6.0 Groundwater Quality Restoration, Surface Reclamation and Facility Decommissioning Plans

Section Summary: This section describes groundwater restoration of wellfields following production, decommissioning, and reclamation of facilities. Certain aspects of the overall restoration plan and process described in Section 6.1 have changed, as discussed below. The established aquifer exemptions are summarized and listed in Section 6.1.1. Section 6.1.2 focuses on groundwater restoration criteria, which have not changed. However, new RTVs for various wellfields are included with this submittal. Section 6.1.3 presents updated restoration schedules and water balances developed for Smith Ranch and the North Butte and Gas Hills Remote Satellites. Section 6.1.4 addresses the groundwater restoration methodology, which has been revised and updated to clarify the steps necessary for successful groundwater restoration for SUA-1548 license areas and includes new discussions regarding the use of bioremediation and selenium treatment. Section 6.1.5 identifies the restoration monitoring requirements, which NRC has previously approved. Section 6.1.6 includes a commitment by Cameco to submit a final groundwater restoration report of findings to regulatory agencies. Sections 6.1.7 and 6.1.8 present a history and status of wellfield restoration activities at the Smith Ranch site. Section 6.1.9 proposes a new groundwater restoration plan. Section 6.1.10 is a history of restoration activities at the Ruth Remote Satellite.

Sections 6.2 through 6.4 include descriptions of subjects addressed and approved in earlier licensing submittals. Section 6.2 describes activities necessary to complete decommissioning including submittal of a decommissioning plan, well plugging and abandonment and surface reclamation. Section 6.3 explains the procedure employed for removal and disposal of project infrastructure (i.e., building and equipment), and Section 6.4 describes the subsequent radiological surveys required post-reclamation. Section 6.5 focuses on financial surety estimates updated for Smith Ranch and added for the remote satellites.

6.1 Groundwater Restoration

ISR is an iterative process, conducted in phases from the installation of the production, injection and recovery wells through the restoration of the affected groundwater. When the uranium concentration of the lixiviant from a portion of or an entire mine unit falls below the predetermined economic recovery limit, uranium extraction/production will cease, and groundwater restoration of the mine unit will commence. In accordance with 10 CFR 40.42(d), once a decision has been made to permanently cease lixiviant injection in a portion of or an entire mine unit, Cameco will start restoration within 60 days of notifying NRC of this decision.

10 CFR 40.42(h)(1) specifies that groundwater restoration must be completed within 24 months after restoration activities have been initiated. If restoration requires more than 24 months to complete, Cameco will notify the NRC and request an alternate schedule for completing restoration. With respect to reclamation of waste disposal areas, uranium recovery licensees are exempt from the requirements in 10 CFR 40.42d(4), g and h. The request will provide adequate justification and information to ensure that restoration will be completed as soon as practical and that the health and safety of workers and the public will be protected (NRC, 2008). Pursuant to 10 CFR 40.42(i), the NRC Staff may approve a request for an alternate decommissioning schedule (including groundwater restoration) if the Staff determines that the request is warranted based on:

- Whether it is technically feasible to allow completion of groundwater restoration or decommissioning activities within the allotted 24-month period;

- Whether sufficient waste disposal capacity is available to allow completion of groundwater restoration or decommissioning activities within the allotted 24-month period;
- Whether a significant volume reduction in wastes requiring disposal will be achieved by allowing short-lived radionuclides to decay over a longer period of time;
- Whether a significant reduction in radiation exposure to workers can be achieved by allowing short-lived radionuclides to decay over a longer time period; and
- Other site-specific factors, case-by-case, such as the regulatory requirements of other government agencies, lawsuits, groundwater restoration activities, monitored natural attenuation, actions that could result in more environmental harm than deferring the groundwater restoration or decommissioning activity, and other factors beyond the control of Cameco.

6.1.1 Aquifer Exemption and Restoration Goals

Prior to commencing operations in an area, Cameco requests an aquifer exemption for the portion of the aquifer to be impacted by ISR activities. Approval of an aquifer exemption by WDEQ and EPA is required before ISR operations can begin. The aquifer exemption removes the production zone from protection under the Safe Drinking Water Act. Approval is based on existing water quality, the ability to commercially produce minerals, and the lack of use as an underground source of drinking water. Groundwater restoration prevents mobilized constituents from affecting aquifers adjacent to the ore zone. Aquifer exemptions have been received by Cameco for the following facilities licensed under SUA-1548:

- Smith Ranch: Monitor well ring of each mine unit (EPA, August 1990)[1].
- Highland: Monitor well ring of each mine unit (EPA, June 1987; September 1991)[2].
- North Butte Remote Satellite: Monitor well ring of each mine unit (EPA, October 1990).
- Gas Hills Remote Satellite: The edge of each mine unit plus 0.40 kilometer (0.25 mile), also including an additional 16-hectare (40-acre) parcel intersected by the 0.40-kilometer (0.25-mile) zone; EPA excluded from the exemption a 0.40-kilometer (0.25-mile) buffer around the Carol Shop well because they concluded that *"water quality at this site is unknown…the aquifer was used as an underground source of drinking water..."* (USEPA, February 2001). WSEO groundwater rights application and well completion record describes the intended water use as *"Miscellaneous," "not used for consumption,"* and *"Water will be put to use in the shop itself and not used for drinking water"* (Nov. 25, 1977). Water quality from the well does not meet drinking water standards and should not be used for drinking water. Cameco is attempting to have the exclusion removed.
- Ruth Remote Satellite: Monitor well ring of each mine unit (EPA, October 1990) .

The approved primary groundwater restoration goal for SUA-1548 is to return the groundwater quality within the affected zone to the standards identified in 10 CFR 40, Appendix A, Criterion 5B(5), which is consistent with pre-operational baseline water quality conditions. Specifically, the groundwater is to be restored to the values provided in the table in 10 CFR Part 40, Appendix A, Criterion 5C. If after employing

[1, 2] With the March 2014 WDEQ approval of the Smith Ranch-Highland combination permit amendment, the aquifer exemption boundary was modified to be a nominal 46 meters (150 feet) beyond the monitor well ring except for areas where containing hydraulically connected mine workings extending beyond the monitor well ring(s), where the aquifer exemption boundary will be 1,000 feet beyond the mine workings.

BPT in an effort to achieve pre-operational baseline, the restoration efforts do not achieve baseline conditions, Cameco may propose ACLs in accordance with 10 CFR Part 40, Appendix A, Criterion 5B(6) that continue to protect public health, safety and the environment and do not produce an unacceptable degradation to the water use of adjacent groundwater resources.

6.1.2 Groundwater Restoration Criteria and Restoration Target Values

The restoration criteria for the groundwater in a mine unit is based on the baseline water quality data collected for each mine unit from the wells completed in the planned Production Zone (i.e., MP-Wells), on a parameter-by-parameter basis pursuant to the methodology described in Section 3.4.4.1 of this TR.

MP well baseline data are screened for outliers and averaged over the mine unit for each parameter. If the data indicate that waters of significantly different quality exist within the same mine unit, the data will be divided into sub-zones and evaluated to determine RTVs for each sub-zone.

Outliers are anomalously high or low values relative to the other values and can compromise a data base. To evaluate outliers, the data are reviewed to identify obvious outliers. These values are then evaluated using the tolerance-limit formula recommended in LQD Guideline No. 4. Once an outlier is identified, the reasons for the outlier will be investigated and the data point will be corrected if possible. If no explanation for the outlier can be ascertained, the data point will be excluded if it fails the tolerance limit statistical screening.

