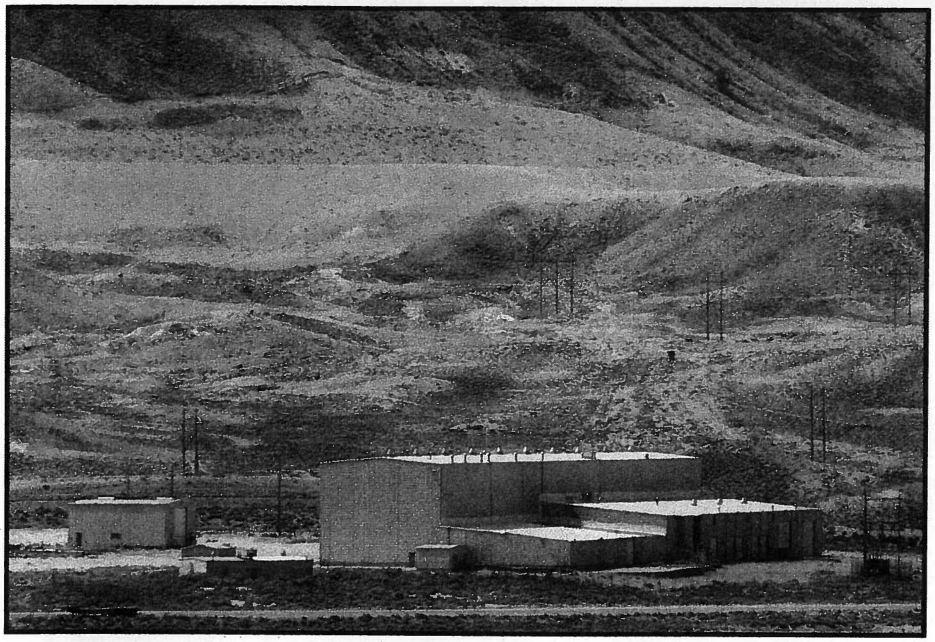
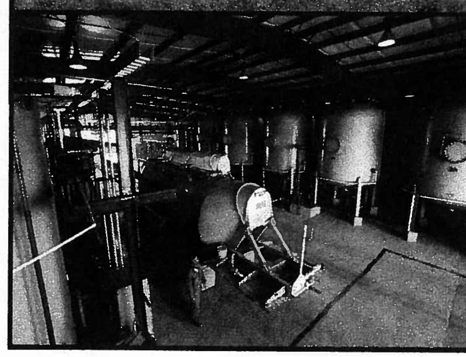
Nuclear Regulatory Commission

Source Material License No. SUA-1548

License Renewal Application

Technical Report





Cameco

Lidstone and Associates, Inc.
Engineering, Geology, & Water Resource Consulting

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APPENDICES

List of Acronyms

ACL	alternate control limit
ACS	American Community Survey
ALARA	as low as reasonably achievable
ALI	annual limit of intake
AML	Abandoned Mine Land (WDEQ)
Anadarko	Anadarko Petroleum Corporation
API	American Petroleum Institute
AQD	Air Quality Division (WDEQ)
AQS	Air Quality System
ASTM	American Society for Testing and Materials
ASCM	alternate sediment control measures
BCR	benefit-cost ratio
bgs	below ground surface
BLM	Bureau of Land Management (U.S.)
BMP	Best Management Practices
BPT	Best Practicable Technology
$CaCO_3$	calcite
Cameco	Cameco Resources (Power Resources, Inc.)
CAP	Corrective Action Plan
CBM	coal bed methane
CDL	Cropland Data Layer
CEQ	Council on Environmental Quality
CGA	Compressed Gas Association
Cleveland-Cliffs	Cleveland-Cliffs Iron Company
CO	carbon monoxide
COE	Corps of Engineers (U.S. Army)
CPF	Central Processing Facility
CPP	Central Process Plant
CRSO	Corporate Radiation Safety Officer
DAC	derived air concentration
DDE	deep dose equivalent
DOT	Department of Transportation (U.S. / Wyoming)
EA	Environmental Assessment
EC	effluent concentration
EAD	Economic Analysis Division (WDAI)
EDX	energy dispersive X-ray
EHS	Environmental Health and Safety
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency (U.S.)
ER	Environmental Report
Everest	Everest Mineral Corporation
EXREFA	Extended Reference Area
FAP	Federal American Partners
FONSI	Finding of No Significant Impact
GPD	Gross Domestic Product
gpm	gallons per minute
GWS	groundwater sweep
H_2O_2	hydrogen peroxide
H_2S	hydrogen sulfide
H_2SO_4	Sulfuric acid
HCL	hydrogen chloride
HDPE	high density polyethylene
Highland	Highland Uranium Project
HPT	Health Physics Technician

HWA	Hayden-Wing Associates, LLC
I-25	Interstate 25
I-90	Interstate 90
IGP	Industrial General Permit
IME	Inberg-Miller Engineers
IMPROVE	Interagency Monitoring of Protected Visual Environments
ISR	in situ recovery
IX	ion exchange
Km	kilometers
KMC	Kerr-McGee Corporation
KOH	potassium hydroxide
kV	kilovolt
Kw	kilowatts
LC	letters of credit
LLD	lower limit of detection
LQD	Land Quality Division (WDEQ)
LRA	License Renewal Application
LSA	low specific activity
LTM	long term monitoring
MBHFI	migratory bird of high federal interest
MCL	maximum contaminant level
MIT	mechanical integrity testing
MLRA	Major Land Resource Area
MSHA	Mine Safety and Health Administration
MW	megawatt
NA_2CO_3	sodium carbonate
NAAQS	National Ambient Air Quality Standards
Na_2S	sodium sulfide
$NaHCO_3$	sodium bicarbonate
NaHS	sodium hydrosulfide
NaOH	sodium hydroxide
NB	North Butte
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NH_3	ammonia
NLCD	National Land Cover Dataset
NCV	Non-Cited Violation
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NO_x	nitrogen oxide
NRC	U.S. Nuclear Regulatory Commission
NWS	National Weather Service
ORC	Operations Review Committee
O_2	oxygen
OSHA	Occupational Health and Safety Administration
PDC	polly diamond carbide
PLC	process logic controller
PM_{10}	particulate matter smaller than 10 micrometers
$PM_{2.5}$	particulate matter smaller than 2.5 micrometers
PMC	Pathfinder Mines Corporation
PRI	Power Resources, Inc.
PSD	Prevention of Significant Deterioration
PSR-1	Purge Storage Reservoir 1
PSR-2	Purge Storage Reservoir 2
PV	pore volume
PWS	Public Water System

QA	quality assurance
QC	quality control
R&D	Research & Development
RAMC	Rio Algom Mining Corp.
Real West	Real West Natural Resources Consulting
redox	reduction-oxidation
RMP	Resource Management Plan
RO	reverse osmosis
RSO	Radiation Safety Officer
RTV	restoration target value
RV	recreational vehicle
WSEO	Wyoming State Engineer's Office
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SFC	Sequoyah Fuels Corp.
SHEQ	Safety Health Environment and Quality (Manager)
SHEQMS	Safety Health Environment and Quality Management System
SHPO	State Historic Preservation Office (Wyoming)
SIA	Special Interest Area
SMC	Solution Mining Corp.
SO_2	sulfuric dioxide
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SR	Smith Ranch
SUA-1548	Source and Byproduct Materials License SUA-1548
SWPPP	Storm Water Pollution Prevention Plan
T&E	threatened and endangered
TCP	Traditional cultural property
TDS	total dissolved solids
TED	total effective dose
TEDE	total effective dose equivalent
TER	Technical Evaluation Report
TLD	Thermoluminescent dosimetry
TPQ	threshold planning quantity
TQ	threshold quantity
TR	Technical Report
TSP	total suspended particulate
TVA	Tennessee Valley Authority
U_3O_8	uranium
UG	Urangesellschaft
UCL	upper control limit
UIC	underground injection control
UO_2	uranium dioxide
UPS	uninterruptible power supply
UPZ	uranium point zone
Uranerz	Uranerz USA, Inc.
USACE	U.S. Army Corps of Engineers
USDW	underground source of drinking water
USEIA	U.S. Energy Information Administration
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
VRM	Visual Resource Management

WDAI	Wyoming Department of Administration & Information
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WL	working level
WLM	working level month
WQD	Water Quality Division (WDEQ)
WYPDES	Wyoming Pollutant Discharge Elimination System
XRD	X-ray diffractometry

1.0 Proposed Activities

1.1 Licensing Action Requested

Power Resources, Inc. (PRI) dba Cameco Resources (Cameco) is requesting that the United States Nuclear Regulatory Commission (NRC) approve the license renewal application (LRA) for Source and Byproduct Materials License SUA-1548 (SUA-1548). The LRA was originally submitted to NRC on August 12, 2010. By letter dated February 4, 2011, NRC Staff provided Cameco with their acceptance review comments. Based on the acceptance review comments as well as comments provided by NRC in meetings dated March 17, 2011 and September 19-20, 2011, Cameco is submitting this LRA supplement for NRC review and approval. This submittal supersedes the August 12, 2010 submittal. Approval of this LRA will authorize Cameco to continue uranium in-situ recovery (ISR) operations at the Smith Ranch site and its related satellite facilities for an additional 10-year renewal period beginning August 12, 2010. Cameco is also requesting approval of the following items that are either new or have been changed since the last renewal:

1. Operations Plan for the Gas Hills Remote Satellite, including yellowcake slurry production, redesign of Evaporation Ponds 1 and 2, increase in satellite flow rate and the use of underground injection control (UIC) Class I disposal wells, as defined later in this section.
2. Operating Plan for the North Butte Remote Satellite, including redesigned surge ponds and satellite, increased satellite flow rate, use of UIC Class I disposal wells, removal of the slurry and dried product option at the satellite, as defined later in this section.
3. Flow rate increases at the Reynolds Ranch Satellite.
4. Refurbishment of the Highland Central Processing Facility (CPF) to allow processing of up to 1.4 million kilograms (3 million pounds) of dried yellowcake per year (approved into license through the Operations Review Committee ORC)/Safety and Environmental Review panel (SERP) process.
5. Processing of toll shipments of loaded ion exchange (IX) resin and slurried yellowcake from other licensed uranium recovery facilities at the Highland CPF.

