staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify the licensee has provided the current and future uses of groundwater in all aquifers, including the uppermost aquifer, the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within a three-mile ~~mile~~ radius of the ISR wellfield.
2. Verify the licensee has provided any declaration of groundwater use or protection of groundwater for a specific use made by Federal or state agencies, including public water supplies, wellhead protection areas or sole source aquifer definitions.
3. Verify that if the EPA or any state has determined that the production unit is an USDW under the SDWA, the licensee provided the documentation from EPA that defined the production unit as an exempt aquifer and included the physical horizontal and vertical location, extent, and boundary of the aquifer exemption.
4. Verify the licensee has provided any state declarations on the current and future uses of groundwater for domestic, livestock, irrigation, and industrial applications, typically known as Class of Use, in the production unit and immediately overlying, underlying and adjacent aquifers to the production unit within a three-mile ~~mile~~ radius of the ISR wellfield.
5. Verify the licensee has provided the documentation for any relevant court-ordered restrictions on groundwater or hydraulically-connected surface water use (e.g., restriction in river basins where groundwater is hydrologically connected to surface water or groundwater limits in an irrigation area).

F.3.5.3 *Acceptance criteria*

The evaluation of the current and future uses of groundwater in the area as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(v) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided the current and future uses of groundwater in any aquifer within a three-mile radius of the ISR wellfield including:
    a. Maps of all existing wells within three miles of the ISR wellfield boundary and a table with their legal description and designated use.
    b. Maps of all surface water use within three miles of the ISR wellfield boundary and a table with their legal description and designated use.
2. The licensee has provided any declaration of groundwater use or protection of groundwater for a specific use made by Federal or state agencies, including public water supplies, wellhead protection areas, or sole source aquifer definitions including:
    a. Identification and description of any EPA-designated public water supply wells including location, rates, and target aquifer.
    b. Identification and description of any available EPA-designated wellhead protection areas and the information provided by the state or municipality.

c. Identification and description of any available EPA sole source aquifers, including their location and extent.
d. Identification and description of available groundwater or surface water use by any city, county, or other municipality that uses aquifers for public water supply including their location and type of use.
e. Identification and description of large groundwater or surface water use (greater than 50 gpm) by a private entity from aquifer or surface water for industry or agriculture (e.g., power plant cooling, irrigation) including the location and type of use.

3. The licensee has identified if the EPA or any state has issued an aquifer exemption under the SDWA for any aquifer within and near the ISR wellfield including:
   a. Any documentation from the state or EPA that declares the production unit or any other aquifer is an USDW pursuant to 40 CFR Part 144.
   b. Any documentation that declares the production unit in the ISR wellfield is an exempt aquifer and therefore not under the protection of the SDWA.
   c. Any documentation or maps from EPA or the state that identify and describe the physical location and extent of the aquifer exemption and the aquifer exemption boundary.
4. The licensee has provided all state declarations on the current and future uses of groundwater for domestic, livestock, irrigation. and industrial applications for aquifers within and near the ISR wellfield (typically known as state Class of Use).
   a. Any documentation and maps from the state that declares the Class of Use of the production unit or overlying, underlying. and adjacent aquifers to the production unit to include the physical location and extent.
   b. Any documentation and maps from the state that declares the Class of Use of the uppermost aquifer at the ISR facility to include the physical location and extent.
   c. Any documentation from the state establishing the concentration levels of hazardous and non-hazardous constituents for each Class of Use declaration for an aquifer (e.g., domestic, stock, agricultural, industrial).
5. The licensee has provided the documentation for any relevant court-ordered restrictions on groundwater or hydraulically-connected surface water use for aquifers within and near the ISR wellfield, including:
   a. Any documentation on Federal or state court restrictions on groundwater or surface water (e.g., restriction in river basins where groundwater is hydrologically connected to surface water or groundwater limits in an irrigation area).
   b. Any maps demonstrating the location and extent of the Federal or state court restrictions on groundwater or surface water use.
   c. Any adjudicated groundwater or surface water rights.

F.3.5.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee the has acceptably evaluated the current and future uses of groundwater in the area, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptably evaluated the current and future uses of groundwater in the area for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section

F.3.5.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.5.3.

The staff finds the licensee has provided the current and future uses of groundwater in aquifers within and near the ISR wellfield, including the uppermost aquifer, production unit, and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration. The licensee has also provided the Federal, state, or court declarations on the current and future uses of groundwater in the aquifers within and near the ISR wellfield, including the uppermost aquifer, production unit, and immediately overlying, underlying, and adjacent aquifers to the production unit.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(v) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(v).

F.3.6 The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality

The sixth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vi) to be considered in the risk assessment of the present or potential hazard to groundwater from a proposed ACL is the existing quality of groundwater, including other sources of contamination and their cumulative impact of the groundwater quality. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. Therefore, the licensee should evaluate the existing quality of groundwater including both hazardous and non-hazardous radiological and non-radiological constituents in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield. The licensee should also evaluate other non-ISR sources of contamination and their cumulative impact of the groundwater quality in these same aquifers. This information is required to conduct the evaluation of the health risk to human or other receptors in the production unit or from the migration of the hazardous constituent at the proposed ACL to immediately overlying, underlying, and adjacent aquifers to the production unit as required in the factors in 10 CFR Part 40, Appendix A, Paragraphs 5B(6)(a)(vii) and 5B(6)(a)(viii).