RTVs are established based upon statistical analysis of the baseline water quality parameters. To account for natural variation in water quality within the mining zone, the RTVs are calculated as the mean plus two standard deviations of the baseline concentrations for each parameter. The exact average baseline value for a particular parameter will probably not be met at the end of groundwater restoration; therefore the restored concentration should fall within a range of acceptable values around the mean baseline value. The mean plus two standard deviations accounts for the variability in the measured values and should encompass 95% of the expected values for a given parameter.

RTVs have been calculated for five mine units at Smith Ranch that are currently in restoration: Mine Units 1, 4/4A, C, D and E (**Table 6-1, Smith Ranch Restoration Target Values)**. Cameco is calculating RTVs for the other mine units in production at Smith Ranch. At the satellites, Cameco will calculate RTVs for the various mine units during the mine unit baseline sampling and analysis program. If, during restoration, the average concentration of a parameter in the designated production area wells within the mine unit (i.e., MP-Wells) is not reduced to the RTV within a reasonable time frame using BPT, Cameco will apply for ACLs consistent with the requirements of Criterion 5B(5) and 5B(6) of Appendix A to 10 CFR Part 40. If approved by NRC, ACLs are considered to be adequate protection of public health and the environment.

6.1.3 Groundwater Restoration Schedule

Schedules for groundwater restoration at Smith Ranch including Highland and Reynolds Ranch are provided in **Tables 3-12, 3-13,** and **3-14**. These tables identify the practical extraction rate range and estimated pore volumes (including flare factor) for each mine unit at Smith Ranch. The schedule for project operations and groundwater restoration for North Butte is provided in **Table 3-15.** The water balance provided in **Table 3-15** identifies the practical extraction rate range and estimated pore volume of each mine unit at North Butte. A restoration schedule has also been developed for the Gas Hills Remote Satellite as part of the water balance for the site. The schedule for project operations and groundwater restoration for Gas Hills is provided in **Table 3-11**.

The proposed water balances for the North Butte and Gas Hills Remote Satellites are preliminary. More detailed restoration schedules will be developed for these sites as hydrologic unit testing further defines the hydrogeologic characteristics of these remote satellites. A water balance has not yet been completed for the Ruth Remote Satellite, so a restoration schedule has not been determined. A restoration schedule for the Ruth Remote Satellite will be provided to NRC once the data have been collected and the schedule has been developed.

The schedules for the mine units at Smith Ranch-Highland, North Butte and Gas Hills Remote Satellites are based on extraction of one pore volume of groundwater sweep (GWS) and treating and re-injecting eight pore volumes of water during clean water injection. The water balances for Smith Ranch and Highland use actual deep disposal well injection rates and show that for Mine Units 1, C, D/D ext where restoration is currently underway, it is estimated less than eight pore volumes will be required to complete restoration. The duration of restoration activities will vary according to the size of the area being restored, the porosity and permeability of the production zone, and the extent to which the groundwater has been affected. The restoration schedule recognizes that it is necessary to isolate restoration from production activities. If restoration areas are not isolated, lixiviant could potentially flow into areas undergoing restoration, thus reducing the effectiveness of restoration efforts and increasing the length of time to achieve groundwater restoration.

The duration of groundwater restoration for each mine unit is affected by many factors. The two most critical factors are the practical extraction rate and number of pore volumes until restoration is achieved. The practical extraction rate is that rate which creates a cone of depression such that lixiviant from adjacent producing mine unit patterns do not flow into mine unit patterns undergoing groundwater restoration.

Groundwater restoration of a mine unit will follow the completion of uranium production consistent with the requirements of 10 CFR 40.42(d). Cameco may ask NRC for delay of groundwater restoration under 10 CFR 40.42(f) if more time is required to complete restoration. If the mine unit or portion of a mine unit being prepared for groundwater restoration is located adjacent to an active production area, restoration activities may need to be delayed until production is completed in the adjacent unit. At that time, the mine unit portion that just completed production may need to serve as a buffer zone between the restoration unit and another unit that is in a production phase. Once production ceases in a mine unit or portion thereof, additional restoration wells may need to be installed and additional equipment replaced or added to header houses, both of which prolong the pre-restoration schedule.

In accordance with 10 CFR 40.42(i), Cameco requests approval of the schedules referenced above as an alternate restoration schedule for the Project. Cameco understands that, except for reclamation of waste disposal areas, 10 CFR 40.42(h)1 requires that restoration be completed within 24 months of commencement. However, based upon past experience, Cameco has developed realistic restoration schedules for the various mine units at Smith Ranch, including Highland and Reynolds Ranch designed to achieve the fastest restoration possible given geologic, hydrologic and technical constraints inherent with the restoration process. Cameco will strive to improve restoration timing (see Section 6.1.8).

6.1.4 Groundwater Restoration Methodology

A combination of at least three major phases of groundwater restoration may be necessary to return the quality of affected groundwater to as near pre-operational conditions as practicable, using BPT, including:

1. Groundwater Treatment and reinjection to reduce TDS. This effectively includes GWS because of the initial high bleed rate (5-20%) needed during the beginning of groundwater restoration. Straight GWS may still be used during restoration for hydraulic control or spot treatment of an area. An equivalent of at least 1 pore volume of groundwater will be "swept" from the formation during this process.
2. Biological Reductant and/or Chemical Reductant Treatment (may include pattern recirculation.
3. Chemical Treatment for pH (if required).

The proposed groundwater restoration methodology is designed to (a) minimize the volume of groundwater consumed during the restoration process and (b) optimize restoration equipment used in treating groundwater. The methodology is based on current, industry-wide practices as well as innovations developed by Cameco. As groundwater restoration technology continues to evolve, alternative restoration methods which can possibly accelerate and/or improve groundwater restoration success will be considered, evaluated and implemented. Regulatory approval will be obtained prior to initiating an alternative restoration method not previously approved by the LQD. The sequence of restoration activities will be determined based on operating experience, wastewater system capacity and the progress of restoration in individual mine units. The various phases of restoration will be used based upon the most efficient means to restore a mine unit. For some mine units, certain phases of restoration may not be selected if deemed unnecessary.

Cameco will accomplish groundwater restoration by employing a series of steps carefully designed in a specific sequence as described below to reduce the dissolved solids level in an efficient and cost effective manner. Depending on the actual circumstances, some of the stages may be omitted or extended in order to optimize a particular objective.

6.1.4.1 Oxidant Termination

The addition of oxidant to the injection system will be terminated at the start of restoration in a mining unit. This action will tend to end additional oxidation reactions. Solubilized uranium in the recovery stream should decrease quickly as the oxidation potential decreases, especially for those chemical species that are readily oxidized.

6.1.4.2 Reagent Termination

After the concentration of oxidized species begins to decrease, leaching chemicals will no longer be added to the injection solution. This procedure will result in decreasing lixiviant strength and, consequently, decreasing the total dissolved solids through normal consumption and bleed stream processes.

6.1.4.3 Treated Water Injection

Groundwater treatment and reinjection will be the primary tool used during the restoration process. Historically, GWS, the process whereby large quantities of groundwater are removed from the production zone and sent to the wastewater disposal system, has been used to draw fresh groundwater from outside the affected area into the patterns to lower the TDS of the impacted groundwater. GWS draws affected water toward each recovery well, thereby containing the affected water volume within close proximity of the peripheral wells in each pattern group. GWS has to be practiced with caution, as excessive pumping can cause undesirable movement of groundwater into other active restoration areas and/or operating mine units in the same formation.