1.2 License Renewal Application Nomenclature

This Technical Report (TR) together with the accompanying Environmental Report (ER) provide the required information to allow approval of this LRA **Figure 1.1, General SUA-1548 Location Map** presents a location map, including transportation routes, for SUA-1548 and consists of:

1. Converse County, Wyoming
   a. Smith Ranch, including all satellites and processing facilities associated with the Smith Ranch properties (**Figure 1.2, Smith Ranch Location Map**)
2. Campbell County, Wyoming
   a. North Butte Remote Satellite
3. Fremont and Natrona Counties, Wyoming
   a. Gas Hills Remote Satellite
4. Johnson County, Wyoming
   a. Ruth Remote Satellite

Figure 1.2 presents more detailed information related to Smith Ranch and its contiguous satellite facilities. Smith Ranch incorporates the Converse County properties as individual satellites. The location of each satellite is presented on **Figure 1.2**. Because of the abundance and importance of historical information, this TR addresses three historic named properties that comprise the Converse County property, collectively referred to as Smith Ranch. They are:

a. Smith Ranch
b. Highland (aka The Highland Uranium Project)
c. Reynolds Ranch

The Central Processing Plant (CPP) is located on Smith Ranch. The Highland CPF and the Selenium Treatment Plant are both located within Highland (see **Figure 1.2**).

The typical ISR process is described in both the ER and the TR. Each property and/or remote satellite is comprised of several mine units, which consist of one or more contiguous uranium roll fronts. Injection and recovery wells are drilled and completed within these mine units. These injection and recovery wells are collectively called a well field or mine unit. Uranium is liberated from its natural mineral state and recovered from the groundwater at each recovery well and piped to a header house. Uranium-bearing fluids (pregnant lixiviant) are delivered from each header house to the CPP, a satellite, or remote satellite for further processing. The barren fluids, less a small bleed to maintain hydraulic control within the mine unit, are refortified with lixiviant reagents and returned to the mine unit to recover more uranium.

An IX facility is located within each of the satellites, CPP and the CPF (when refurbished), where the uranium is removed from the groundwater and loaded onto the surface of the IX resin. The Gas Hills Remote Satellite will also have the capability of producing yellowcake slurry. Uranium laden IX resin and/or slurry produced at the satellite or remote satellite facilities is transported via U.S. Department of Transportation (DOT) approved transport trailers to the CPP and/or the CPF (**Figure 1.2**) for final processing into yellowcake. Final processing at the CPP is accomplished using low heat rotary vacuum dryers. These vacuum dryers do not produce significant particulate emissions that can escape into the environment. Dried yellowcake is the commercial end product for SUA-1548. The CPF is a second processing plant under SUA-1548. It is currently (2011) inactive, but Cameco is in the process of refurbishing and upgrading this processing facility to allow additional capacity for IX and yellowcake production. By letter dated September 15, 2011, Cameco advised NRC of their plans to renovate the Highland CPF. Phase I includes the dismantling and disposal of the Highland offices and extraneous equipment and materials outside the CPF building and the modernization of electrical services. Phase II includes the removal and replacement of tanks, vessels and piping within the CPF, and Phase III includes the removal and disposal of the existing calciner dryer and installation of at least two low temperature rotary vacuum dryers. The work has been reviewed and approved through the ORC/SERP process. Phase I started during the fourth quarter of 2011. Once operational, this facility will receive IX resin and/or slurry from the remote satellites as well as from third party licensed uranium recovery facilities. The CPF will have the capability to produce dried yellowcake, which will be transported by truck to a uranium conversion facility.

When a mine unit or a portion of a mine unit is exhausted of economically recoverable uranium, it is placed into groundwater restoration. This restoration process is described in Section 6.0. During the production and restoration processes, a certain amount of liquid waste water is generated. Cameco utilizes several methods to handle and dispose of waste water, including evaporation ponds, UIC Class I disposal wells, and land application. Cameco is currently (January 2012) exploring the option of using UIC Class I disposal wells at the Gas Hills Remote Satellite to augment the planned evaporation methodologies. The Selenium Treatment Plant located at Satellite No. 2 (**Figure 1.2**) removes selenium and radium from "treated" process and bleed water prior to disposal by land application via a storage reservoir and pivot irrigator.

1.3 Document Format

Per discussions with NRC Staff, Cameco has prepared a comprehensive document that includes both past and current information applicable to this LRA. Cameco received an acceptance review dated February 4, 2011 and has incorporated NRC staff comments identified as Enclosure 1 into this LRA. In that same letter, the NRC recommended that Cameco consider guidance provided in Regulatory Guide 3.46 (June 1982); NURGE-1748 (August 2003); and NURGE-1569 (June 2003). Cameco has prepared the current document to conform to this regulatory guidance. Since receiving the acceptance review comments, Cameco representatives have attended two public meetings with NRC staff: a one day meeting in Washington DC on March 17, 2011 and a two day meeting and pre-submission license application review in Casper, Wyoming on September 19 and 20, 2011. Meeting minutes and NRC staff comments and recommendations made at these meetings were memorialized in NRC Staff memoranda dated respectively April 26, 2011 and October 28, 2011. Cameco has incorporated these suggestions into the LRA.

As stated above, this LRA consists of a TR and an ER. This TR is a stand-alone document that addresses the guidance provided by NURGE-1569 and NRC Regulatory Guide 3.46. The TR summarizes both new and historical technical information for SUA-1548. Cameco has provided a summary statement at the front of each chapter that describes what information is new and what information has been previously reviewed by the NRC. The TR appendices contain numerous detailed designs, construction specifications and consultant reports to provide a complete 10-year history of SUA-1548.

The ER provides environmental baseline information and environmental assessments of the actions proposed in the LRA. The ER addresses the guidance provided in NURGE-1748 and contains cross references to a series of appendices that are part of the Wyoming Department of Environmental Quality (WDEQ) Permit to Mine for each facility within SUA-1548. Specifically, Cameco presents detailed baseline information to the WDEQ as part of their State of Wyoming permitting process. In recognition of the NRC's regulations at 10 CFR 51 implementing the National Environmental Policy Act (NEPA) for baseline data as they pertain to the ER, Cameco has summarized this information in Section 3.0 of the ER and has referenced the detailed baseline reports as well as federal and state concurrences, which are part of the WDEQ application. To ensure that this supplemental information is available for NRC Staff review, Cameco has incorporated one hard copy and one electronic copy of these documents as part of this LRA submittal.

1.4 2011 Historical Development and Current Status of Smith Ranch SUA-1548

Tables 10.1 through **10.4** in Section 10.0 summarize the federal and state permitting/licensing status of SUA-1548. SUA-1548 is currently (January 2012) in timely renewal. All Smith Ranch satellites and the Highland Satellites No. 2 and No. 3 (**Figure 1.2**) are fully operational and deliver uranium laden IX resin to the CPP. The CPP processes the IX resin and produces dried yellowcake in accordance with the conditions and requirements of SUA-1548. The dried yellowcake is transported to a uranium conversion facility located in Port Hope, Ontario, Canada for further processing.

1.4.1 NRC License History

The previous SUA-1548 LRA was approved by the NRC in May 2001. The Licensee at that time was Rio Algom Mining Corp. (RAMC). In 2002, PRI entered into a Purchase Agreement to acquire the Smith

Ranch Facility (SUA-1548) from RAMC and requested a direct transfer of control of SUA-1548 from RAMC to PRI in June 2002. The NRC approved the license transfer on July 11, 2002, as Amendment 3 to SUA-1548.

In March 2003, PRI requested that SUA-1511 (Highland) be combined with SUA-1548 (Smith Ranch) and that the surviving License be SUA-1548. At the same time, PRI requested that the Ruth/North Butte License SUA-1540 and the pending Gas Hills License Amendment to SUA-1511 also be added to the combined License SUA-1548. On August 18, 2003, the NRC issued Amendment 5 to SUA-1548 approving the consolidation of the Highland, Ruth and North Butte licenses into SUA-1548. The NRC disallowed inclusion of the Gas Hills facility on the premise that it would be premature since the NRC Staff had not yet completed their review of the amendment request. Once approved, the Gas Hills Remote Satellite would be amended into SUA-1548. The NRC subsequently approved the Gas Hills Remote Satellite as Amendment 6 to SUA-1548 on January 29, 2004.

In January 2005, PRI requested a license amendment to incorporate the Reynolds Ranch Satellite into SUA-1548. The NRC approved the request and issued Amendment 11 to SUA-1548 on January 31, 2007.

In October 2006, PRI requested a license amendment to allow construction and operation of the Smith Ranch Satellite SR-2. The NRC Staff approved the license amendment request and issued Amendment 12 to SUA-1548 on January 10, 2008.

In response to a Notice of Violation (NOV), PRI submitted a license amendment request dated March 20, 2008 requesting changes to Chapter 9 of the license application related to management organization and administrative procedures. The NRC Staff approved the license amendment request and issued Amendment 13 to SUA-1548 on August 18, 2008.

On March 12, 2009, NRC Staff issued Amendment 14 to SUA-1548 approving the financial surety update for the Gas Hills Remote Satellite.

On June 19, 2008, PRI requested an amendment to allow processing of third party uranium loaded IX resin at the SR CPP. The NRC Staff approved the amendment request and issued Amendment 15 to SUA-1548 to allow a maximum of 365 toll shipments of third party uranium loaded IX resin to be delivered and processed at the Smith Ranch CPP each calendar year.

On December 31, 2008, PRI submitted a request for annual surety update approval for the Gas Hills, Ruth and North Butte Remote Satellite facilities. Additionally, this amendment requested approval for the addition of UIC Class I disposal well SR-HUP No. 10 (December 4, 2009). NRC Staff approved the amendment request and issued Amendment 16 on March 11, 2010.

These amendments are described in more detail in **Table 1-1, Summary of SUA-1548 Amendments Since Last Renewal**.