F.3.6.1 *Areas of review*

The areas of review include the current quality of groundwater in the immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield after restoration is completed. This includes the groundwater quality obtained from the environmental monitoring of all private wells for radionuclides before and during operation and restoration. This area of review also includes changes to the water quality of the immediately overlying, underlying, and adjacent aquifers compared to the background water quality in these aquifers described in the license application. Finally, this area of review includes the presence of potential contamination from non-ISR related sources to the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within and near the ISR wellfield and the licensee's assessment of their cumulative impact on the groundwater quality.

F.3.6.2 *Review procedures*

The staff should evaluate if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the existing quality of groundwater, including other sources of contamination and their cumulative impact of the groundwater quality. For an ISR wellfield, "the groundwater" in this factor is the groundwater in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within three miles. Other sources of contamination should be considered within this radius. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify that the licensee provided the current quality of groundwater in the immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield.
2. Verify the licensee identified the presence of potential contamination from non-ISR sources in the production unit and overlying, underlying, and adjacent aquifers to the production unit.
3. Verify the licensee evaluated the cumulative impact from any potential contamination from non-ISR sources on groundwater quality in the production unit and overlying, underlying, and adjacent aquifers to the production unit.

F.3.6.3 *Acceptance criteria*

The staff review of the existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vi) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided the current groundwater quality in and near the ISR wellfield in any aquifer within three miles or any distance where it could be hydraulically connected or influenced by the production unit including:
    a. An evaluation of the groundwater quality within the ISR wellfield by sampling and analyzing a suite of hazardous and non-hazardous radiological and non-radiological constituents (see SRP Section 2.7 Table 2.7.3-1) in ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield
    b. An evaluation of the groundwater quality outside the ISR wellfield from sampling and analyzing a suite of hazardous and non-hazardous radiological and non-radiological constituents (see SRP Section 2.7 Table 2.7.3-1) in private wells in overlying, underlying, and adjacent aquifers to the production unit within a reasonable distance of the ISR wellfield.
2. The licensee has described and provided an evaluation of the potential contamination sources in and near the ISR wellfield in any aquifer within three miles or a distance where it could be hydraulically connected to the ISR wellfield aquifers including:
    a. Any existing surface and subsurface disturbance associated with uranium, mineral, or coal mining disturbances, such as open abandoned mine pits, underground mine workings, ore storage pads, mill tailings impoundments, and any associated groundwater contamination.
    b. Any existing hazardous waste landfills or Superfund sites and any associated groundwater contamination.

c. Any existing municipal or industrial landfills or other industrial facilities and any associated groundwater contamination (e.g., dewatering of gravel pits)
d. Any existing contamination that has come from spills or leaks from buried pipelines from other private industries and any associated groundwater contamination.
e. Any unlined surface waste impoundments or other waste ponds associated with oil and gas production and other industries (e.g., drilling mud pits, coal bed methane produced water, fly ash, and tailings from mineral production) and any associated groundwater contamination.
f. Any waste injection wells, permitted under the SDWA Underground Injection Control regulations, for the ISR facility or for produced water from oil and gas operations or for non-hazardous and hazardous waste from industry and any associated groundwater contamination.
g. Any site with land application of wastes (e.g., livestock waste lagoons, food processing waste lagoons, sewage) and any associated groundwater contamination.
h. The location and extent of any prior contamination sources that were remediated (e.g., abandoned mine pit remediation, reclaimed waste impoundments) and any associated groundwater contamination.
i. The location and documentation for any permitted waste discharges to surface water from Federal or state entities (e.g., NPDES permits).

3. The licensee has evaluated the cumulative impact from any potential contamination from non-ISR sources on groundwater quality within and near the ISR wellfield in any aquifer within three miles or a distance where it could be hydraulically connected to the ISR wellfield aquifers, including:
   a. An analysis of the expected range of increase in a concentration level of all hazardous constituents in the overlying, underlying, and adjacent aquifers based on the additional concentrations from non-ISR sources and the impact to their groundwater use for domestic, livestock of agricultural purposes (e.g., the proposed ACL for uranium will meet the uranium standard for drinking water at a production unit aquifer exemption boundary, but the uranium plume from a mine pit near the aquifer exemption boundary will cause exceedance of drinking water standards.)
   b. An analysis of the expected range of increase in a concentration level of all non-hazardous constituents in the overlying, underlying, and adjacent aquifers based on the additional concentrations from non-ISR sources and the impact to their groundwater use for domestic, livestock, or agricultural purposes (e.g., the proposed ACL for nitrate in the production unit will meet the drinking water standard at a production unit aquifer exemption boundary, but nitrate from leakage of septic tanks near the aquifer exemption boundary will cause an exceedance of drinking water standards.)

F.3.6.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee has acceptably evaluated the existing quality of groundwater in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield, including other sources of contamination and their cumulative impact on the groundwater quality, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptably evaluated the existing quality of groundwater, including other sources of contamination and their cumulative impact of the groundwater quality for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.6.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.6.3.