Practical experience with restoration at Smith Ranch-Highland has shown that the large recovery volume associated with GWS results in a very large consumptive use of groundwater because a large quantity of wastewater has to be disposed. GWS will reduce the TDS but is not an efficient technique to effectively achieve acceptable concentrations of other constituents. Cameco has found that groundwater treatment (such as RO) and reinjection operations reduces the TDS and other byproducts of the mining process faster than GWS alone and uses significantly less water. During production, the typical bleed to maintain hydraulic control is between 0.5 and 1.5%. Groundwater treatment using RO to treat the water will result in a net bleed of 5 to 20% unless a source of makeup water from other sources is used. The increased bleed rate during RO treatment will effectively draw the affected water plume towards the recovery wells while the clean water injection will effectively reduce the concentration of TDS and trace elements in a more efficient and timely manner. The bleed during groundwater treatment and reinjection will be managed to recover production flare and to limit unintended groundwater movement from production areas completed in the same aquifers. Various considerations for properly using this restoration methodology include:

1. Selection of existing pattern wells to be used for Groundwater Treatment and Reinjection/GWS.

The chosen wells will be screened across the optimum stratigraphic interval within the aquifer for effective sweep. Laterally, the wells will be located where pumping can be balanced to prevent migration of affected groundwater volumes away from pattern areas and limit the incursion of affected water that may lie outside the monitor well ring. Preference will be given to wells located in zones with the highest TDS concentration.

2. The volume of groundwater to be treated and disposed.

The water balance assumes nine pore volumes of groundwater treatment/GWS. All affected wastewater from the mine units that is not treated and reinjected will be treated in the wastewater treatment system and disposed via UIC Class I disposal wells. If the water meets WYPDES discharge limits, it may also be discharged to the surface under a WYPDES surface discharge permit or a land application permit.

3. Configuration of injection and production wells.

The optimum configuration will use the available treatment facility capacity to systematically circulate treated water through the aquifer via the existing well patterns. The pattern size and configuration will be determined for each header house during the restoration planning process.

4. Required time to complete treated water injection into a mine unit or portion of a mine unit.

The time required to complete treated water injection will depend on the initial water quality within the mine unit patterns being restored. Typically, more time will be required to restore the groundwater quality of the first set of patterns within a mine unit as compared to those patterns that are adjacent to already treated patterns. Experience has shown that treated water injection works best when the treated water is directed to only a small number of patterns at one time before advancing to the next pattern area(s). The restoration plan assumes that complete restoration will require nine pore volumes of water treatment. The timeline for restoration is based on the water treatment capacity assumptions in the production water balance.

5. Monitoring of indicator parameters to confirm completion of treated water injection phase.

   Completion of the treated water injection phase in each pattern is determined by the reduction in concentration of selected water quality parameters to their final RTV. Decreasing chloride, bicarbonate and sulfate concentrations are typically indicative of effective formation sweep. The uranium concentration will be reduced (e.g., 2 to 3 mg/L) during treated water injection but may not be completely eliminated until biological remediation has been conducted and/or a chemical reductant has been added to the injection stream.

6. Other water treatment that may be used.

   Treated groundwater may contain a significant amount of entrained oxygen because of the water handling system and the treatment process. Because the injection of excess oxygen has a negative effect on restoration progress, the excess oxygen will be removed using a vacuum degasser and/or a catalytic bed using hydrogen gas. The oxygen gas is removed when the treated water is distributed over packing material in a tall vertical tank while a vacuum is pulled on the vessel. An additional benefit of the vacuum degassing process is the removal of some residual carbon dioxide from the water. The use of the catalytic bed and hydrogen gas to remove oxygen will remove oxygen from the water to lower levels but will not remove carbon dioxide from the water stream.

The bleed water withdrawn during restoration may be treated by RO or a similar process. The treated water, called permeate, will be reinjected, recycled through the process plant and/or potentially surface discharged under a WYPDES surface discharge permit or through a permitted land application facility. Should it become apparent that surface discharge or land application is a viable option the proper permits will be obtained from WDEQ/WQD. Discharge locations and discharge water quality and flow volume monitoring will be performed in accordance with applicable permit requirements.

6.1.4.4 Biological/Chemical Reductant

If certain parameters remain elevated during restoration efforts, the use of bioremediation (i.e., bioreduction) and/or the addition of a reducing agent or chemical reductant will be implemented. Typically, this additional process is used as necessary on individual mine units or on a pattern-by-pattern basis. Bioremediation and/or redunctant addition may be used before, during or after the groundwater treatment/reinjection phase using pattern recirculation.

The use of bioremediation and/or introduction of chemical reductants into the formation may be effective in reducing the effect of the ISR process and immobilizing redox sensitive parameters such as selenium, arsenic and uranium. Bioremediation has been demonstrated to be effective in a laboratory setting, but further studies are needed to demonstrate a positive effect in an actual mine unit. Cameco believes that bioremediation techniques for groundwater restoration can be developed and is actively researching this area.

Bioremediation is accomplished through the injection of nutrients into the groundwater so that native bacteria in the orebody can reduce redox-sensitive species such as metals. Nutrients include electron donors such as molasses, ethanol, methanol, cheese whey, cooking oil or other food sources. The choice of the nutrient is based on the native bacteria species present. The food that best stimulates biological remediation is determined by performing microcosm studies. A microcosm is an artificial, simplified ecosystem used to simulate and predict the behavior of the natural ecosystem under controlled conditions.

Prior to implementing a bioremediation program Cameco will submit a proposal to the NRC and LQD for review and concurrence including:

- The stated goal of the bioremediation, and the target conditions that will be evaluated during the program.
- A control plan to limit oxygen introduction into the formation.
- The testing results addressing the carbon source and its effect on the bacterial population in the wellfield.
- A discussion on the nutrient forms such that they can be uniformly applied to the wellfield.
- The target concentrations in the wellfield for the nutrients and chemical additives (based on bench testing results).
- Assurance that the wells, piping, pumps etc. are in proper working order, prior to the test.
- A monitoring plan, which defines interim goals, while providing flexibility to make corrections depending on interim results.
- Procedures to address biofouling and undesirable precipitation (such as carbonate).

If a native bacterial assemblage is not available within the formation, chemical reductants may be required. Chemical reductants typically consist of a sulfur compound such as gaseous hydrogen sulfide (H_2S) or dilute solutions of sodium hydrosulfide (NaHS) or sodium sulfide (Na_2S).

6.1.4.5 Chemical Addition for pH Adjustment

Adjustment of pH may assist in immobilizing certain parameters, particularly metals. NaOH and KOH are commercially available and are commonly used for pH adjustment, although other pH adjusting chemicals may be used. This step may be combined with groundwater treatment and reinjection or as the final stage of injection.

6.1.4.6 Stabilization

Once the average concentration of the recovery stream meets the goals as stated above, the restoration operation will terminate in that mining unit. A final round of samples will be collected from the designated restoration sampling wells to document the success of the aquifer restoration program. At this point, the post-restoration stability monitoring period will begin and continue for 12 months. The post restoration monitoring will include quarterly sampling of the MP wells and sampling of the monitoring wells (M, MO and MU wells) once every two months.

If no significant increasing trends are identifiable during the stabilization period, restoration will be deemed successful. A summary report requesting approval of restoration will be submitted along with the appropriate water quality data. After written notice is received that restoration has been achieved, wells will be plugged and the surface reclaimed as described later. Stabilization sampling is discussed in more detail in Sections 6.1.5.2 and 6.1.5.3.

6.1.4.7 Wastewater Disposal

The excess water created by the restoration process is disposed of through land application and/or deep well injection. There are currently (January 2012) 10 Class I deep disposal injection wells permitted (eight of which have been drilled) for the disposal of excess water generated by both mine unit and yellowcake processing operations. In addition to the deep disposal wells, PSR-2 and a land application facility allows for the disposal of treated process water by evaporation and land application.