1.4.2 State of Wyoming Permitting History

Within the State of Wyoming, a separate mining and reclamation permit is required for each property. Historically Smith Ranch held a mining permit under WDEQ Permit No. 633 and Highland held a mining permit under WDEQ Permit No. 603. These permits are still active. In March of 2010, Cameco submitted to WDEQ a Combined Permit Application for Smith Ranch and Highland. Cameco received Completeness Review comments from the WDEQ and addressed these comments in May of 2011. As part of the May resubmission, Cameco incorporated the Reynolds Ranch property. Prior to this resubmission, the United States Department of the Interior, Bureau of Land Management (BLM) approved Cameco's Plan of

Operations and completed an Environmental Assessment (EA) of the proposed satellite and associated well fields at Reynolds Ranch. The BLM approved the Reynolds Ranch Plan of Operations and published their Finding of No Significant Impact (FONSI) in January 2011. The updated WDEQ permit application combining Permits 633 and 603 (Smith Ranch, Highland and Reynolds Ranch) into WDEQ Permit 633 is currently (January 2012) under Technical Review by the WDEQ.

SUA-1548 incorporates several remote satellite facilities, each of which is separately permitted by the State of Wyoming. The North Butte Remote Satellite WDEQ Permit to Mine No. 632 was originally issued to Uranerz USA, Inc. (Uranerz) in 1991. This permit was transferred from Uranerz to Pathfinder Mines Corporation (PMC) (aka Cogema) in 1992 and subsequently transferred to PRI in 2001. Cameco submitted updated baseline, operational and restoration information related to North Butte to WDEQ in April 2011. Permit update is currently in Technical Review. Cameco anticipates having the North Butte Remote Satellite in operation (pending NRC license condition approval and WDEQ Permit to Mine update approval) by 2013.

The Gas Hills Remote Satellite Permit to Mine was initially approved by the WDEQ in 2001 (Permit No. 687). Cameco submitted a permit update to WDEQ in 2009. The permit update is currently (December 2011) in the final stages of technical review. Additionally, BLM is preparing an Environmental Impact Statement (EIS) to address the ISR impacts to the land and water resources of the Gas Hills in accordance with NEPA regulations at 40 CFR 1500-1508 and BLM's Departmental Manual 516. It is anticipated that the EIS process will be completed by April 2012. Cameco anticipates that the Gas Hills Remote Satellite will be operational (pending NRC license condition approval, WDEQ Permit to Mine update approval, and BLM approval) by 2014.

The Ruth Remote Satellite Permit to Mine was initially approved by the WDEQ in 1990 as Permit No. 631 (Uranerz). This permit was first transferred to PMC and was later transferred to PRI in 2001. Cameco is not actively pursuing development of the Ruth Remote Satellite at the time of this LRA (January 2012). Prior to commencement of ISR activities, baseline environmental data, environmental impact analyses, and the operations and reclamation plans will be updated and provided to NRC.

1.5 Proposed Action: All SUA-1548 Licensed Facilities

Cameco is requesting that NRC Staff approve this LRA. This LRA includes updated technical information, detailed new technical information, a summary of SERPs, which have been subjected to numerous NRC inspections, updated MILDOS calculations and updated and new discussion on environmental resources, impacts, and mitigative actions.

License Condition 10.2.1of SUA-1548 requires that before engaging in any commercial ISR activity *not previously assessed* by the NRC at the North Butte and Ruth remote satellites, Cameco must prepare a new *Operating Plan* in accordance with the guidance in NUREG-1569, for NRC review and approval and must also prepare and record an environmental evaluation of such activity.

On August 18, 2003, the NRC issued Amendment No. 5 to SUA-1548 approving the consolidation of the Highland, Ruth, and North Butte licenses into SUA-1548. NRC had performed an environmental evaluation for North Butte in its 1990 EA which covered both the North Butte and Ruth facilities. Cameco may initiate operations of the North Butte remote satellite within the operating envelope previously reviewed and approved by the NRC Staff. Changes to plans at North Butte requiring additional evaluation include updated design plans for North Butte surge ponds and satellite facility as well as flow rate increases at the North Butte facility from the current approved flow rate of 17,034 to 23,000 liters/minute (4,500 to 6,000 gallons/minute). The MILDOS model has been revised to take into consideration the increased flow rate from 252 to 379 liters/second (4,000 to 6,000 gallons/minute), and that there will be no slurried or dried yellowcake produced at the North Butte Remote Satellite. Finally, the primary method for process waste water disposal will be UIC Class I disposal wells only rather than the previously assessed combination of disposal wells and solar evaporation ponds. The ponds to be built at North Butte will be used only to temporarily hold water to provide surge capacity for the disposal wells. All other aspects of the North Butte Remote Satellite Plan have not changed from the 1990 NRC Staff evaluation and EA. The above referenced changes are described within Sections 3.0, 4.0 and 6.0 and comprise Cameco's Operating Plan for the North Butte Remote Satellite. Cameco's environmental assessment of these changes is provided in the ER.

License Condition 10.3.2 of SUA-1548 requires that prior to the onset of commercial ISR activities at the Gas Hills Remote Satellite, Cameco must prepare a new *Operations Plan* in accordance with the guidance in NUREG-1569 for NRC review and approval. This requirement differs from the requirement for North Butte and Ruth in that it does not limit the submittal to *"those activities not previously assessed by the NRC."*

NUREG-1569 provides guidance for the content of new license applications, renewals, and amendments. Figure 2 from NURGE-1569 describes the Operations plan as "Details on how a facility will be operated, and the basis for performance-based licenses." Several of the sections prescribed by the guidance and included in this LRA are useful for evaluating the overall context of Cameco's facilities within the affected environment. However, the *details on how the facilities will be operated and the basis for the performance-based license* are reflected in Sections 3 through 6 of NUREG-1569. These four sections require a description of the proposed facility, effluent control systems, operations, and restoration/decommissioning. Cameco therefore is defining Sections 3.0 through 6.0 as its updated Operations Plan for the Gas Hills Remote Satellite. The updated environmental evaluations encompassing these plans are provided in the ER.

Since Cameco is not actively developing the Ruth Remote Satellite at this time (January 2012) and available data for Ruth are limited, Cameco will defer submittal of an operating plan and updated environmental evaluation for Ruth until closer to the time of commencing operations. At that time, Cameco will satisfy the outstanding requirement for the Ruth Remote Satellite in License Condition 10.2.1.

With this LRA, Cameco is also requesting authorization to increase the approved flow rate for the Reynolds Ranch Satellite from 17,000 to 23,000 liters/minute (4,500 to 6,000 gallons/minute).

Under the framework of this TR, Cameco has presented operational information and information relating to the affected environment as well as a summary of potential impacts from the proposed action, and an evaluation of alternatives to the proposed action in accordance with NRC guidance provided in NURGE-1569. Cameco has completed an evaluation of the proposed action and reasonable alternatives and is requesting that the NRC approve the proposed action.

SUA-1548 currently allows Cameco to receive and process up to 365 third party shipments of loaded IX resin at the CPP per calendar year. Within the framework of NRC's Equivalent Feed Policy (NRC-2011-0217), Cameco plans to receive third party shipments of loaded IX resin from other licensees at the refurbished Highland CPF. The loaded IX resin is no different than "equivalent feed" as defined in the Equivalent Feed Policy and should not require a license amendment to receive and process the material at the CPF or the CPP. Cameco is requesting that the NRC reauthorize the refurbished Highland CPF to receive slurried source material from third party licensees (toll processing) for the purpose of drying, packaging, and transporting the material to a uranium conversion facility on their behalf. This action was previously evaluated by the NRC Staff and subsequently approved on March 15, 1993 as Amendment No. 46 to NRC License SUA-1511 for the Highland Uranium Project (NRC, 1993).

1.6 Environmental Consultations

There have been numerous official consultations held with state and federal agencies during the course of obtaining approval to operate and continuing to operate Wyoming ISR facilities, including US Fish and Wildlife Service (USFWS), Wyoming Game and Fish Department (WGFD), Wyoming State Historic Preservation Office (SHPO), BLM, and the US Army Corps of Engineers (USACE). A record of these consultations is provided in **Table 10.5, Agency Consultations**.

1.7 Location of SUA-1548 Facilities

1.7.1 Smith Ranch

The Smith Ranch property is a commercial uranium ISR facility located in the southern Powder River Basin within Converse County and is owned and operated by Cameco. The property consists of three contiguous project sites, the Highland site, the Smith Ranch site and the Reynolds Ranch site.

The main office complex and CPP is approximately 35 kilometers (22 miles) northeast of the town of Glenrock and 40 kilometers (25 miles) northwest of Douglas (**Figure 1.1**). The project consists of approximately 16,187 hectares (40,000 acres). Access to the site from the intersection of State Highway 93 and State Highway 95 is by Converse County Road 31, also known as the Ross Road. **Figure 1.3, Smith Ranch General Site Map** shows the general project location, access and the location of process areas including satellite buildings, mine units, pipelines, impoundments, major roads and the main office complex. As of January 2012, a total of five satellite facilities and two processing plants are located at Smith Ranch. **Figure 1.4, Smith Ranch East Area, Figure 1.5, Smith Ranch Central Area, Figure 1.6, Smith Ranch West Area, Figure 1.7, Smith Ranch South Area, and Figure 1.8, Smith Ranch Southwest Area** provide greater detail of the areas depicted on **Figure 1.3**. **Figure 1.9, Reynolds Ranch Detailed Site Map** shows the location of the Reynolds Ranch Satellite.

1.7.2 North Butte Remote Satellite

The North Butte Remote Satellite site is located in the southern Powder River Basin in southwest Campbell County. The site is approximately 80 kilometers (50 miles) from the City of Gillette and 64 kilometers (40 miles) from the Town of Wright. The permit area contains approximately 409 hectares (1,010 acres) and includes portions of Sections 18 and 19 T44N, R75W and Sections 13, 23, 24 and 25 in T44N, R76W (**Figure 1.10, North Butte General Site Map**). The site can be accessed from State Highway 50 near Savageton. From Highway 50, travel is west and south on Van Buggenum Road, then Christensen Road for approximately 10 kilometers (6 miles) to an existing oil field road owned by T-Chair Ranch. There will be two main access routes to the Project site that will utilize the T-Chair Road. To access the site from the northeast side of the license area, travel along the T-Chair Road for approximately 2 kilometers (1 mile). At that point turn north onto a graveled coal bed methane (CBM) road and travel approximately 1 kilometer (0.8 mile) and turn west onto the Project access road. This road begins at a point located in the NENE of Section 19, T44N, R76W. This access road will be a combination of existing and new roadway that will cover a distance of approximately 3 kilometers (2 miles) to the satellite facility.