The staff finds the licensee has provided the current quality of groundwater in the immediately overlying, underlying, and adjacent aquifers to the production unit within the ISR wellfield. The licensee has identified and quantified potential contamination from non-ISR sources in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit. Furthermore, the licensee has evaluated the cumulative impact from any potential contamination from non-ISR sources on groundwater quality in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vi) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vi).

F.3.7 The potential for health risks caused by human exposure to waste constituents

The seventh factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii) to be considered for the present or potential hazard to groundwater from a proposed ACL is the potential for health risks caused by human exposure to waste constituents. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. If an ACL is proposed for a hazardous constituent, an incremental risk is incurred to human receptors as opposed to achieving the background or maximum contaminant level concentration in 10 CFR Part 40, Appendix A, Paragraphs 5B(5)(a)or (b). Therefore, this factor requires the licensee to describe the potential for health risks caused by direct human exposure from groundwater within immediately overlying, underlying, and adjacent aquifers to the production unit or hydraulically-surface water which may be impacted by migration of the hazardous constituent from the production unit if the proposed ACL is established.

To conduct this health risk assessment, the licensee should assess the potential for health risks at all the locations, known as “points of exposure,” where a human receptor may be exposed from migration of the hazardous constituent from the production unit at the proposed ACL. The production unit in an ISR wellfield is typically located deep in the subsurface in a confined aquifer, so the potential points of exposure are wells in the immediately overlying, underlying, and adjacent aquifers to the production unit that are used for domestic, livestock, agriculture or industrial purposes. In addition, the licensee should also evaluate if the production unit is connected to, or located in, an upper aquifer close to the land surface to identify any point of exposure in hydraulically-connected surface water where a human receptor may be exposed to the hazardous constituent if it migrates from the production unit. The wells in the production unit are not points of exposure for humans, as the production unit and a buffer zone are exempted from protection as a drinking water source by the EPA under the SDWA. However, should the production unit not be an exempt aquifer, points of exposure should be considered in the

production unit. The licensee should use actual point of exposure locations based on aquifer exemption boundaries or existing well locations, or conduct analytical or numerical groundwater flow modeling to identify theoretical points of exposure in overlying, underlying, and adjacent aquifers and hydraulically-connected surface water to the production unit that may be impacted by migration of the hazardous constituent from the production unit if the proposed ACL is established. The licensee should also use analytical or numerical contaminant transport modeling to determine the probable concentration of the hazardous constituent at identified actual or theoretical points of exposure. Once the hazardous constituent concentrations at these points of exposure are estimated, the licensee can then determine the potential incremental health risks to human receptors based on the consumption of groundwater or hydraulically connected surface water or ingestion of crops irrigated with groundwater or hydraulically-connected surface water sources from a point of exposure impacted by migration of the hazardous constituent from the production unit if the proposed ACL is established. The licensee should also consider and provide any actions or any mitigation measures to reduce any significant incremental human health risk at actual or theoretical points of exposure that are practical and durable (e.g., institutional control on water use).

F.3.7.1 *Areas of review*

The areas of review include the licensee's evaluation of the incremental human health risk from the hazardous constituent at the proposed ACL in the production unit and its predicted concentration from migration from the production unit to points of exposure in immediately overlying, underlying, and adjacent aquifers to the production unit and hydraulically-connected surface water to the production unit. This includes actual points of exposure using the aquifer exemption boundary or existing wells or theoretical points of exposure using analytical or numerical groundwater flow modeling to predict the migration pathways of the hazardous constituent at the proposed ACL from the production unit to immediately overlying, underlying and adjacent aquifers to the production unit and any hydraulically-connected surface water. The review of points of exposure includes any analytical or numerical contaminant transport modeling provided by the licensee to estimate the hazardous constituent concentration at the proposed ACL at these actual or theoretical points of exposure. This review includes the licensee's baseline risk assessment of the human health risk from all hazardous constituents at the ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit at the approved background hazardous concentration limit (10 CFR Part 40, Appendix A, Paragraph 5B(5)(a)) before ISR wellfield operations and from any known background hazardous constituent concentrations in hydraulically-connected surface water. The review also includes licensee's evaluation and technical basis for the incremental human health risks from the hazardous constituent at its estimated concentrations at these points of exposure. Finally, this area of review addresses whether the licensee considered reasonable actions and/or provided mitigation measures to reduce any significant incremental human health risk that are practical and durable.

F.3.7.2 *Review procedures*

The staff should evaluate if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the~~-~~ potential for health risks caused by human exposure to waste constituents. For an ISR wellfield, the "waste constituent" in this factor is the hazardous constituent at the proposed ACL at all ~~point of compliance~~point of compliance wells in the production unit and in immediately overlying, underlying, and adjacent aquifers and any hydraulically-connected surface water to the production unit. The staff should use the following