The groundwater extracted and treated during production and restoration contains selenium. The Satellite No. 2 Selenium Treatment Facility treats water from Satellites No. 2 and 3 for the removal of selenium, thereby allowing a treated stream to be discharged into PSR-2 for eventual disposal by land application. The Selenium Treatment Facility also includes a radium removal circuit. After removal of uranium and Ra-226, the water is pumped into selenium removal columns where the selenium is captured in an iron-sand media. When the media reaches selenium saturation, the media is removed, dewatered, and disposed at a NRC licensed disposal facility. New iron-sand media is installed in the selenium removal column, and the column is put back into service.

Operating experience has shown that the rate of land application and evaporation during the summer months sufficiently reduces the contained volume (water level) in PSR-2 such that continuous inflow to the reservoir can occur during the winter months when land application cannot be done.

The current plan for water disposal at the North Butte Remote Satellite is to dispose of excess water exclusively through deep well injection. North Butte has two permitted UIC Class I disposal injection wells, and one of them has been installed (January 2012). Additional disposal wells will be permitted and installed as required. It is estimated that four UIC disposal wells will be required over the life of the North Butte Satellite.

Two surge ponds will be maintained at North Butte to store wastewater from the satellite facility prior to deep well injection. The design of the ponds meets the guidance provided in NRC Regulatory Guide 3.11 (NRC, 2008) and the standards provided in 10 CFR Part 40, Appendix A, Criterion 5(A).

At the Gas Hills Remote Satellite, excess water will be disposed of in evaporation ponds and/or through deep well injection. Cameco is drilling two test injection wells for determination of a suitable receiving formation and its hydraulic properties of the formation. Initially, two evaporation ponds will be constructed and four additional ponds will be installed during the life of the project. The design of the evaporation ponds meets the guidance provided in NRC Regulatory Guide 3.11 (NRC, 2008) and the standards provided in 10 CFR Part 40, Appendix A, Criterion 5(A).

The wastewater disposal methodology at the Ruth Remote Satellite has not been determined. Two evaporation ponds remain from the Ruth R&D project, and these ponds may be used again once Ruth becomes operational. Deep well injection may also be considered, although no permitted wells currently exist.

6.1.4.8 Restoration of Stacked Ore Horizons

Restoration of stacked ore horizons is conducted through either twinned or recompleted wells, depending upon the separation distance between the two completion intervals. If the separation distance is small (< 15 feet), restoration will be conducted as for single-well completions. If the separation distance is greater than 15 feet, restoration will be performed in a slightly different manner. After the lower-most completion zone has been mined out, the injection/production wells will be temporarily sealed using a neat cement slurry or other methods approved for use by the WDEQ/LQD. Mining will then progress to the upper zone. After mining has been completed in the upper zone, the temporary seals in the lower zones will be removed thereby opening the wells to both mining zones. Restoration will then proceed as for a single completion well with the same target restoration and stability values for both zones treated as a single hydrologic unit.

Needed restoration pore volumes will be estimated using the same criteria as for single completion mine units. The key parameter in calculating pore volumes is the thickness of the completed screen interval plus the vertical flare factor. Prior to starting production in the second completion, the pore volume calculation will be revised to incorporate the thickness of the additional completion interval. The revised values will be included in the updated surety calculations. If twinning is used instead of multiple completions, the total pore volume of both completion intervals will be calculated and provided in the surety estimate prior to production from the first interval.

6.1.5 Groundwater Restoration Monitoring

6.1.5.1 Operational Monitoring

At the start of groundwater restoration in each mine unit or portion thereof, groundwater from each MP well is sampled and analyzed for the parameters in **Table 6-2, Groundwater Restoration Monitoring Parameters,** and compared to the MP-wells baseline characterization of that mine unit. This sampling effort will characterize an "end of injection" water quality average. To track the progress of restoration the MP wells in active restoration areas will be sampled and analyzed for conductivity, chloride and uranium once every two months, with at least 45 days between sampling events. In the event inclement weather or malfunction delay scheduled groundwater sampling for more than seven days, Cameco will notify the NRC and LQD. Depending on the results of initial restoration sampling, other parameters, such as selenium, may be tracked during restoration to evaluate the need for bioremediation/reductant addition, pH control, etc.

The perimeter wells (M wells), overlying aquifer wells (MO or MS-wells), and underlying aquifer wells (MU or MD-wells) are sampled once every two months (with at least 45 days between sampling events) and analyzed for the excursion parameters chloride, total alkalinity or bicarbonate, and conductivity. Static water levels are also measured in these wells prior to sampling.

6.1.5.2 Restoration Stability Sampling

Once active restoration has been completed, Cameco will notify LQD and NRC and submit a restoration report that documents how restoration was conducted, data to support the decision to enter stability monitoring, and the current end of restoration mine unit conditions. Following the submission of the restoration report, a minimum one-year stability monitoring period commences to demonstrate that the restoration standard can be maintained. The groundwater restoration stability monitoring program consists of:

1. Continued routine excursion monitoring for alkalinity, chloride and conductivity at M, MO and MU monitor wells.
2. Sampling of the MP-wells at the beginning of the stability period and quarterly thereafter. **The minimum sampling period per Cameco Resources LQD Permit to Mine 633 is one year. (one end of mining sample and four quarterly samples.)** LQD, NRC and/or Cameco may determine that additional stability sampling beyond the first five events may be necessary. **Cameco will continue sampling until enough data is gathered to obtain a robust statistical sample for the constituents of concern (up to three years). The final number of sampling events required for the stability statistical analysis will be determined on a mine unit by mine unit basis.** Samples will be analyzed for the parameters in **Table 6-2**.
3. Restoring wells on excursion status to 10 CFR 40, Appendix A Criterion 5B(5) standards or approved ACL concentrations.
4. In the event that one agency (NRC or WDEQ) approves restoration of a mine unit before the other agency has concurred that restoration is complete, excursion sampling of the M, MO

and MU monitoring wells will continue at a specified schedule based on site specific conditions and determined through hydrologic analysis to ensure protection of down gradient groundwater.

In the event inclement weather or malfunction delay scheduled groundwater sampling for more than seven days, Cameco will notify the NRC and LQD.

Routine excursion monitoring for alkalinity, chloride and conductivity at perimeter, overlying and underlying monitor wells will continue until NRC approves restoration. The MP-wells will be sampled at the beginning of the stability period and quarterly thereafter. Cameco will consult with NRC should additional restoration stability monitoring appear to be required after completing the initial four quarters of stability monitoring. Should the stability monitoring show that the mine unit is not stable, Cameco will continue to monitor quarterly for up to three additional years. After three years, Cameco will discuss the statistical analysis of the data, an alternative monitoring plan, and a corrective action plan as part of an ACL application to the NRC. Cameco will apply appropriate groundwater statistical and modeling methodologies to analyze the groundwater quality data and to determine potential trends.

6.1.5.3 Determination of Restoration Success

At the end of the stability period, Cameco will evaluate mine unit groundwater restoration and stability by (a) comparison of groundwater monitoring data to the RTVs and (b) no increasing indicator parameter concentrations. Cameco will prepare a report of this evaluation for regulator review and approval. Should the stability data show that the mine unit is not stable, stability monitoring will continue for up to an additional three years. After three years Cameco will discuss with NRC the statistical analysis of the data, an alternative monitoring plan, and a corrective action plan as part of an ACL application.

After concurrence from the WDEQ and NRC that the restoration goals have been achieved and stability criteria have been met, decommissioning and surface reclamation of the restored area will be initiated as described in Sections 6.2 and 6.3.