The site can also be accessed from the south on the T-Chair Road. One travels past the CBM road turn-off, continues in a westerly direction past the Pfister Ranch and goes north across Willow Creek. This existing gravel road will be used by Cameco to reach the Project access road which starts at a point located in the NENW of Section 25, T44N, R76W. This access road is an existing road built by Cleveland-Cliffs Iron Company (Cleveland-Cliffs) during the initial development of the North Butte ore body. Cameco plans to upgrade this road, which is all within the permit boundary, for a distance of approximately 2 kilometers (1 mile) to the proposed satellite facility. These two access roads are shown on **Figure 1.10**.

1.7.3 Gas Hills Remote Satellite

The Gas Hills Remote Satellite is located in the eastern portion of the Gas Hills Uranium District of south-central Wyoming, in Natrona and Fremont Counties. The site is located approximately 105 kilometers (65 miles) west of Casper and 72 kilometers (45 miles) east of Riverton. The license area is approximately 3,455 hectares (8,500 acres) (**Figure 1.11, Gas Hills East Site Map** and **Figure 1.12, Gas Hills West Site Map**). Access to the Gas Hills Remote Satellite from Riverton is provided by Wyoming State Highway 136. From Riverton take Wyoming State Highway 136 for approximately 72 kilometers (45 miles) east. When the highway ends, head northeast on Dry Creek Road, which is unpaved, for approximately 6 kilometers (4 miles) to the AML Road. Travel the AML Road south for approximately 6 kilometers (4 miles) to the Carol Shop Road. Turn west onto the Carol Shop Road and travel approximately 0.5 kilometer (0.3 mile) to the Carol Shop entrance. From Casper, take US-20 W/US-26 W for approximately 72 kilometers (45 miles) to Waltman, then head southwest on County Road 212 for approximately 39 kilometers (24 miles) to the Fremont County line , most of which is unpaved. Continue on same road (now called Dry Creek Road for approximately 5 kilometers (3 miles) to the AML Road. Travel the AML Road south for approximately 6 kilometers (4 miles) to the Carol Shop Road. Turn west onto the Carol Shop Road and travel approximately 0.5 kilometer (0.3 mile) to the Carol Shop entrance.

1.7.4 Ruth Remote Satellite

The Ruth Remote Satellite is located in the southeastern corner of Johnson County, Wyoming (T42NR77W, Sections 13, 14, 24) (**Figure 1.13, Ruth Site Map)**. The license area covers approximately 572 hectares (1,414 acres). It is approximately 101 kilometers (63 miles) north of Casper, and 116 kilometers (72 miles) southwest of Gillette. From Gillette take State Highway 50 south for approximately 82 kilometers (51 miles) to State Highway 387 west and then follow State Highway 387 west for approximately 24 kilometers (15 miles). The site can be accessed by then driving north on an unpaved road for approximately 8 kilometers (5 miles). From Casper take Interstate 25 (I-25) north for approximately 34 kilometers (22 miles) to State Highway 259 north. Follow State Highway 259 north for approximately 29 kilometers (18 miles) to State Highway 387 E. Follow State Highway 387 E for approximately 27 kilometers (17 miles) to an unpaved road that will take you to the site after approximately 8 kilometers (5 miles).

1.8 Project and Ownership History

1.8.1 Smith Ranch

The southern Powder River Basin has a long uranium mining history. From the early 1970s through the mid-1980s, companies such as Bear Creek Uranium, Kerr McGee Nuclear, RAMC, Tennessee Valley Authority (TVA), and Exxon Minerals produced uranium from the sandstone deposits within or near the current license boundary by conventional open pit or underground mining methods. Most of these mines were shut down and/or reclaimed by 1985 because of poor uranium market conditions.

The NRC first authorized Kerr-McGee Corporation (KMC) to conduct Research & Development (R&D) ISR operations at the Smith Ranch site in June 1981 under WDEQ Permit to Mine 304-C and Source Material License SUA-1387, with a corresponding EIS issued at that time (46 FR 30924). In February 1984, SUA-1387 was amended to reflect that Sequoyah Fuels Corporation (SFC), a wholly-owned subsidiary of KMC, was the NRC licensee for the Smith Ranch R&D operations (NRC, 1984). The NRC renewed SFC's NRC license for continued R&D operations by letter dated January 29, 1988 (NRC, 1988b). In support of the license renewal, the NRC staff published a FONSI) in the Federal Register on January 7, 1988 (53 FR 459). RAMC acquired the Smith Ranch ISR site in December 1988 (Quivira Mining Corp., 1988). On June 18, 1991, WDEQ issued Permit to Mine 633 to RAMC. On March 12, 1992, the NRC issued Source Material License SUA-1548 to RAMC, which authorized expansion of the Smith Ranch R&D operations into commercial scale production (NRC, 1992a). SUA-1548 replaced R&D License SUA-1387. An EA documenting the NRC Staff's environmental review was published in the Federal Register on January 10, 1992 (57 FR 306). Source Material License SUA-1548 was renewed on May 8, 2001 (NRC, 2001c), and the FONSI published in the Federal Register on May 4, 2001 (66 FR 22620). PRI acquired RAMC's Smith Ranch properties in July 2002 and, by letter dated August 18, 2003, the NRC approved the integration of the Highland Uranium Project license into the Smith Ranch license (NRC, 2003d). With that integration, combined operations at Smith Ranch were authorized under Source and Byproduct Materials License SUA-1548. The NRC staff did not prepare an EA/FONSI as this action was considered administrative and organizational in nature.

Results of core studies confirmed the two pilot R&D projects at the Smith Ranch site could successfully utilize a leaching solution of bicarbonate/carbonate with hydrogen peroxide and oxygen. The pilots were authorized by WDEQ, Land Quality Division (LQD) with Permits 5RD and 13RD and by the NRC under license SUA-1387. These tests, conducted in uranium deposits at depths of 152 meters (500 feet) and 229 meters (750 feet), have demonstrated the feasibility of mining the uranium reserves in the project area using ISR methods.

The initial Smith Ranch ISR pilot, the Q-Sand pilot, operated from October 1981 until May 1986. The Q-Sand pilot was a 0.4 hectare (1 acre), 379 liters/minute (100 gallons/minute) operation. Uranium recovery from the pilot exceeded the forecast recovery and aquifer restoration, completed in May 1986, was deemed acceptable, as was the completion of a 1-year aquifer stability demonstration period. The Q-Sand pilot surface area is encompassed by Mine Unit 1 and surface reclamation will include both. The second ISR pilot, the O-Sand pilot was a 1 hectare (2 acre), 568 liters/minute (150 gallons/minute) test which began operation in July 1984. The O-Sand pilot performed as forecast, confirming the amenability of the ore to ISR mining. The O-Sand Mine Unit was placed on stand-by in 1991 and is fully contained within the approved Mine Unit 3 commercial operation. Both the O-Sand Pilot and Mine Unit 3 will be restored and reclaimed together. The pilots, authorized under NRC Source Material License SUA-1387 and WDEQ R&D Licenses 5RD and 13RD, operated without an excursion of leach solution, without a lost time accident, without serious injury to any employee, and without health or safety risks to the public, or significant adverse impact to the environment.

The Smith Ranch CPP is located at the original site of the Bill Smith mine shaft and underground mine. The underground mine was operational from 1976 through the early 1980s. The ore removed from the mine was transferred by truck to the Exxon mill for processing. As a result, there are no mill tailings associated with the mining at the Bill Smith mine. There were two open pit mines located north of Smith Ranch. These mines were in Sections 3, 28 and 33, T37N, R73W, and were mined under WDEQ Permit to Mine 304-C. The mined areas were reclaimed, revegetation confirmed, and bond release requested with the March 25, 1994 Annual Report/Bond submittal for WDEQ Permit 304-C.

The removal of the head frame was completed in 1991 and disposed in 1993. The 2003 annual report states that the plugging of the shaft was completed in 1994 and was removed from the surety at that time. Two of the three settling ponds were reclaimed as described in the 1997 WDEQ annual report. The vent shaft has been plugged and is located under the south end of the CPP office complex.

Two pilot R&D projects were completed at Highland by Exxon during the period 1972 to 1981. These projects were operated under WDEQ Permit No. 218-C and NRC License SUA-1064. The first pilot R&D project, known as the "Original R&D" was operated from 1972 to 1976. This project investigated the technical feasibility of ISR utilizing different concentrations of sodium bicarbonate and hydrogen peroxide within the leach fluid.

The second pilot R&D project (known as the "Expanded R&D"), which was operated from December 1978 to September 1981, demonstrated the technical feasibility of ISR utilizing gaseous oxygen, sodium bicarbonate and gaseous carbon dioxide within the leach fluid, the ability to control leach fluids within the mining zone, and the restorability of the affected groundwater to its original use suitability. Reports concerning the results of the pilot activities, including restoration of affected groundwater, were previously submitted to NRC and WDEQ.

A portion of the Highland facilities are located adjacent to the reclaimed Exxon Highland Uranium Mine, which used conventional open pit and underground mining methods, and was in operation from 1971 to 1984. The underground mine was shut down with the shaft sealed by 1985. In 1985, Exxon sold their remaining uranium reserves to Everest Minerals Corp. (Everest) who developed the remaining Highland reserves using ISR technology. Highland began commercial uranium production in 1988.

Also during this time period, Silver King Mines, Inc. operated an underground uranium mine for TVA in the Section 14 area of Highland (North Morton Ranch Mine) during the late 1970s and early 1980s. The mine was shut down and the shaft sealed in the mid-1980s. Everest acquired the reclaimed property from TVA, which allowed expansion of the operation to the west in 1993. Open pit uranium mining also occurred from the mid-1970s through 1986 at Union Pacific Resources' Bear Creek site, which is approximately 24 kilometers (15 miles) northeast of the Smith Ranch license area.