review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify the licensee provided actual points of exposure based on the production unit aquifer exemption boundary, existing wells, and/or theoretical points of exposure derived from analytical or numerical groundwater flow modeling to predict migration pathways from the production unit to the immediately overlying, underlying, and adjacent aquifers to the production unit and hydraulically-connected surface water.
2. Verify the licensee used the analytical and numerical contaminant transport modeling of the hazardous constituent at the proposed ACL to estimate the hazardous constituent concentration at these points of exposure in immediately overlying, underlying, and adjacent aquifers to the production unit and hydraulically-connected surface water.
3. Verify the licensee has provided a baseline risk assessment of the human health risk from all hazardous constituents at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers at the approved background hazardous concentration limits before ISR wellfield operation and known hydraulically- connected surface water locations. The staff should review if the licensee assessed the baseline human health risks based on the consumption of drinking water at the points of exposure or ingestion of crops irrigated by groundwater or hydraulically-connected surface water at these points of exposure at the approved background hazardous constituent concentration limits.
4. Verify the licensee evaluated the incremental human health risks from any predicted increase in concentration of the hazardous constituent after migration from the production unit at the proposed ACL to real or theoretical points of exposure in immediately overlying, underlying, and adjacent aquifers including the technical basis for this assessment. Verify the licensee assessed the potential incremental human health risks based on the consumption of drinking water or ingestion of crops from points of exposure in groundwater or hydraulically connected surface water.
5. Verify if the licensee considered reasonable actions and/or provided mitigation measures to reduce any significant incremental human health risk that are practical and durable.

F.3.7.3 *Acceptance criteria*

The evaluation of the potential for health risks caused by human exposure to waste constituents as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii) is acceptable if the licensee has met the acceptance criteria listed below:

1. Verify the licensee has identified the points of exposure using aquifer exemption or other known water use boundaries, existing wells locations, and/or the theoretical points of exposure from analytical or numerical groundwater flow modeling to predict migration pathways from the production unit to immediately overlying, underlying, and adjacent aquifers and hydraulically-connected surface water by providing:
    a. The basis for all real points of exposure including:
        i. The boundary of the production unit or any other exempt aquifer if used for the point of exposure, including information on the horizontal and vertical location of the aquifer exemption boundary, and the basis for the aquifer exemption (e.g., that it is mineral bearing).
        ii. The boundary of any USDW if used for the point of exposure, including information provided by the licensee concerning the underground drinking water aquifer, including its water quality and its location.

iii. The location of existing wells or surface water rights locations if used for the point of exposure including any information obtained from the review conducted for the factor in Appendix F, Section F3.4.

b. The basis for all theoretical points of exposure identified using acceptable groundwater flow modeling (see SRP Section 6.1.1).

2. Verify the licensee used analytical or numerical contaminant transport or geochemical modeling to provide estimates of the concentration of the hazardous constituent at the actual or theoretical points of exposure in immediately overlying, underlying, and adjacent aquifers to the production unit and hydraulically-connected surface water over time by providing:

a. A description of the likely mechanisms that affect potential migration of the hazardous constituent at the proposed ACL from the production unit based on its chemical and physical characteristics under the prevailing and anticipated flow, contaminant transport, and geochemical conditions in the production unit including dilution in surrounding ground water, sorption of the hazardous constituent to the soil matrix, and immobilization of the hazardous constituent from geochemical and biochemical reactions.

b. Acceptable analytical or numerical contaminant transport modeling which addresses likely mechanisms that affect migration of the hazardous constituent (see SRP Section 6.1.1), including attenuation from geochemical or biochemical equilibrium reactions, is estimated by use of acceptable modeling software packages (e.g., USGS PHREEQC).

c. The source term for any contaminant transport or geochemical modeling, which is derived from distribution of the hazardous constituent at the proposed ACL in the production unit based on field measured values for any contaminant transport or geochemical modeling.

d. Aquifer geochemistry data to model the attenuation of contaminants and the technical justification for the values. Acceptable parameter estimation methods are direct measurement, use of a conservative bounding estimate, reference to literature values for similar aquifer conditions, and laboratory studies of aquifer materials.

e. Calibration and verification of the analytical or numerical contaminant transport or geochemical models are done using field measured observations of observed water levels or known concentration levels of constituents at observation wells.

3. Verify the licensee has provided a baseline risk assessment of the human health risk from hazardous constituents at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers and hydraulically-connected surface water locations at the approved background hazardous concentration limits before ISR wellfield operation by providing:

a. The acceptable uses of the water at the approved background hazardous constituent concentration limits at the ~~point of compliance~~point of compliance wells based on current EPA primary drinking water standards (i.e., MCLs) and/or state water quality standards.

b. The baseline human health risks are based on the consumption of drinking water at approved background hazardous constituent concentration limits at the ~~point of compliance~~point of compliance wells or ingestion of crops irrigated by groundwater or known hydraulically-connected surface water locations at the approved background hazardous constituent concentrations using current information on reference doses or similar information.

4. Verify the licensee evaluated the incremental human health risks based on the predicted hazardous constituent concentration at the real or theoretical points of exposure in

immediately overlying, underlying, and adjacent aquifers and hydraulically-connected surface water and the technical basis for this assessment by providing:

a. The potential incremental human health risks based on the consumption of drinking water or ingestion of crops from points of exposure of this hazardous constituent at the predicted concentration in groundwater or hydraulically-connected surface water.
b. The potential for incremental health risk from the hazardous constituent based on current information on reference doses, or similar information, and the difference between the background water standard and the predicted concentration for the hazardous constituent.