6.1.6 Smith Ranch Restoration History

6.1.6.1 Mine Unit 1

Mine Unit 1 has been undergoing restoration since September 2006. Mine Unit 1 produced from 1997 to 2006. Groundwater sweep was performed until May 2007. The RO and de-carbonation phase began in May 2007. The de-carbonation system was shut down in November 2009 to eliminate residual oxygen from the system being sent back to the aquifer. As of July 25, 2011, sodium sulfide is being added to the system as a reductant concurrent with RO treatment. Restoration using RO reinjection and sodium sulfide addition in Mine Unit 1 is continuing as of January 2012.

6.1.6.2 Mine Unit-4/4A

Mine Unit 4/4A has been undergoing restoration since December 2010. Mine Unit 4/4A produced from September 1999 to December 2010. RO treatment continued until April 2011, when technical issues related to the reject brine IX recovery process necessitated temporary cessation of restoration. Restoration activities recommenced in May 2011. Additional groundwater modeling has been performed and replacement wells will be installed in those areas of the mine unit that require them.

6.1.7 Highland Restoration History

6.1.7.1 Mine Unit A

In November 2003, LQD conditionally approved Mine Unit A restoration after concluding that the restoration effort used BPT, and the groundwater had been restored to its class of use. The NRC approved the Mine Unit A restoration on January 15, 2004 (see also PRI / Kearney, 2004). However, Both LQD and NRC wanted additional monitoring to validate the fate and transport model, which predicted that the downgradient groundwater quality would be protected through natural attenuation. As a condition of approval of the groundwater restoration in Mine Unit A, the LQD required continued long-term monitoring downgradient of the restored mine unit. A Long-Term Monitoring (LTM) Plan was approved by the agencies and implemented beginning June 2004. The LTM predicted that Ra-226 and redox sensitive parameters should decrease over time as the restored groundwater moved toward and through the more reducing environment; specific target end values were not proposed. Mine Unit A produced from 1988 to 1991. Active groundwater restoration was performed from 1991 to 1998, followed by a 13-month stability monitoring period from February 1999 to April 2000. Pursuant to a 1996 discussion with LQD, it was agreed that a calculated pore volume is equivalent to 3.7 hectare-meters (30 acre-feet) of water. Pore volumes of groundwater extracted and/or treated and reinjected were as follows:

- 1.3 pore volumes of groundwater sweep.
- 12.4 pore volumes of RO sweep.
- 1.95 pore volumes of groundwater sweep for excursion control.
- 1.9 pore volumes of recirculation for reductant addition.
- 0.2 pore volumes of groundwater sweep during recirculation for excursion control.

The LTM plan was implemented from June 2004 through March 2005, when NRC gave final approval of Mine Unit A restoration. Cameco plugged and abandoned the Mine Unit A wells in accordance with applicable rules and regulations, as reported to LQD in the 2005 third and fourth Quarter Reports.

Actual groundwater concentrations are similar to those predicted in the LTM Plan to occur by natural attenuation. Wells MP-4 and I-21 are completed in the production zone, and samples from these wells are representative of restored production fluids. LTM-4 is a monitor well completed in the flare from the production zone. M-3 and M-4 are wells completed in the 20-Sand down gradient of Wells MP-4, I-21, and LTM-4. Actual concentrations of Fe, Mn, Se, and Ra-226 down gradient of MP-4 are similar to the concentrations at the perimeter wells. While uranium concentrations are slightly higher than predicted, Well LTM-4 (inside the monitor well ring) exhibits uranium concentrations below the baseline concentration of 0.05 mg/L.

6.1.7.2 Mine Unit B

WDEQ approved Mine Unit B groundwater restoration on April 2, 2008. Mine Unit B was in production from January 1988 to July 1991. Active groundwater restoration was performed from July 1991 to June 2004, followed by a six-month stability period from June to December 2004. LQD raised concerns about Well BM-42, groundwater from which had reported excursion parameters and uranium concentrations exceeding the UCLs since November 2002. As detailed in 3.10.2.1, groundwater collected from a well subsequently installed to replace Well BM-42 did not exhibit excursion, and LQD agreed that Well BM-42 had been restored to class of use.

Because of WDEQ concerns about elevated arsenic concentrations reported in groundwater from Wells MP-14, MP-21 and MP-22, an additional six months of stability sampling was conducted. The additional sampling results showed arsenic concentrations decreasing over time and that the mine unit average arsenic concentration was less than the drinking water standard. Another set of samples collected in

October 2006 demonstrated groundwater quality stability within the mine unit. Final pore volumes of groundwater extracted and/or treated and reinjected were as follows:

- 2.93 pore volumes of groundwater sweep
- 13.47 pore volumes of RO sweep
- 0.92 pore volumes of recirculation for uranium removal
- 0.88 pore volume of bioremediation treatment
- 1.09 pore volume of sodium sulfide treatment
- 5.22 pore volumes of bleed for hydraulic control

PRI initially submitted a groundwater stability report to LQD in 2005 (PRI, 2005). In June 2009, Cameco wrote to request that NRC approve Mine Unit B restoration (Cameco, 2009). NRC rejected the request (USNRC, September 2010) because (a) Well BM-42 remained on excursion status and (b) Mine Unit B had been pumped during the stability (no pumping) period. The NRC had stated in NRC Regulatory Issue Summary 2009-5 (1) The Process for Scheduling Licensing Reviews of Applications for New Uranium Recovery Facilities; and, (2) The Restoration of Groundwater at Licensed Uranium In Situ Recovery Facilities that NRC determined that “Criterion 5B of Appendix A, of 10 CFR Part 40 contains the appropriate standards that will be applied to groundwater restoration at ISR facilities”.

The mine unit average concentrations of uranium and other constituents exceed baseline concentrations and the limits from Criterion 5B of Appendix A. In May 2013, Cameco submitted to the NRC for evaluation and approval of an ACL application for Mine Unit B under 10 CFR Part 40, Appendix A, Criterion 5 (C). As of July 2014, the ACL application remained under review.

6.1.7.3 Mine Unit C

Production from the 50-Sand aquifer in Mine Unit C began by injection of lixiviant in the C8 and C10 pattern groups in July 1989. Injection of lixiviant into the last group of patterns remaining in production was stopped on May 11, 1999. Preparation for restoration of the groundwater in the northern portion of Mine Unit C began in the spring of 1997.

Groundwater Recirculation and Degassing

In July 1999, PRI completed construction of a groundwater IX recirculation loop between the northern portion of Mine Unit C and Satellite No. 2 to reduce the concentration of residual uranium which remained in solution after production had ended. The second phase of this operation was to remove residual carbon dioxide gas from the re-circulated groundwater. A de-carbonator was installed for this purpose at Satellite No. 2 and began operating on March 7, 2003.

However, in early 2009, the use of the de-carbonator unit was discontinued due to concerns related to re-introducing oxygen into the injection stream. The addition of oxygen into the injection stream is believed to keep uranium in solution, such that it inhibits the desired precipitation of uranium. Also, the addition of oxygen to the injection stream may be a contributing factor to the increase in uranium concentration by mobilizing additional uranium in the ore zone of the formation. Groundwater recirculation and degassing was discontinued at Satellite No. 2 by May 31, 2010.

Reverse Osmosis

Three RO units were installed in 2006, and the RO permeate was passed through the de-carbonator. However, in order to proceed with the Mine Unit C Bioremediation Project, Cameco discontinued use of RO units as of April 10, 2009 after LQD approval (LQD, April 2009).

Bioremediation Project

Cameco proposed bioremediation to assist with groundwater restoration. Bioremediation had previously been used in Mine Unit B to lower the groundwater selenium concentration, achieving selenium concentrations averaging 0.009 mg/L at the end of active groundwater restoration.