Between 1989 and 2000, Highland produced approximately 454 metric tons (500 tons) of uranium per year. Cameco acquired PRI and the Highland Project in 1997.

The Reynolds Ranch satellite facility was previously owned by Solution Mining Company (SMC). During 1980 to 1990, SMC installed wells, collected water quality data and performed two aquifer tests within the Reynolds Ranch area. SMC never permitted the property which was subsequently purchased by RAMC and then PRI (Cameco). This area was incorporated into SUA-1548 with License Amendment 11 dated January 31, 2007.

1.8.2 North Butte Remote Satellite

Uranium was first discovered in the Pumpkin Buttes area in 1950 by Dr. David Love, when the US Geological Survey (USGS) performed an aerial gamma survey over the area. Dr. Love later confirmed uranium deposits in the area when conducting ground surveys. Between 1953 and 1967, 55 uranium mines operated in Campbell County, but with very small production rates. With the advent of ISR in the 1970s and the increase in the price of uranium, interest in the Pumpkin Buttes deposits increased. In the mid-1970s Wyoming Mineral Corp. developed and began operating the Irigaray Ranch ISR operation. Also during this time period, uranium orebody development and ISR pilot projects were initiated within the Pumpkin Buttes District by other companies.

In the late 1970s, Cleveland-Cliffs owned the uranium claims known as North Butte and planned to operate a conventional underground mine. Cleveland-Cliffs performed environmental and cultural studies at the site and submitted a WDEQ Permit to Mine application to the LQD for a conventional underground mine. The application was subsequently withdrawn in the early 1980s.

Uranerz purchased the project from Cleveland-Cliffs during the 1980s and proceeded to develop an ISR Permit to Mine application for the LQD and a Source Materials License application for the NRC. The application was submitted to both agencies on March 7, 1989.

Uranerz never commenced construction on the project and subsequently sold the property to PMC in 1991. The LQD permit (No. 632) was transferred from Uranerz to PMC in March 1991. The NRC license (SUA-1540) was transferred to PMC in January 1992. PMC added approximately 20 hectares (50 acres) to the original permit area and revised the application. These revisions included an increase in flow rate and a relocation of the evaporation ponds, plant, and access roads. Their original plan was to start construction in mid-1992 but was delayed because of a change of company ownership and economic conditions.

In 1992, PMC drilled 40 monitoring wells in the Mine Unit 1 and 2 areas for acquisition of baseline data including 20 perimeter ore zone wells, nine upper sand wells, two upper sand wells, and nine ore zone/baseline restoration wells. Mechanical integrity testing (MIT) was completed in 1993. In 1996, four quarters of baseline water quality data were collected from the monitoring wells together with pump testing to establish communication with the monitoring wells within the ore zone. Twenty additional hydrology test wells were installed in 1996, and aquifer testing of those wells was completed in 1997.

PMC continued to delay construction for economic reasons through 2001 when PRI purchased the project. The LQD permit and NRC license were transferred to PRI in November 2001. In 2003, PRI requested and received subsequent approval from NRC, as License Amendment 5, to add the North Butte and Ruth properties to SUA-1548. NRC Licenses SUA-1540 and 1401 were then terminated. This amendment established Smith Ranch as the primary ISR facility with Highland, North Butte, Gas Hills and Ruth to be operated as satellite facilities to Smith Ranch.

1.8.3 Gas Hills Remote Satellite

The Gas Hills Uranium District was discovered in 1953 by prospector Neil McNeice. Word of the discovery spread and a rush to stake claims ensued. Within the next few years, thousands of claims were staked and a series of small open pit mines were developed on shallow oxidized ore deposits. The ore was sold to the Atomic Energy Commission at buying stations and shipped by rail to Edgemont, South Dakota for processing. By the mid to late 1950s, a uranium mill was constructed in Riverton which began milling Gas Hills' uranium ore. During the late 1950s, significant uranium deposits were discovered beneath the water table and large scale mining commenced. Over the next few years, properties were consolidated and three processing mills constructed in the Gas Hills District. By the early 1960s, production from the district approached 4,536 metric tons (5,000 tons) per day of ore that averaged greater than 0.20% U_3O_8. Production at these levels continued more or less until the early 1980s, at which time the drop in uranium prices forced the closure of the mines and mills. Although intermittent production has occurred since that time, most activity in the District has involved mine and mill reclamation. Total production from the District during its history is approximately 45,000 metric tons (50,000 tons) U_3O_8.

Mining claims covering the Gas Hills Remote Satellite license area were initially staked by a variety of small operators and companies during the 1950s. Most of the claims were consolidated when three of the companies, Gas Hills Uranium, Federal Resources, and Radorock Uranium, formed a partnership and constructed a mill. Gas Hills Uranium changed their name to American Nuclear, and Federal Resources acquired Radorock. The subsequent mining group was called Federal American Partners (FAP). FAP signed a property development partnership agreement with TVA during the early 1970s who commenced an ambitious program of open pit and underground mine development. During this time, the last significant property consolidation occurred with the Partnership's purchase of Western Nuclear's East Gas Hills property. TVA subsequently acquired all interest in the property from the partnership and maintained the property through the 1980s. The undeveloped portions of the property were sold to PRI in 1991, who in turn sold a 25% interest to Urangesellschaft (UG) under an operating agreement between PRI and UG. In 1994 PRI acquired the TVA's Buss property, and in 1996 re-acquired UG's 25% interest in the undeveloped ISR properties.

1.8.4 Ruth Remote Satellite

The Ruth Remote Satellite shares much the same history as the North Butte Remote Satellite up until the 1980s. In 1981, Ruth was granted the Source Material License SUA-1401 for R&D scale operations. These operations built upon existing facilities in order to support the North Butte ISR operations. ISR activities were terminated in 1984 and decommissioning and restoration followed, although neither were ever fully completed. The property was sold to PMC in 1991, along with North Butte and finally to PRI in 2001. The only activities conducted at the Ruth Remote Satellite since it was purchased by PRI have been routine pond inspections and well abandonment. Additional development of the Ruth Remote Satellite is anticipated to occur near the end of the next renewal period.

1.9 Land Ownership

The Smith Ranch license area of SUA-1548 consists of approximately 16,187 hectares (40,000 acres) of private, state and federal surface and mineral ownership. Land or mineral ownership has not changed significantly since the 2001 renewal with the exception of the Reynolds Ranch Satellite area which was amended into the license in January 2007. Future changes of ownership are not envisioned at this time. The North Butte Remote Satellite consists of approximately 409 hectares (1,010 acres) of private surface ownership with mineral ownership being primarily private with minor state and federal ownership. The Gas Hills Remote Satellite has about 3,455 hectares (8,500 acres) all of which belongs to Cameco. With the acquisition of the mineral rights for the Gas Hills, Cameco acquired certain surface facilities, including a large surface mine shop (the Carol Shop), and associated utilities. The Ruth Remote Satellite is approximately 572 hectares (1,414 acres). Land ownership at Ruth is a mix of both private and public lands and includes T-Chair Land Company, Cameco, BLM, and Moore Land Company Trust.

1.10 Description of Existing Facilities

1.10.1 Ore Body Locations and Estimated Uranium Content

1.10.1.1 Smith Ranch

The uranium ore deposits at Smith Ranch occur at depths of 61 to 366 meters (200 to 1,200 feet) below surface. The ore is hosted in fluvial, arkosic sandstones of the Paleocene Fort Union and Eocene Wasatch Formations. The Fort Union and Wasatch Formations are locally separated by a laterally prevalent coal seam known as the School Coal. Individual host sand units have been correlated and named, and are separated by semi-continuous, confining layers usually composed of shale, siltstone or claystone. The Tertiary sediments dip gradually toward the Powder River Basin syncline (generally 0 to 5 degrees). Faulting in these Tertiary sediments is rare.

In cross-section, redox fronts, also called roll fronts, generally form C-shaped rolls, concaving toward the oxidized side of the roll front. In plan view, mineralization occurs in sinuous redox fronts within the host sandstones. The best ore accumulations typically occur where the redox fronts are the most sinuous. Hematite and limonite coatings on sand grains are prevalent on the oxidized side of the front, and feldspars have been totally or partially altered to kaolinite. Sands on the oxidized side of the front are generally orange to red to brown in color. There is virtually no uranium on the oxidized side of the roll front, although there may be a false radiometric uranium signature resulting from remnant radium and radium daughter products. Thorium and thorium daughter products are typically not mobilized by the ISR fluids.

On the reduced side of the roll front, the feldspars are unaltered. Reductants such as carbonaceous materials (lignite) and reduced mineral forms such as pyrite may also be present. The host sands on the reduced side of the roll front are usually gray to green-gray in color. The economically recoverable uranium mineralization is concentrated on the reduced side of the roll front, which at Smith Ranch and North Butte typically results in uranium ore thicknesses ranging from approximately 1 to 8 meters (2 to 25 feet).

The two most common uranium ore minerals are uraninite (UO_2) and coffinite [$U(SiO_4)1\text{-}X(OH)_4X$] that occur as precipitated coatings on the sand grains. These minerals both contain uranium in the +4 valence (or reduced) state. The chemical reduction of the uranium during ore emplacement is accomplished by the interaction of the oxidized ore-bearing groundwater with organic carbon and pyrite that were naturally present within the sandstones near these redox boundaries.

At Smith Ranch, the shallower ore deposits are contained within the Q-Sand at approximate depths of 137 to 152 meters (450 to 500 feet) below the surface. At the Reynolds Ranch Satellite area, the shallower ore deposits are contained within the U/S Sand at approximate depths of 116 to 160 meters (380 to 525 feet) below the surface. Most of the remaining economic uranium mineralization at Smith Ranch and Reynolds Ranch occurs in the O-Sand at approximate depths of 213 to 274 meters (700 to 900 feet) below the surface. These ore body sands are synonymous with the 30, 40, 50, and 60-Sands at Highland. Smith Ranch Appendix D5, Figure D5-3-4 shows the regional correlation of the production sand units between Reynolds Ranch, Smith Ranch, and Highland. Current reserve estimates indicate a proven and probable reserve remaining at Smith Ranch (including Highland and Reynolds Ranch) of 3,640 metric tons (4,012 tons) with an average grade of approximately 0.1% U_3O_8 (see Section 3.3.1.2).