5. Verify that if the licensee determined the incremental health risk is unacceptable (i.e., the health risk exceeds 10^{-4}) at actual or theoretical points of exposure in the production unit, immediately overlying, underlying, or adjacent aquifer or hydraulically-connected surface water, the licensee considered actions and/or provided mitigation measures to reduce any significant incremental human health risk that are practical and durable by:

a. Providing mitigation measures such as institutional controls (e.g., land use restrictions and well use restrictions) that are durable and enforceable that reduce or eliminate the risk.
b. If the groundwater is contaminated by a hazardous constituent at a point of exposure such as a domestic well, informing the state agency which permits the domestic well that the well owner should be notified it does not meet drinking water standards based on the EPA MCLs or known or predicted cancer risks for the hazardous constituent.
c. If the groundwater is contaminated by hazardous constituent at a point of exposure, asking the state to reclassify the groundwater use if it is not found to meet its current Class of Use or other use classification.

F.3.7.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee has acceptably evaluated the potential for health risks caused by human exposure to waste constituents, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptable evaluated the potential for health risks caused by human exposure to waste constituents for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.7.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.7.3.

The staff finds the licensee has provided the potential for health risks caused by human exposure to waste constituents from the production unit and immediately overlying, underlying, and adjacent aquifers to the production unit after operation and restoration. The licensee provided actual points of exposure based on the production unit aquifer exemption boundary, existing wells, or theoretical points of exposure derived from analytical or numerical groundwater flow modeling to predict migration pathways from the production unit to identify in immediately overlying, underlying and adjacent aquifers to the production unit and hydraulically-connected surface water. The licensee used contaminant transport modeling to provide estimates of the concentration of the hazardous constituent at these points of exposure in immediately overlying, underlying, and adjacent aquifers to the production unit and

hydraulically-connected surface water. The licensee has provided a baseline risk assessment of the human health risk from all hazardous constituents at all ~~point of compliance~~point of compliance wells in the production unit and immediately overlying, underlying, and adjacent aquifers and known hydraulically-connected surface water locations at the approved background hazardous concentration limits before ISR wellfield operation. The licensee evaluated the incremental human health risks based on all hazardous constituent concentrations at points of exposure in immediately overlying, underlying, and adjacent aquifers including any predicted increase in concentration of the hazardous constituent after migration from the production unit at the proposed ACL and the technical basis for this assessment. The licensee assessed the potential incremental human health risks based on the consumption of drinking water or ingestion of crops from points of exposure in groundwater or hydraulically-connected surface water. The licensee considered reasonable actions and/or provided mitigation measures to reduce any significant incremental human health risk that are practical and durable.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii).

F.3.8 The potential damage to wildlife, crops, vegetation and physical structures caused by exposure to waste constituents

The eighth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(viii) to be considered in the evaluation of the present or potential hazard to groundwater from a proposed ACL is the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. If an ACL is proposed for a hazardous constituent, a potential or present hazard risk is incurred as opposed to achieving the MCL or the background concentration pursuant to 10 CFR Part 40, Appendix A, Paragraph 5B(6). Therefore, this factor requires the licensee to describe the potential damage to wildlife, crops, vegetation, and physical structures caused by direct or indirect exposure to the hazardous constituent from points of exposure in the restored production unit if the proposed ACL is established. It also requires the licensee to address any potential damage to wildlife, crops, vegetation, and physical structures caused by direct or indirect exposure to groundwater from points of exposure within immediately overlying, underlying, and adjacent aquifers to the production unit which may be impacted by migration of the hazardous constituent from the production unit if the proposed ACL is established.

F.3.8.1 *Areas of review*

This area of review includes the licensee's identification and description of wildlife, crops, vegetation, and physical structures that may receive direct or indirect exposure from groundwater or hydraulically-connected surface water from points of exposure. This review includes estimated concentrations of the hazardous constituent at the point of exposure in the groundwater or hydraulically-connected surface water that may cause damage to wildlife, crops, vegetation, and physical structures, and whether the licensee provided any mitigation measures to limit the amount of damage that are practical and durable (e.g., institutional control on water use).

F.3.8.2 *Review procedures*

The staff should review if the licensee has provided sufficient information to address the potential adverse effects on groundwater from the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents. For an ISR wellfield, the "waste constituent" in this factor is the hazardous constituent at the point of exposures in the groundwater and hydraulically-connected surface water that have been impacted by the migration of the hazardous constituent at the established ACL in the production unit. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify the licensee identified and described any wildlife, crops, vegetation, and physical structures that may receive direct or indirect exposure from groundwater or hydraulically-connected surface water at points of exposure identified in the staff review of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii).
2. Verify the licensee determined the concentration level of the hazardous constituent at the point of exposure in the groundwater or hydraulically- connected surface water and evaluated how this hazardous constituent concentration may cause damage to wildlife, crops, vegetation and physical structures.
3. Verify the licensee considered and provided any mitigation measures to limit the amount of damage that are practical and durable (e.g., institutional control on water use).