After the success of the Mine Unit B Bioremediation Program, further laboratory experiments were conducted to identify other food sources that would stimulate the naturally occurring bacteria present in the aquifer on site and return the aquifer to reducing conditions faster than what was achieved in Mine Unit B. Laboratory tests identified two potential food sources better for stimulating the growth of the naturally occurring bacteria and accelerating the reduction of selenium, uranium, and other redox sensitive ions. Limited bioremediation testing using the new food began in February 2006. Plugging problems associated with the well screens were experienced using only cheese whey as a substrate, and the experiment was suspended. Cameco reviewed the substrate injection and surmised that switching the substrate to a combination of methanol plus cheese whey would relieve some of the plugging problems experienced using cheese whey only.

WDEQ approved Cameco's request to proceed with bioremediation throughout Mine Unit C, and the program began with injection of substrate on April 20, 2009. The concentration of selenium plunged early in the experiment and remained low throughout the project. However, bioremediation did not reduce uranium concentrations as expected, and the bioremediation project ended in January 2010.

Cameco submitted a report to LQD (Cameco, March 2010) concluding that the results of the bioremediation program were inconclusive because the project was hampered by biologic and chemical factors. The most important of these was the inadequate injection/delivery of substrate to the formation because of inoperative wells in portions of the mine unit (failed wells), wells clogging during the course of organic carbon addition, and the existence of an adjacent underground mine drift. The plugging problem appeared limited to the well bore and, in many instances, jetting and swabbing restored flow to the wells. A secondary problem was oxygen contamination from forced draft de-carbonation and from wells pumping off. The LQD reviewed, commented on, and asked questions about this report (WDEQ, April 2010). Cameco responded to LQD comments during the 3rd Quarter of 2010.

Cameco submitted a conventional groundwater restoration plan for Mine Unit C to LQD (Cameco, February 2011). Restoration in Mine Unit C is continuing as of January 2012.

6.1.7.4 Mine Units D and D-Extension

Mine Units D and D-Extension have been in active restoration since April 2011. Injection of lixiviant into the last group of patterns remaining in production was halted in April 2007 in Mine Unit D and February 2007 in Mine Unit D-Extension because of the need for infrastructure upgrades. Infrastructure upgrades began in winter 2009, and, Cameco installed 35 replacement wells in the mine unit between June 2010 and April 2011.

6.1.7.5 Mine Unit E

Mine Unit E is currently (2012) undergoing restoration preparations, including the installation of 177 replacement wells and refurbishment of header houses. GWS is still occurring in some areas and RO treatment is ongoing at those header houses that have received adequate GWS.

6.1.8 Groundwater Restoration Improvements

Since the previous license renewal, Cameco has developed and implemented several procedures that have resulted in improving and expediting groundwater restoration within the Smith Ranch site mine units. Cameco will continue during the next license period to research, experiment, and adjust operations that effect more timely and cost effective groundwater restoration at the Smith Ranch project sites.

Prior to restoration, Cameco reviewed injection well MIT reports for Mine Units C, D/D-Extension, E, 1, and 4 to determine if wells needed to be repaired/replaced and whether additional injection/production wells may be needed to facilitate restoration. This assessment resulted in the replacement/addition of approximately 300 wells within these wellfields to provide sufficient coverage for enhanced groundwater recovery and more effective overall restoration. Pre-restoration well assessment will be continued in the future.

Prior to restoration, Cameco also inspected and refurbished header houses at Mine Units C, D, E, 1 and 4, including bellholes and pipelines. The purpose of refurbishment was to reduce restoration delays and interruptions caused by forseeable equipment and materials failures. Inspection and refurbishment will be continued throughout restoration to maximize and more effectively direct restoration flow. Pre-restoration header house assessment will be continued in the future.

Cameco has continued to expand disposal capacity for GWS and RO reject water since the last license renewal. Currently at the Smith Ranch-Highland site, wastewater is disposed of via seven Class I UIC deep disposal wells and one land application irrigator system. Cameco completed rehabilitation activities (a.k.a. work over) on the Morton and Vollman deep disposal wells to restore injection capacity for the disposal of restoration brines and other fluids. Cameco installed three additional deep disposal wells (SHRUP 6, SHRUP 9 and SHRUP 10) during the renewal period, which created even more disposal capacity. For long-term maintenance of injection well infrastructure, Cameco initiated an anti-scalant treatment program to preserve well integrity and maintain injection efficiency. Cameco permitted three additional deep disposal wells under the UIC regulations that will be installed as needed for disposal capacity. To maximize restoration, RO capacity was increased from 3,410 liters per minute (900 gpm) to approximately 8140 liters per minute (2,150 gpm) during 2011-2012.

In some cases such as in complex hydrogeological settings, Cameco may also use groundwater flow and mass transport model simulations as a tool to optimize the restoration process.

Effluent disposal via land application previously was limited or prohibited by selenium and radium concentrations exceeding the land application permit limits. However, technology advancements and infrastructure development have reduced selenium and radium concentrations to levels allowed for land application. Cameco constructed a Selenium Removal Plant adjacent to Satellite-2 to treat wastewater after radium removal and prior to land application. The plant removes sufficient selenium from the water to allow the continued use of PSR-2 and the related pivot irrigator. Evaluation of selenium removal and subsequent land application indicate that land application of the treated wastewater does not pose a substantial risk to public health or the environment.

Cameco conducted groundwater restoration bioremediation experiments at the Smith Ranch (in 2003) and Crow Butte (in 2009) facilities. Nutrients used in these experiments included methanol coupled with molasses. Subsequent experiments were performed using cheese whey coupled with methanol. The results of these small-scale experiments showed that bioremediation works to reduce redox-sensitive constituents but can be problematic to implement. Cameco continues to explore the possibility of bioremediation as an aid to restoration through a research partnership with the University of Wyoming.

Cameco is committed to continuing research efforts in the area of groundwater restoration to identify process risks and technology or methodologies that can be used to reduce the volume of water that needs to be treated to achieve desirable restoration outcomes. Additional in-house studies designed to provide methods for increasing disposal capacity and improving water management are ongoing and will also serve to accelerate restoration progress. Cameco is also working with the University of Wyoming School of Energy Resources on other research topics in ISR restoration of potential benefit to the Wyoming uranium industry. These research programs are being funded by the State of Wyoming.

Other ongoing restoration research programs being conducted at the Smith Ranch-Highland site include:

- Field evaluation of the restorative capacity of the aquifer down gradient of an active uranium ISR mining site during the operational phase, through Los Alamos National Laboratory.
- Critical Evaluation of Restoration Goals based on Improved Geochemical and Toxicological Characterization of Baseline and Post-Mining Site Conditions, through Colorado State University and South Dakota School of Mines.
- Cameco has also allowed researchers from Lawrence Berkley Laboratory and the USGS access to core material for groundwater restoration research programs that are funded by other outside sources.

6.1.8.1 Ruth Restoration History

The Ruth R&D project restoration was conducted from February 1984 through December 1984. During this restoration phase the TDS were reduced in the affected groundwater using a phased plan incorporating RO technology, together with a reduction phase using hydrogen sulfide gas. At the termination of the restoration phase, the stabilization period was initiated and continued through December 1985. Both the NRC and WDEQ approved the restoration in letters dated February 1986 and March 1986, respectively.

6.2 Decontamination and Decommissioning

6.2.1 Introduction

The goal of surface reclamation is to return disturbed areas to their pre-ISR land use of livestock grazing and wildlife habitat. The baseline soils, vegetation and radiological data will be used as a guide in evaluating final reclamation success. Vegetation success criteria will be in accordance with Section 6.2.4 of this TR. In concurrence with the landowner desires and approved by the NRC and WDEQ, an alternative use may be justified. For example, if the landowner desires to retain certain roads or buildings, this will be discussed with the regulatory agency.