1.10.1.2 North Butte Remote Satellite

The North Butte Remote Satellite contains three primary mineralized sand members. These sand members were identified by Uranerz as "C", "B", and "A" in descending order. The "C" sand member is the shallowest and the "A" sand member is the deepest. The primary ore-bearing member of the three sand units is the "B" sand. In most portions of the North Butte Remote Satellite area, these sand members are separate and distinct. However, in a substantial portion of the area, the separating aquitards between the sands thin and allow vertical contact between either the "A" and "B" members or the "B" and "C" members. In these areas, there are effectively only two recovery zones.

The North Butte Remote Satellite production zone, with its three sand members, is bounded above and below by thick aquitards. The upper and lower aquitards are composed of claystone, siltstone, and shaley lignite interbeds.

The North Butte Remote Satellite ore body is a typical Powder River Basin roll front deposit. The oxidation front extends from the northeast to the southwest. The sand members also have several vertically superimposed individual roll fronts. Due to the occasional vertical contact between the mineralized sand members, there are often several smaller fronts, which overlay each other.

The uranium mineralization at the North Butte Remote Satellite is present as amorphous uranium oxide, or sooty pitchblende with some subordinate carnotite. The host sandstones are composed of quartz, feldspars, and rock fragments with locally occurring carbon fragments. Grain size ranges from very fine-grained sand to small granules. The sandstone is weakly to moderately cemented and friable. Occasional occurrences of pyrite and calcite as cementing materials can be observed. The uranium is deposited upon individual detrital sand grains or upon and within authigenic clays in the interstices. The interstitial clays present are primarily montmorillonite with lesser amounts of kaolinite. Hematite, along with minor amounts of limonite, is common oxidation products of pyrite within the host rock. Accessory biotite and muscovite are also present. Current reserve estimates indicate a probable reserve at the North Butte Remote Satellite of 3,723 metric tons (4,104 tons) with an average grade of approximately 0.1% U_3O_8.

1.10.1.3 Gas Hills Remote Satellite

At Gas Hills the ore-bearing sands are poorly consolidated arkosic sandstones composed mostly of angular to subrounded quartz and feldspar grains with accessory biotite, muscovite, garnet, traces of complex silicates, and carbon. The coarse portions of these sands, which tend to be subrounded, also contain lithic fragments composed primarily of granite (Hazen, 1996). Within the ore zones, aggregates of sand grains tend to be cemented by calcite and clay minerals. The general petrology is consistent with the granitic source rocks to the south.

On the oxidized side of the roll front, the sandstone has been altered as a result of oxidizing groundwater moving through a reducing host rock. The alteration is most commonly seen as bleaching of the feldspars and clays, and oxidation of the iron-bearing minerals. However, the alkaline solutions which emplaced the uranium ore bodies left the overall rock fabric unaffected.

The two most common uranium ore minerals are uraninite, UO_2, and coffinite, $U(SiO_4)_{1-x}(OH)_{4x}$ and are predominately found between 143 and 201 meters (460 and 660 feet) below the surface (Frondel, 1967). Both minerals occur as intimate intergrowths (Ludwig and Grauch, 1980; King and Austin, 1966; Hazen, 1996). These minerals both contain uranium in the 4+ valence state, which is the reduced oxidation state for uranium. The chemical reduction of the uranium during ore emplacement was accomplished by the interaction of groundwater with organic carbon and pyrite. This has resulted in an intimate association of the uranium minerals with carbon, an association which has been verified by electron microprobe analysis (Ludwig and Grauch, 1980; Hazen, 1996). The economically recoverable mineralization is concentrated on the reduced side of the roll front; on the oxidized side of the roll front deposit, there are virtually no economic concentrations of uranium. Current reserve estimates indicate a probable reserve at the Gas Hills Remote Satellite of 8,611 metric tons (9,492 tons) with an average grade of approximately 0.1% U_3O_8.

1.10.1.4 Ruth Remote Satellite

The ore body at the Ruth Remote Satellite is similar to that described at North Butte. Production zones are in the A, B, and C sandstone units of the Wasatch Formation. The uranium is primarily found in several vertically separated roll front deposits and one large roll front deposit, where the B and C sands are mixed. The ore deposit at Ruth is about 152 to 183 meters (500 to 600 feet) below the surface. It is elongated and is approximately 610 meters (2,000 feet) in length and 91 to 152 meters (300 to 500 feet) in width. Current reserve estimates detail an indicated and inferred reserve at the Ruth Remote Satellite of 1,926 metric tons (2,123 tons) with an average grade of approximately 0.1% U_3O_8. Cameco is not actively pursuing development of the Ruth Remote Satellite at the time of this LRA (January 2012). Prior to ISR at the Ruth Remote Satellite, more detailed information regarding reserves and anticipated production will be developed and provided to NRC.

1.10.2 Solution Extraction Method and Recovery Process

ISR involves the use of a leaching solution, called a lixiviant, to extract the uranium from the geologic formation in which it occurs, without physically removing the ore-bearing strata. For uranium ISR, the lixiviant typically consists of native groundwater to which an oxidant (typically oxygen or hydrogen peroxide) and a complexing agent (typically sodium bicarbonate and/or carbon dioxide) have been added. ISR is accomplished by injecting the lixiviant through injection wells and circulating it through the ore-bearing strata, where the uranium is mobilized and placed into solution with the lixiviant. The resultant uranium-bearing solution is extracted from the ground via adjacent production wells. The uranium laden groundwater is then routed via underground pipelines to a surface IX facility. Once the IX resin has removed the uranium from the lixiviant, the majority is returned to the mine unit for recirculation through the uranium-bearing sandstone. A small purge or bleed volume is removed prior to reinjection and is directed to a treatment and disposal facility. The uranium rich eluate is then piped to the precipitation circuit where the uranium is precipitated using hydrogen peroxide or ammonia. The precipitated uranium is thickened, washed and filtered to remove excess water and is then dried and packaged for shipment to a conversion facility. Section 3.6 provides a detailed description of the Smith Ranch ISR process.

1.10.3 Operating Plans, Design Throughput and Annual Production

The plan is to continue to operate the Smith Ranch CPP at an annual production rate of 907 metric tons (1,000 tons) U_3O_8. The NRC license allows a maximum annual production rate of 2,268 metric tons (2,500 tons) U_3O_8. To support this production rate, satellite flow is anticipated to be 112,414 liters/minute (29,700 gallons/minute), excluding Ruth and Gas Hills. Current satellite flows are as follows:

- Satellite 2: 12,000 liters/minute (3,200 gallons/minute)
- Satellite 3: 19,000 liters/minute (5,000 gallons/minute)
- Satellite SR1: 17,000 liters/minute (4,500 gallons/minute)
- Satellite SR2: 19,000 liters/minute (5,000 gallons/minute)
- Satellite Reynolds: 23,000 liters/minute (6,000 gallons/minute) (estimated)
- North Butte Remote Satellite: 23,000 liters/minute (6,000 gallons/minute) (estimated)
- Gas Hills Remote Satellite: 51,000 liters/minute (13,500 gallons/minute)
- Ruth Remote Satellite: To be determined.

Additional details on operating plans and schedules are provided in Sections 3.0 and 6.0.

1.10.4 Schedules for Construction, Startup and Duration of Operations

Pending regulatory approval, plans are to construct the Reynolds Ranch and North Butte satellite facilities and have them operational in 2013. Current plans for the Gas Hills Remote Satellite are to have it constructed and operational in 2014. Additionally, it is currently planned to refurbish the Highland CPF, install two vacuum rotary dryers and have it operational as an additional resin transfer and yellowcake processing facility by 2013. Current operations duration is approximately 30 years. Additional discussion related to project plans and schedules is provided in Sections 3.0 and 6.0.

1.10.5 Waste Management and Disposal

Process waste water disposal at the SUA-1548 license areas include deep well injection, land application, and solar evaporation. Domestic wastes from the facilities are disposed in conventional septic/leach field systems permitted by the WDEQ, Water Quality Division (WQD). Non-radioactive solid wastes, such as packing material, office trash, etc. is stored on site and periodically transported to a municipal landfill for disposal. Used petroleum products are stored on site in accordance with state and federal requirements and are either used for facility heating or periodically collected and removed from the site by a commercial used oil recycler. Solid 11.e(2) byproduct materials are stored in appropriately labeled and covered containers located in secure areas at the CPP and satellite facilities which are periodically transported by commercial licensed trucking firms to an NRC licensed facility for disposal. Cameco currently has a disposal agreement with Denison Mines (USA) Corp. for disposal of radioactive solid wastes at their White Mesa tailings facility near Blanding, Utah. A more detailed discussion of these waste management systems is provided in Section 4.0.

1.10.6 Plans for Groundwater Quality Restoration, Decommissioning, and Site Reclamation

Project reclamation generally consists of three major activities which include:

1. Groundwater Restoration;
2. Facility Decommissioning; and
3. Surface Reclamation.

Mine unit groundwater restoration and reclamation occur concurrently with operations. Once the economic recovery limit of a mine unit has been reached, uranium recovery operations cease, and groundwater restoration commences. The purpose of aquifer restoration is to return the mine unit groundwater quality to the standards provided in 10 CFR 40, Appendix A, Criterion 5(B)5. Criterion 5(B)5 requires groundwater restoration to baseline or the maximum contaminant level (MCL), whichever is higher. According to NURGE-1569, groundwater restoration at ISR facilities should protect water resources outside of the exempted zone. This can be done by restoring groundwater to pre-operational conditions. NURGE-1569 recognizes that baseline conditions may not be attainable because of geochemical changes within the aquifer during uranium production. Therefore, secondary standards that still protect water resources, especially those outside of the exempted zone, may be acceptable. If baseline or the MCL are not attainable through the use of best practicable technology (BPT), Criterion 5(B)5 allows the licensee to submit an application to NRC for approval of alternate concentration limits (ACL). The proposed ACL will be approved if the NRC Staff determine that the proposed concentrations will not be hazardous to the public or the environment.