F.3.8.3 *Acceptance criteria*

The evaluation of the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(viii) is acceptable if the licensee has met the acceptance criteria listed below:

4. The licensee identified and described any wildlife, crops, vegetation, and physical structures that may receive direct or indirect exposure from groundwater or hydraulically-connected surface water by providing:
    a. Surveys of wildlife (e.g., migratory birds) and endangered species (e.g., sage grouse) that could be impacted by contact with hazardous constituent at concentration levels expected in the groundwater and hydraulically-connected surface water at points of exposure.
    b. Land use surveys of agricultural crops and other vegetation that could be impacted by contact (e.g., irrigation) with the hazardous constituent at concentration levels expected in groundwater or hydraulically-connected surface water at points of exposure.
    c. Surveys of physical structures and infrastructure that could be impacted by contact with the hazardous constituent at concentration levels expected in groundwater or hydraulically-connected surface water at points of exposure.
5. The licensee determined the concentration level at the point of exposure of the hazardous constituent in the groundwater or hydraulically-connected surface water and evaluated how this hazardous constituent concentration may cause damage to wildlife, crops, vegetation, and physical structures, and the estimated cost of the damage, including:
    a. The expected impact to identified wildlife from the hazardous constituent at the estimated concentration level (e.g., migratory birds and selenium).

b. The expected impact to any identified crops or other vegetation from the hazardous constituent at the estimated concentration level (e.g., levels of selenium in irrigated hay that are toxic to cattle).
c. The expected impact to any physical structures and infrastructure from the hazardous constituent at the estimated concentration level.

6. The licensee considered and provided any mitigation measures to limit the amount of damage and determined if the measures are practical and durable (e.g., institutional control on water use).

F.3.8.4 *Evaluation findings*

If the staff review, as described in this section, results in the acceptance that the licensee the has acceptably evaluated the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has acceptable evaluated the- potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.8.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.8.3.

The staff finds the licensee has identified and described any wildlife, crops, vegetation and physical structures that may receive direct or indirect exposure from groundwater or hydraulically-connected surface water from points of exposure identified in the staff review of factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii). The licensee determined the concentration level of [INSERT NAME OF CONSTITUENT] at the point of exposure in the groundwater or hydraulically-connected surface water and evaluated how this [INSERT NAME OF CONSTITUENT] concentration may cause damage to wildlife, crops, vegetation, and physical structures. If damage is expected, the licensee has provided mitigation measures to limit the amount of damage that are practical and durable.

Based on the information provided in the application and the detailed review conducted of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(viii) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5(B)(6)(a)(viii).

F.3.9 The persistence and permanence of the adverse potential effects

The ninth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ix) to be considered in the evaluation of the present or potential hazard to groundwater and hydraulically-connected surface water from a proposed ACL is the persistence and permanence of the adverse potential effects. For an ISR wellfield, the hazardous constituent at the proposed ACL in the production unit at the end of restoration is a potential source of contamination to surrounding groundwater. If an ACL is proposed for a hazardous constituent, a potential or present hazard risk is incurred as opposed to achieving the MCL or the background concentration pursuant to 10 CFR Part 40, Appendix A, Paragraph 5B(6). Therefore, this factor requires the licensee to describe the

persistence and permanence of the adverse potential effects to groundwater and hydraulically-connected surface water from the restored production unit if a proposed ACL is established.

F.3.9.1 *Areas of review*

This area of review includes information provided by the licensee to describe the persistence and permanence of the potential adverse effects on the quality of groundwater or hydraulically-connected surface water that is impacted by migration of the hazardous constituent at the established ACL. The review includes the licensee's analytical or numerical groundwater flow and transport modeling to predict how the concentration of the hazardous constituent will change over time in the groundwater or hydraulically-connected surface water at the points of exposure identified in the staff review of the factor in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii). This review also includes the licensee's evaluation of whether the adverse effects to the groundwater and hydraulically-connected surface water quality will remain the same or decrease with time at the points of exposure to a level that will reduce health risks to humans or damage to wildlife, crops, vegetation, and physical structures.

F.3.9.2 *Review procedures*

The staff should evaluate if the licensee has provided sufficient information to address the persistence and permanence of the potential adverse effects on groundwater from the persistence and permanence of the adverse potential effects. For an ISR wellfield, the time frame for the "persistence and permanence" evaluation should be considered over a reasonable time period (e.g., based on groundwater flow) proposed by the licensee for radiological and non-radiological constituents with proposed ACLs. The staff should use the following review procedures to determine if the licensee has demonstrated compliance with these regulations:

1. Verify if the licensee has identified and described the processes that influence the persistence and permanence of the potential adverse effect on the quality of groundwater or hydraulically-connected surface water that is impacted by migration of the hazardous constituent at the established ACL over longer time frames.
2. Verify if the licensee has provided any analytical or numerical contaminant reactive or geochemical modeling to predict how the concentration of the hazardous constituent will change over longer time frames in the groundwater or hydraulically-connected surface water at the points of exposure.
3. Verify if the licensee has evaluated if the adverse effects to the groundwater and hydraulically-connected surface water quality will remain the same or decrease with longer time periods at the points of exposure to a level that will reduce health risks to humans or damage to wildlife, crops, vegetation, and physical structures.