As stated in Section 6.1 of this TR, 10 CFR 40.42 requires timely groundwater restoration and decommissioning/surface reclamation of uranium recovery facilities, including ISR facilities. The following sections generally describe the planned decommissioning activities and procedures for SUA-1548 facilities. At least 12 months prior to the planned commencement of final decommissioning of the entire license area or an individual area within the license, Cameco will submit to NRC a detailed Decommissioning Plan for their review and approval. The final decommissioning plan will include a description of:

- Planned decommissioning activities,
- Structures and equipment to be decommissioned,
- Methods planned to ensure protection of workers and the environment from radiation hazards,
- The planned final radiation survey (benchmark analysis), and

- An updated, detailed cost estimate.

6.2.2 Well Plugging and Abandonment[3]

Following regulatory concurrence by both WDEQ and NRC that groundwater restoration has been completed within a mine unit or for the license area as a whole, wells will be abandoned in accordance with applicable State and Federal regulations. Following are typical well abandonment requirements:

1. The abandonment material may be neat cement slurry, sand-cement grout, bentonite chips or other plugging materials as approved by the LQD Administrator, which will prevent the movement of fluids into or between unauthorized zones or water-bearing strata.
2. Except for bentonite chips, the abandonment material will be mixed with water and pumped through the drill pipe, or a tremie pipe in the case of a hose reel, filling the well from bottom to top.
3. The well will remain open for at least 48 hours to allow for settling of the abandonment fluid. As needed, additional abandonment materials will be added to the well until the well has been plugged to within at least 0.6 meters (2 feet) of the surface.
4. After the fluid level has stabilized, the soil around the well collar will be excavated to expose the casing to at least 0.6 meters (2 feet) bgs. The casing will then be cut off at a minimum of 0.6 meters (2 feet) bgs.
5. A cement or concrete hole plug will be placed in the top of the casing. If cement is used to plug the well and it is within 0.9 meters (3 feet) of the surface, a concrete plug will not be required.
6. If the abandoned well is a monitor well contained within a monitor well ring surrounding a mine unit, a steel plate will be placed on top of the well casing concrete plug showing the permit number, well identification, and date of plugging. The marking device will be installed at a minimum depth of 0.6 meters (2 feet) bgs.
7. The excavated area around the abandoned well and any surface disturbance will be backfilled with the excavated material to the original surface and seeded with the approved seed mixture.
8. A written abandonment report will be completed for each abandoned well, providing detailed documentation of the abandonment, which will be placed in the individual well file and reported to WDEQ and the WSEO in accordance with LQD Rules and Regulations Chapter 11, Section 15(e).
9. The boundaries of each mine unit and the location of the monitor well ring around each mine unit will be recorded as a deed notice with the appropriate county, in accordance with LQD Rules and Regulations Chapter 11, Section 8(h)(i).

Should a well have artesian flow to the surface, a counter pressure will be applied to force the abandonment fluid into the annular space of the well. This counter pressure will be maintained for the length of time required for the abandonment fluid to set or fully hydrate to permanently seal off the flow and/or pressure of the artesian aquifer such that surface or subsurface leakage will not occur. The well

[3] This section has been revised to ensure that it complies with WDEQ/LQD Rules and Regulations Chapter 11 revisions enacted November 20, 2013 and Cameco well abandonment procedures.

will then be abandoned as described in 1 through 9 above. Written abandonment reports for wells that are artesian to the surface will be submitted to the appropriate State agencies.

6.2.3 Surface Disturbance

Construction of ISR processing facilities causes long-term surface disturbances. Lesser surface area is also disturbed short term during well drilling, pipeline installations, road construction, and header house construction. Disturbances associated with drilling, mine unit construction and pipeline installation are relatively limited and are reclaimed and seeded in the same season. Vegetation typically can be re-established over these areas within two years of the initial disturbance.

6.2.4 Surface Reclamation

All disturbed surfaces will be scarified and contoured, if necessary, followed by topsoil placement and seeding with the WDEQ-approved seed mix. As ISR construction does not necessitate major changes in the natural topography, no major recontouring is anticipated, and the existing ground topography will closely mirror the final ground topography.

The reclamation area will not be left as a "hole," nor will it be significantly elevated above the existing ground surface. Salvaged topsoil will be used for reclamation purposes, and stockpiled and salvaged topsoil will be replaced on the final ground surface. Areas to receive topsoil will be treated first with a harrow, chisel plow or conventional disk to relieve compaction. Topsoil will be placed in a single lift to avoid compaction. If necessary, the replaced topsoil will be disked to create a proper seedbed. On slopes of 4H:1V or flatter, topsoil will be placed along the contour. Topsoil thicknesses generally will be uniform and reflect the approximate thickness of topsoil originally available at the locality being reclaimed. Cameco will determine this replacement thickness on site, typically by augering adjacent undisturbed surface to determine original topsoil thickness. The undisturbed ground will be smoothly transitioned into the disturbed ground following replacement of the topsoil. Topsoil will not be placed if site conditions are excessively wet, dry or frozen. Such ground conditions would cause excessive clods or frost chunks to form and may impart undesirable physical characteristics to the final seedbed.

Once the surface reclamation activities are completed, the area will be seeded with the approved seed mix. Seeding is completed in the spring or fall during the year in which the topsoil is replaced. Seeding is completed either during the fall seeding window (mid-October until frozen ground conditions) or, if spring seeding is required, no later than mid-April. Seeding is typically done using a drill seeder, or seed may be hand broadcast if the area is small.

In addition to seeding areas that require topsoil replacement, seeding will also occur where vegetation has been removed or disturbed. These would most likely be areas within the mine units where no topsoil was removed and normal operations have impacted the vegetation. These areas will be scarified to loosen the surface soil prior to seeding. No seeding will be conducted when the ground is frozen or snow covered. The reclaimed surface will be available for unrestricted use at the end of the decommissioning/reclamation process.

6.3 Procedures for Removing and Disposing of Structures and Equipment

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to decommissioning of structures, equipment or scrap, preliminary radiological surveys will be conducted to characterize the levels of contamination on structures and equipment and to identify potential hazards. These surveys will include alpha, beta and gamma surveys and smear surveys, where appropriate. In general, the operational contamination control program, as discussed in Section 5.8.6 of this TR, will be applicable to decommissioning of structures. The surveys will support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This initial decontamination will generally consist of washing accessible surfaces with high-pressure water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used. The wash water will be contained and properly disposed.

6.3.2 Removal of CPP, CPF and IX Buildings and Ancillary Equipment

The majority of the equipment in the process buildings as well as the buildings themselves, may be reusable, depending on age and functionality. Alternatives for the disposition of buildings and equipment are discussed below.

All potentially contaminated equipment and materials including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

1. Removal to a new location within SUA-1548 for future use;
2. Removal to another licensed facility for use;
3. Decontamination to meet unrestricted use criteria for release, sale or use by others; or
4. Disposal at an NRC-licensed disposal facility, if the equipment or materials cannot be decontaminated to unrestricted release criteria.

It is anticipated that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts are unsuccessful, the material will be transported to an NRC-licensed disposal facility. Cement foundation pads and footings will be broken up and (a) buried on site if approved by the regulatory agencies and surface owners, (b) transported to a solid waste disposal site, or (c) if contaminated, transported to an NRC-licensed disposal facility.

6.3.2.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with NRC guidance. Release limits for alpha radiation are as follows:

- Removable alpha contamination of 1,000 disintegrations per minute/100 square centimeters.
- Average total alpha contamination of 5,000 disintegrations per minute/100 square centimeters over an area no greater than 1 square meter.
- Maximum total alpha contamination of 15,000 disintegrations per minute/100 square centimeters over an area no greater than 100 square centimeters.