Water outside the production zone and within adjacent aquifers must be protected. Additionally, water outside the aquifer exemption boundary must be protected to applicable US Environmental Protection Agency (EPA) MCL per 40 CFR 141, as amended July 1, 2001. Restoration Target Values (RTV) are designed to protect water resources under the SUA-1548. RTV are developed on a parameter-by-parameter basis for each mine unit. Baseline water quality data is averaged from wells completed in the planned Production Zone, which are assumed to reflect pre-ISR values. RTV are defined for each mine unit as the mean of the baseline data plus two standard deviations. The RTV provide an acceptable range of values to protect water resources.

Groundwater restoration is typically accomplished using a combination of techniques including groundwater sweep, groundwater treatment and reinjection, chemical reductant addition to precipitate heavy metals back into the formation, and bioremediation. After groundwater restoration and stability have been achieved in a mine unit and regulatory concurrence has been granted, all wells are plugged and abandoned followed by the removal of subsurface and surface facilities and surface reclamation and vegetation seeding. Additional discussion of groundwater restoration and decommissioning are provided in Section 6.0.

1.10.7 Surety Arrangements

A restoration/decommissioning/reclamation financial surety for the Smith Ranch license areas is typically maintained as a letter-of-credit in favor of the State of Wyoming and the BLM, if BLM-administered lands are involved. The financial surety amount is recalculated on an annual basis and submitted to LQD and NRC for review. The most recent Smith Ranch submittal included the cost of construction and operation of the first mine unit and satellite facility at Reynolds Ranch. The October 2011 North Butte estimate included construction of the first mine unit, satellite, deep disposal wells and ancillary structures. The Gas Hills financial surety (December 2011) estimate included construction of additional drill holes, monitor wells and deep disposal test wells. The December 2010 estimate for the Ruth Remote Satellite of $183,000 included decommissioning and disposal of existing buildings and ponds, surface reclamation and well plugging and abandonment. The financial surety calculations and bonding mechanisms/instruments are discussed in more detail in Section 6.0.

1.10.8 Record of Amendments and Changes Since the Last Renewal

This section provides a summary of major changes to Source Material License SUA-1548 achieved through license amendments approved since the last permit renewal submittal of November 15, 1999. It should be noted that no changes to the license, including the North Butte, Gas Hills and Ruth Remote Satellites, were made through the amendment process between November 15, 1999 and the date the last renewal for SUA-1548 was issued (May 8, 2001). The amendments are numbered sequentially with Amendment No. 0 corresponding to the May 8, 2001 renewal.

Table 1-1, Summary of SUA-1548 Amendments Since Last Renewal provides the Amendment number, the date issued, a summary of the topics addressed, and the License sections, if any, that have changed due to each amendment. Four of the amendments (Nos. 5, 6, 11 and 12) provide for the addition of satellite sites to SUA-1548. Ten of the amendments (Nos. 1, 3, 4, 5, 6, 7, 8, 10, 11 and 14) addressed, at least in part, changes to the dollar amounts of financial surety instruments to reflect additions of satellites or other changed conditions requiring financial surety updates. Five amendments (Nos. 1, 2, 5, 9 and 15) were focused on operational changes. Four amendments (Nos. 3, 4, 5 and 13) were focused on changes to management organization, ownership or other administrative functions.

1.10.9 Record of Safety and Environmental Review Panel Since the Last Review

This section provides a summary of changes made using the SERP pursuant to the performance-based License Condition No. 9.4. The date of the SERP, its number, a synopsis of the change and result of the SERP review and compliance with NRC criteria are provided in **Table 1-2, Summary of SERPS**. Since the SERP numbering system has changed since the last renewal (SERPS are now numbered on an annual basis; prior to 2004, SERPS were numbered sequentially without regard to year), tracking SERPS by date is the best means of identifying a specific SERP. The SERPS have been provided to the NRC on an ongoing basis in the semi-annual report. If any SERP resulted in a revision to the application text, the revision has been incorporated into this LRA.

The NRC allows changes to be made to the facility, a process, or procedures and/or conduct tests or experiments not presented in the license renewal submittal (as updated) via the SERP process, provided the changes are consistent with NRC conclusions regarding the license as documented in supporting NRC documents (e.g. EA, Safety Evaluation Report [SER], Technical Evaluation Report [TER], etc.). To determine whether this requirement is met, each SERP is evaluated against the conditions stated in License Condition 9.4b. Each of these requirements is stated as a question, as listed below. If the response to each question is 'No' or 'N/A', then the SERP has met the requirement of being consistent with NRC conclusions:

- Does the proposed change result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license renewal submittal (as updated);
- Does the proposed change result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system or component important to safety previously evaluated in the license renewal submittal (as updated);
- Does the proposed change result in any appreciable increase in the consequences of an accident previously evaluated in the license renewal submittal (as updated);
- Does the proposed change result in any appreciable increase in the consequences of a malfunction of a structure, system, or component previously evaluated in the license renewal submittal (as updated);
- Does the proposed change create a possibility for an accident of a different type than any previously evaluated in the license renewal submittal (as updated);
- Does the proposed change create a possibility for a malfunction of a structure, system, or component with a different result than previously evaluated in the license renewal submittal (as updated); and
- Does the proposed change result in a departure from the method of evaluation described in the license renewal submittal (as updated) used in establishing the Final SER, the EA, or TER, or other analysis and evaluations for license amendments.

Topics covered by SERPS include proposed changes to operations, management, and training. They also include the performance of tests to evaluate changes to operation and reviews of hydrologic test documents for new mine units.

1.10.10 Documentation of Inspection Results Since the Last Renewal

NRC inspection reports for SUA-1548 covering the years 2000 through 2010 (includes inspections of the Highland facilities after consolidation of properties in 2002 per License Amendment 5, dated August 18, 2003) are summarized in **Table 1-3, Summary of NRC Inspection Topics and Findings for Smith Ranch (SUA-1548)**. During this time period, a total of 18 NRC inspections occurred at Smith Ranch. A total of six inspections occurred at the Highland facility between 2000 and 2002 prior to consolidation with Smith Ranch. A total of 11 violations, three non-cited violations and one unresolved item resulted from the Smith Ranch inspections. As of May 2011, two violations and one unresolved item remained open as a result of the 18 Smith Ranch inspections.

NRC inspection reports for Highland (SUA-1511) covering the years 2000 through 2002, prior to consolidation with License SUA-1548, are summarized in **Table 1-4, Summary of NRC Inspection Topics and Findings for Highland Uranium Property (SUA-1511)**. During this time period, a total of six inspections occurred at Highland. These six inspections resulted in one violation which was subsequently withdrawn by NRC.

1.10.11 License Violations Identified During NRC or WDEQ LQD Inspections

1.10.11.1 Background

NRC inspection reports for Smith Ranch (SUA-1548) covering the years 2000 through 2010 were reviewed for occurrences of NOV and Non-Cited Violation (NCV). NRC inspection reports for Highland (SUA-1511) covering the years 2000 through 2002 were also reviewed for occurrences of NOVs and NCVs. Records review under SUA-1511 was performed to document occurrence of NOVs or NCVs at Highland prior to the consolidation of Smith Ranch and Highland properties under a single license.

NOVs require response from the licensee in the form of a written statement or explanation to the NRC within 60 days of the effective NOV date. NOV replies must include "(1) the reason for the violation, or, if contested, the basis for disputing the violation or severity level, (2) the corrective steps that have been taken and the results achieved, (3) the corrective steps that will be taken to avoid further violations, and (4) the date when full compliance will be achieved" (NRC, 2000d). Typically, the licensee's NOV reply is acknowledged by the NRC as "responsive," and the NOV will be documented as "closed" in a subsequent NRC Inspection Report.

NOVs are categorized for severity by the NRC using levels I, II, III and IV, with I being the highest severity level and IV being the lowest. All of Cameco's NOVs were categorized by the NRC as Severity Level IV. Severity Level IV is defined by NRC as follows: *Violations at Severity Level IV involve noncompliance with NRC requirements that are not considered significant based on risk* (NRC, 2005a). Cameco's NOVs in the previous renewal period can generally be described as posing no significant risk to health or environment. In all cases, Cameco provided the required response. All NOVs have been documented as closed to the NRC's satisfaction.

NRC's "*Enforcement Policy*" describes NCVs "*as having very low safety significance*" (NRC, 2005a). The process for dispositioning an NCV is further described as follows:

> *"NCVs... are documented as violations in inspection reports (or inspection records for some materials licensees) to establish public record of the violations, but are not cited in Notices of Violation which normally require written responses from licensees. Dispositioning violations in this manner does not eliminate the NRC's emphasis on compliance with requirements nor the importance of maintaining safety. Licensees are still responsible for maintaining safety and compliance and must take steps to address corrective actions for these violations. While licensees are not required to provide written responses to NCVs, this approach allows licensees to dispute violations described as NCVs"* (NRC, 2005a).

All NCVs were documented as both "opened" and "closed" within the duration of the on-site inspection in which they occurred. In each occurrence of an NCV, a single NRC inspection report provides the documentation of the NCV, the corrective actions taken or planned by Cameco, and NRC's acceptance of the effectiveness of corrective actions, closing the NCV.

1.10.11.2 Notices of Violation for Smith Ranch

During the time period of 2000 through 2010, 18 inspections were conducted at Smith Ranch. A total of nine NOVs and three NCVs were opened. All NOVs and NCVs are documented in subsequent reports as "closed", with the exception of one NOV which resulted from the most recent inspection (NRC, 2009g). Cameco has replied in writing to the outstanding NOV, and NRC has acknowledged the reply as "*responsive to the concerns raised in our Notice of Violation*" (NRC, 2009h).

The NOVs and NCVs for Smith Ranch are summarized in **Table 1-5, Notices of Violation and Non-Cited Violations for Smith Ranch During the Period of 2000 through 2010**.