F.3.9.3 *Acceptance criteria*

The evaluation of the persistence and permanence of the adverse potential effects as required in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ix) is acceptable if the licensee has met the acceptance criteria listed below:

1. The licensee has provided information to identify and describe the processes that influence the persistence and permanence of the potential adverse effects on the quality of groundwater or hydraulically-connected surface water that is impacted by migration of the hazardous constituent from the production unit at the established ACL by providing:

a. Identification and description of the significant physical, chemical, and biological processes that will impact the persistence of each hazardous constituent at points of exposure in groundwater or hydraulically-connected surface water over longer time frames (e.g., based on groundwater flow).
b. An evaluation of the parameters and estimated values for the chemical, physical, or biological processes that impact the hazardous constituent during longer time periods using field or literature-based parameters (e.g., radioactive decay, biodegradation, interaction with oxygen in surface water, etc.)

2. The licensee has provided any analytical or numerical contaminant reactive or geochemical modeling to predict how the concentration of the hazardous constituent will change over longer time frames (e.g., based on groundwater flow) in the groundwater or hydraulically-connected surface water at the points of exposure by providing:
   a. Predictive contaminant reactive and geochemical modeling of the future concentration of the hazardous constituent at points of exposure in groundwater and hydraulically-connected surface water over time (see SRP Section 6.1.1) using field or literature based parameter values for relevant chemical, physical, or biological processes.
   b. Calibration or verification of contaminant reactive and geochemical modeling of the future concentration of the hazardous constituent at points of exposure in groundwater and hydraulically-connected surface water over time (see SRP Section 6.1.1) using observations from ~~point of compliance~~point of compliance or other wells (e.g., private wells) or surface water monitoring locations, as available.
3. The licensee evaluated if the adverse effects to the groundwater and hydraulically-connected surface water quality will remain the same or be reduced with time at the points of exposure to a level that will reduce health risks to humans or damage to wildlife, crops, vegetation, and physical structures by providing:
   a. Evaluation of trends of the hazardous constituent concentration with time that show a decreasing or no trend at points of exposure in groundwater and hydraulically-connected surface water (e.g., selenium trend shows its concentration will reach a regulatory limit in 100 years).
   b. Evaluation of any reduction in hazardous constituent concentration at points of exposure that shows it will lead to a significant reduction in health risks to humans or damage to wildlife, crops, vegetation and physical structures over a longer time period (e.g., within 20 years the concentration of selenium is predicted to fall below the toxicity level in hay for livestock consumption).

F.3.9.4 *Evaluation Findings*

If the staff review, as described in this section, results in the acceptance that the licensee the has acceptably evaluated the persistence and permanence of the adverse potential effects, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has evaluated the persistence and permanence of the adverse potential effects for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the *in situ* recovery facility. This review included an evaluation using the review procedures in standard review plan Appendix F, Section F.3.9.2 and the acceptance criteria outlined in standard review plan Appendix F, Section F.3.9.3.

The staff finds the licensee has identified and described the processes that influence the persistence and permanence of the potential adverse effect on the quality of groundwater or hydraulically-connected surface water that is impacted by migration of [INSERT NAME OF CONSTITUENT] at the established ACL over longer time frames. The licensee has provided analytical or numerical contaminant reactive or geochemical modeling to predict how the concentration of [INSERT NAME OF CONSTITUENT] will change over longer time frames in the groundwater or hydraulically-connected surface water at the points of exposure. The licensee has evaluated if the adverse effects to the groundwater and hydraulically-connected surface water quality will remain the same or decrease with longer time periods at the points of exposure to a level that will reduce health risks to humans or damage to wildlife, crops, vegetation and physical structures.

Based on the information provided in the application and the detailed review conducted of the factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ix) for the present and potential hazard to groundwater from the proposed ACL for [INSERT NAME OF CONSTITUENT] in the production unit at the _____ *in situ* recovery facility, the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ix).

F.3.10 References

NRC. Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills." Washington, DC. NRC, Office of Standards Development. April. 1980. ADAMS Accession No. ML003739941.

F.4 The Present and Potential Hazard to Hydraulically-Connected Surface Water

A licensee may propose an ACL for a hazardous constituent after groundwater restoration in a production unit in an ISR wellfield pursuant to 10 CFR Part 40, Appendix A, Paragraph 14(f) pursuant to Paragraph 5B(6). These regulations state that a proposed ACL may be established for a hazardous constituent, if it will not pose a substantial present or potential hazard to human health or the environment as long as the ACL is not exceeded. Furthermore, Paragraph 5B(6)(b) lists ten factors that must be considered by the Commission to make the present and potential hazard finding for hydraulically-connected surface water from the hazardous constituent at the proposed ACL in the production unit.

For ISRs, the ten factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b) are used to assess the risk of the potential or present hazard to surface water that is hydraulically-connected to the production unit in the wellfield. The evaluation of a hydraulic connection between the production unit and surface water will be conducted in the staff review using the guidance in SRP Section 2.7 and then re-evaluated in the staff review of factor 5B(6)(a)(ii) for hydrogeological characteristics of the facility and surrounding land. At the majority of ISRs, the evaluation of these factors for a proposed ACL for a hazardous constituent will not be required because the production unit will not be located in the uppermost aquifer or at a shallow depth where it will be hydraulically connected to surface water; therefore, in those instances, the licensee does not have to address these factors for a proposed ACL. However, if the licensee determines that the production unit is hydraulically connected to surface water the licensee must assess these factors on a site-specific basis after the approved wellfield restoration plan pursuant to 14(b)(5) is implemented to achieve the approved hazardous constituent concentration limits in the production unit in the ISR wellfield.