Decontamination of surfaces will be to ALARA . Non-salvageable contaminated equipment, materials, and dismantled structural sections will be transported to an NRC-licensed disposal facility. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR 173.427.

Any underground or above-ground petroleum storage tanks will be closed in accordance with Wyoming Statute 35-11 Article 14 (Wyoming Storage Tank Act of 2007), as applicable. If the tank(s) is registered with the WDEQ/Storage Tank Program, the Program authorities will be notified of the proposed closure, and Cameco will coordinate required closure sampling.

6.3.2.2 Preparation for Disposal at Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(2) byproduct material, the following procedures will be used.

- Exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated, equipment will be washed down to permit safe handling.
- Equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.
- Equipment in the building such as large tanks may be transported on flatbed trailers. Smaller items such as links of pipe and ducting material will be crushed to reduce the volume and placed in lined roll-off containers or covered dump trucks, or drummed for delivery to the disposal facility.
- Contaminated buried main trunk lines and sump drain lines will be excavated and removed for transportation to an NRC-licensed disposal facility.
- Contaminated HDPE liners and contaminated soils underlying the surge ponds and reservoirs will be excavated and removed for transportation to an NRC-licensed disposal facility.

6.3.3 Waste Transportation and Disposal

Pursuant to License Condition 9.6 of SUA-1548, materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed at an NRC-licensed disposal site. A current disposal agreement will be maintained with a minimum of one licensed disposal facility throughout the duration of licensed operations. Should Cameco contract with a new disposal facility, Cameco will notify the NRC in accordance with License Condition 9.6 of SUA-1548.

Transportation of contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be conducted in accordance with the DOT Hazardous Materials Regulations (49 CFR Part 173) and the NRC transportation regulations (10 CFR 71).

6.4 Procedures for Conducting Post-Reclamation and Decommissioning Radiological Surveys

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium.

“Benchmark” modeling will be performed and submitted with the decommissioning plan required by License Condition 9.11 of SUA-1548. The NRC issued a Final Rule (64 FR 17506) on April 12, 1999 that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. An amendment to Criterion 6(6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site decommissioning plan or included in license applications. Cameco will use RESRAD Version 6.4 or later versions to calculate radiation doses and estimate cancer risks to the existing population groups and to derive cleanup standards for radioactively contaminated soils.

Cameco will use site-specific parameters and NRC guidance (Appendix E to NUREG-1569) to conduct benchmark modeling. This guidance discusses acceptable models and input parameters.

6.5 Financial Surety

6.5.1 Financial Surety Estimates and Arrangements

Cameco maintains NRC-approved financial surety arrangements in the form of letters of credit (LCs) issued for each individual site licensed under SUA-1548. Consistent with 10 CFR 40, Appendix A, Criterion 9, which states in part *"…In order to avoid unnecessary duplication and expense, the Commission may accept financial sureties that have been consolidated with financial or surety arrangements established to meet requirements of other Federal or state agencies…,"* the NRC has accepted financial surety instruments listing the WDEQ as the "beneficiary" and/or the WDEQ and Department of Interior, BLM, together as "co-beneficiaries." The amounts of the LCs are based on estimates that assume third-party costs and incorporate reclamation obligations for both existing operations and planned expansions within the upcoming year. The term "reclamation" encompasses groundwater restoration, facility decommissioning and surface reclamation activities, including the off-site disposal of 11e.(2) byproduct material.

License Condition 9.5 of SUA-1548 requires submittal of a revised financial surety arrangement within three months of NRC approval of a revised closure plan (if the estimated costs exceed the amount covered in the existing LCs). It is Cameco's understanding that this condition does not apply until final decommissioning activities are performed on a project-by-project basis.

Proposed annual updates to the financial surety amounts for each project are submitted to the NRC at least 90 days prior to the anniversary dates listed in License Condition 9.5 of SUA-1548. These dates coincide with the WDEQ Permit to Mine Annual Report and Surety Estimate Update due dates and allow for coordination and submittal of the annual updates to multiple agencies (NRC, WDEQ, and BLM) at one time. Cameco's LCs are issued on an annual auto-renewal basis to ensure that the financial surety arrangement is extended for one year in the event NRC has not approved a proposed financial surety update within 30 days of the LC's expiration (i.e., auto-renewal) date. Cameco's annual updates include the necessary supporting documentation and detail showing a breakdown of costs and basis for cost estimates, including adjustments for inflation (e.g., based on Consumer Price Index) and maintenance of a 25% contingency.

In the event of plans for expansion or operational changes that were not included in the previous year's surety update, Cameco submits an updated financial surety package for NRC approval at least 90 days prior to the commencement of construction activities. Cameco coordinates submittal of the annual updates to both agencies (NRC and WDEQ) and forwards copies of the WDEQ's surety review(s) and final surety arrangements upon WDEQ approval. The annual estimate updates identify NRC-related aspects (e.g., decontamination, decommissioning, 11e.(2) byproduct disposal, etc.) and are consistent with the groundwater restoration, facility decommissioning and surface reclamation portions of the license application for the project. The annual estimates are also consistent with Appendix C to NUREG-1569.

Cameco continuously maintains NRC-approved LCs in the amounts identified in License Condition 9.5 of SUA-1548. A comparison between the (minimum) financial surety amounts identified in SUA-1548, Amendment No. 16, and current (August 2011) LC amounts are provided below:

- Smith Ranch — SUA-1548 Amount ($14,456,300)
  Current LC Amount ($120,044,303)
- Highland — SUA-1548 Amount ($21,278,100)
  Current LC Amount ($92,730,470)
- Ruth — SUA-1548 Amount ($181,000)
  Current LC Amount ($181,000)

- North Butte — SUA-1548 Amount ($442,000)
  Current LC Amount ($1,745,000)
- Gas Hills — SUA-1548 Amount ($1,944,000)
  Current LC Amount ($3,068,800)
- Reynolds Ranch — SUA-1548 Amount ($3,331,600)
  Current LC Amount ($78,839,439) (Included in Smith Ranch)

Cameco has recently submitted updated cost estimates associated with the North Butte and Gas Hills Remote Satellite Operations Plans updates, and will submit updated cost estimates for Ruth Remote Satellite and Reynolds Ranch Satellite at least six months prior to the expected commencement of construction of commercial facilities at these sites.

6.6 References

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Cameco/Angelo Kallas. March 5, 2010. Report to LQD/Lowell Spackman RE: Bioremediation Final Report, Mine Unit C Restoration TFN 5 6/97.

Cameco/Tom Cannon. February 23, 2011. Report to LQD/Lowell Spackman RE: Mine Unit C Biorestoration, Proposed Draft Plan for Completion of Restoration of Mine Unit, Permit 603, Cameco Resources (CR).

PRI/B. Kearney. January 14, 2004. Letter to USNRC/G. Janoskco RE: Smith Ranch-Highland Uranium Project, Docket No. 40-8964, SUA1548, A-Wellfield Groundwater Restoration Information.

PRI/B. Kearney, May 5, 2005, Letter to LQD/Lowell Spackman RE: Mine Unit B Ground Water Restoration Stability Report.

Rio Algom Mining Corp. 1991. Letter to WDEQ RE: Responses to Comments; Page 23 references EPA concurrence on groundwater classification and aquifer exemption.

US Environmental Protection Agency. 1990. Letter to WDEQ concurring with groundwater classification and aquifer exemption boundary for Smith Ranch.

US Environmental Protection Agency. 1990. Letter to WDEQ concurring with groundwater classification and aquifer exemption boundary for North Butte.

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