This guidance in this section is for the staff review of the information provided by the licensee to address all of the listed factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b) that the staff must consider to make a finding on the present or potential hazard to hydraulically-connected surface water from the hazardous constituent at the proposed ACL in the production unit. Specifically, this section provides guidance to staff on the information needed to evaluate the present and potential hazard by addressing the factors that may contribute to an adverse effect on hydraulically-connected surface water to the production unit if the proposed ACL was established. The staff should review and may establish an ACL for the hazardous constituent based on its independent evaluation of the licensee's assessment of this present and potential hazard to hydraulically-connected surface water to the production unit.

F.4.1 The volume and physical and chemical characteristics of the waste in the licensed site including its potential for migration

The first factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(i) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the volume and physical and chemical characteristics of the waste in the licensed site including its potential for migration. The guidance for this factor is the same as for factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(i) for groundwater found in Appendix F, Section F3.1. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.4.2 The hydrogeological characteristics of the facility and surrounding land

The second factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(ii) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL. The guidance for this factor is the same as for factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ii) for groundwater found in Appendix F, Section F3.2. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.4.3 The quantity and quality of groundwater and direction of groundwater flow

The third factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(iii) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the quantity and quality of groundwater and direction of groundwater flow. The guidance for this factor is the same as for factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(iii) for groundwater found in Appendix F, Section F3.3. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.4.4 The patterns of rainfall in the region

The fourth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(iv) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the patterns of rainfall. The guidance for this factor is the same as that required in SRP Section 2.5, Meteorology. Therefore, the staff should review the information provided by the licensee to update the patterns of rainfall in the region as needed for the proposed ACL using the guidance in SRP Section 2.5.

F.4.5 The proximity of the licensed site to surface waters

The fifth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(v) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the proximity of the licensed site to surface waters. The guidance for this factor is the same as that required in SRP Section 2.7, Hydrology, and also addressed in Appendix F, Section F3.4. Therefore, the staff should review the information provided by the licensee to update the proximity of the licensed site to surface waters as needed for the proposed ACL using the guidance in SRP Section 2.7.

F.4.6 The current and future uses of surface waters in the area and any water quality standards established for those surface waters

The sixth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(vi) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the current and future uses of surface waters in the area and any water quality standards established for those surface waters. The guidance for this factor is the same as that required in SRP Section 2.7, and also addressed in Appendix F, Section F3.5. Therefore, the staff should review the information provided by the licensee to update the current and future uses of surface water in the area, and any surface water quality standards established as needed for the proposed ACL, using the guidance in SRP Section 2.7 and Appendix F, Section F3.5.

F.4.7 The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality

The seventh factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(vii) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality. The guidance for this factor is the same as that required in SRP Section 2.2, and also addressed in Appendix F, Section F3.6. The existing quality of surface water is also data collected under the surface water monitoring program reviewed by staff in SRP Section 5.7.8. Therefore, the staff should review the information provided by the licensee to update the existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality as needed for the proposed ACL using the guidance in SRP Sections 2.2 and 5.7.8, and Appendix F, Section 3.6.

F.4.8 The potential for health risks caused by human exposure to waste constituents

The eighth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(viii) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the potential for health risks caused by human exposure to waste constituents. The guidance for staff review of this factor is the same as the review of factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(vii) for groundwater found in Appendix F, Section F3.7. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.4.9 The potential damage to wildlife, crops, vegetation and physical structures caused by exposure to waste constituents

The ninth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(ix) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents. The guidance for staff review of this factor is the same as the review of factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(viii) for groundwater found in Appendix F, Section F3.8. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.4.10 The persistence and permanence of the adverse potential effects

The tenth factor listed in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(b)(x) to be considered in the risk assessment of the present or potential hazard to hydraulically-connected surface water from a proposed ACL is the persistence and permanence of the adverse potential effects. The guidance for staff review of this factor is the same as the review of factor 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a)(ix) for groundwater found in Appendix F, Section F3.9. Therefore, the licensee need not provide an evaluation of this factor for hydraulically-connected surface water.

F.5 Overall Evaluation Finding on the ACL

If the staff review, as described in Sections F.1 through F.4, determines that the licensee proposed an acceptable ACL for a hazardous constituent which is as low as reasonably achievable, and after considering practicable corrective actions, the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded, the following conclusions may be presented in the safety evaluation report.

NRC has completed its review of the information provided by the licensee to demonstrate it has evaluated the requirements and factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6) for the proposed ACL for [INSERT NAME OF CONSTITUENT] at the _____ *in situ* recovery facility. This review included an evaluation using the review procedures and acceptance criteria in standard review plan Appendix F, Sections F.1 through F.4.

Based on the information provided in the application and the detailed review conducted that the proposed ACL for [INSERT NAME OF CONSTITUENT] is as low as reasonably achievable, and after considering practicable corrective actions, the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the ACL is not exceeded, and after considering the factors in 10 CFR Part 40, Appendix A, Paragraph 5B(6)(a) and (b), the staff concludes the proposed ACL is in compliance with 10 CFR Part 40, Appendix A, Paragraph 5B(6).