1.10.11.3 Notices of Violation for Highland

In the time period of 2000 through 2002, a total of six inspections occurred at Highland. One NOV was opened (NRC, 2001a) during the February 5-8, 2001 site inspection. The violation is described as follows:

> *"On seven occasions from November 22, 2000 to January 17, 2001, the licensee failed to perform swipe tests for removable alpha contamination when total alpha contamination was identified to be greater than 20 dpm/100cm^2. In all seven instances, the licensee surveyed and released*

from the restricted area, project trucks and truck parts that had measured alpha contamination ranging from 417 to 770 dpm/100cm^2 without having performed swipe tests of the equipment" (NRC, 2001a).

PRI replied to the NOV by contesting the applicability of the release criteria used by the NRC in the NOV. PRI cited NRC guidance that *"provides limits of 1,000 dpm/cm^2 removable alpha and 5,000 dpm/100cm^2 average (fixed and removable) alpha contamination for release of equipment for unrestricted use"*, and further stated *"...that the surveys were conducted appropriately, and materials were released from the site in accordance with license requirements, NRC regulations requirements, guidance and policy"* (PRI, 2001b).

The subsequent NRC inspection report documented NRC's acceptance of PRI's reply and withdrawal of the NOV as follows:

> *"A violation was identified regarding performance of swipe surveys for removable alpha contamination when the total alpha contamination action levels had been exceeded. It appeared that equipment was released from the restricted area for unrestricted use without adequate surveys being performed.*
>
> *The licensee disputed the violation, and the NRC reviewed the basis for the disputed violation and agreed. Subsequently, by letter dated May 21, 2001, the NRC concluded that the violation would be withdrawn"* (NRC, 2001d).

1.10.12 References

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2.0 Site Characterization and Description

Section Summary: General information regarding a variety of site characterizations (i.e. geology, seismology, hydrology, ecology, etc.) is discussed in Sections 2.2 through 2.5. Section 2.2 describes the Smith Ranch project site, for which site characteristics remain the same since the last license renewal, with the exception of the Reynolds Ranch Satellite, which has been incorporated into this discussion. Sections 2.3, 2.4 and 2.5 present the site characteristics for the North Butte, Gas Hills and Ruth Remote Satellites, respectively. Though these three project areas had been previously amended to SUA-1548, the information described in these sections is new to this LRA.

2.1 Introduction

Cameco is requesting renewal of SUA-1548 for the continuation of uranium ISR operations at Smith Ranch. SUA-1548 is a consolidation of Highland, Smith Ranch (including the Reynolds Ranch Satellite) and also includes remote satellite facilities at Gas Hills (Fremont and Natrona Counties), North Butte (Campbell County) and Ruth (Johnson County). **Figure 1.1** shows the location of the Smith Ranch site, Gas Hills, North Butte, and Ruth Remote Satellite locations and nearby towns and roads. This application also provides the information required by License Conditions 10.2.1 and 10.3.2 for the North Butte and Gas Hills Remote Satellites so that commercial ISR operations can proceed at these remote satellites.

2.2 Smith Ranch

2.2.1 Site Location and Layout

The Smith Ranch site is located in the southern Powder River Basin in Converse County. The Powder River Basin is bounded on the west by the Bighorn Mountains and the Casper Arch (large, northwest-trending asymmetric anticlinal structure that connects the Bighorn Mountains with the Laramie Mountains and separates the Powder River Basin from the Wind River Basin) and to the south by the Laramie Range-Hartville Uplift. Less distinct are the northern and eastern margins of the basin. The broad Black Hills Uplift forms the eastern demarcation, and the Miles City Arch forms the northern boundary. Topography in the permit area is characterized by gently rolling upland areas and broad stream valleys that are dissected by numerous ephemeral draws with relatively steep slopes and rounded ridge crests. A regional geologic map of the Powder River Basin is provided in Appendix D5 of the Smith Ranch WDEQ Permit.

The main office complex and CPP are located approximately 35 kilometers (22 miles) northeast of the town of Glenrock and 40 kilometers (25 miles) northwest of Douglas (**Figure 1.1**). Total project area encompasses approximately 16,200 hectares (40,000 acres). Access to the site from the intersection of State Highway 93 and State Highway 95 is by Converse County Road 31, also known as the Ross Road. **Figure 1.3** shows the general project location and access to the Project. Additional plate information also highlights the location of process areas including satellite buildings, mine units, pipelines, impoundments, major roads and the main office complex. As of January 2012, five satellite facilities and two processing plants were located at Smith Ranch. **Figures 1.4** through **1.8** provide greater detail of the areas depicted on **Figure 1.3**.

2.2.2 Uses of Lands and Waters Adjacent to Smith Ranch

The Powder River Basin population is primarily rural and contains abundant reserves of natural resources. Development of these natural resources, including coal, oil, gas, CBM, wind energy, and uranium, influence the economic growth of the region now and presumably in the near future. In addition to the energy industry, agriculture, manufacturing, and tourism also contribute to the economic health of this part of Wyoming.

Various locations near Smith Ranch are slated for exploration of oil and gas drilling into the Niobrara Shale. Several oil and gas companies have begun enhanced oil recovery (EOR) programs at existing oil fields within Converse County. For example, following environmental approval, Australia-based Linc Energy will start EOR at its Wyoming oilfields by injecting carbon dioxide (CO_2) into the South Glenrock B Unit 34 in the Powder River Basin. Required CO_2 supplies will initially be delivered to the field operations by trucks until a pipeline system can be built to provide this commodity. Furthermore, new directional drilling capabilities provide a means of developing multiple wells from one drill pad location. Cameco's Smith Ranch operations will not affect existing oil and gas activities, based on current oil company development plans.

The target formation (Niobrara Shale) for oil and gas drilling operations is significantly deeper than the uranium-bearing zone where the ISR operations are focused. The uranium-bearing zone and Niobrara Formation are separated by the thick, marine Pierre Shale. Although targeting the Niobrara Shale has been successful in the Colorado Denver-Julesburg Basin, oil and gas production potential from the Niobrara Shale in the Powder River Basin is still under scrutiny.

Converse County is a rural Wyoming County that comprises approximately 1.1M hectares (2.7M acres) of land. The urban areas of Douglas and Glenrock constitute less than 2% of the total area, while transportation systems account for approximately 4.5% of the area. Historically, the area was homesteaded and dry-land farmed. Today, the area remains remote and contains a low population density that is primarily dominated by agricultural pursuits. The majority of inhabitants living in the area reside on dispersed ranch locations. Sheep and cattle grazing comprise the major past and present land use in the area and at the project site. The Vollman Ranch is the only inhabited residence located within the current license area.

From the 1970s to the early 1980s, areas within and adjacent to Smith Ranch were extensively mined for uranium. Both surface and underground mining methods were employed, with the majority of uranium ore being recovered by surface mining methods. Within the license area boundary, there is limited disturbance from both underground and surface mining activities. Detailed regional existing land use conditions within 80 kilometers (50 miles) of the site and the evaluation of land use within 8 kilometers (5 miles) from the center of the site are provided in Section 3.1 of the ER.

Streams within the project area are all ephemeral and many areas drain internally to small playas. Small stock ponds have been constructed on some of the ephemeral streams. Surface waters in the area are used for stock watering and are also utilized by wildlife.

More than 1,400 groundwater rights are on file with the Wyoming State Engineer's Office (WSEO) within Smith Ranch and within a 5 kilometer (3 mile) area of the license boundary. The vast majority of these groundwater rights are for wells installed for hydrologic monitoring, dewatering purposes at decommissioned conventional uranium mining operations, and ISR activities at Smith Ranch. There are 162 groundwater rights associated with wells installed for livestock water, and there are three wells used for irrigation purposes. A total of 32 groundwater rights within 5 kilometers (3 miles) of Smith Ranch are permitted for domestic supply. Half of these wells are dual use domestic water rights combined with livestock, industrial, or irrigation purposes. The remaining 16 water rights are permitted strictly for domestic use according to the WSEO records.

A total of five groundwater rights are permitted for domestic supply within the Smith Ranch license boundary. Two are permitted for domestic/industrial dual use and one is permitted for domestic/stock dual use. Two groundwater rights are permitted strictly for domestic supply wells. The first well, Mason

#1 is located in the northwest area of the Reynolds Ranch Satellite area. The well is 36 meters (118 feet) in depth. The second domestic well is associated with the Vollman Ranch house, which is located near the center of Smith Ranch. This well is 55 meters (180 feet) in depth.

Three Public Water System (PWS) wells exist in the vicinity of Smith Ranch. They include Power PRI/Smith Ranch (PWS # 5601500), Fort Fetterman State Historical Site (PWS # 56080174), and the Town of Douglas (PWS # 5600137). The first water system is located on site; the remaining two are 27 kilometers (17 miles) south, and 38 kilometers (23 miles) southeast of the Smith Ranch site, respectively.

Detailed discussion of water rights in the vicinity of Smith Ranch is presented in Section 3.4 of the ER.

2.2.3 Population Distribution

The nearest communities from Smith Ranch are Glenrock and Rolling Hills, Converse County incorporated towns located southwest of the site on US Highway 20-26 and State Highway 95, respectively, and the Cities of Casper and Douglas. Casper is located southwest of Smith Ranch in Natrona County, and Douglas is located southeast of Smith Ranch in Converse County. Both Casper and Douglas are located along I-25. The largest growth rates in the five-county region surrounding Smith Ranch since 2000 occurred in Campbell, Johnson, and Natrona Counties, primarily because of ongoing mineral and oil and gas resource development in the Powder River Basin. Between 1980 and 1990, the state population declined primarily because of declines in historic agricultural economic sectors, while the high growth rates in Campbell, Johnson, and Converse Counties indicated boom years in oil, coal, and gas development during this decade.

The population in Converse County grew at a slower rate between 2000 and 2008 than in previous decades, and therefore the growth rates are more in line with state growth rates. The total population within the 80 kilometer (50 mile) radius from the center of Smith Ranch is approximately 75,420 people. Most of the area within the 80 kilometer (50 mile) radius is rural, with the majority of the population residing in the small communities near Smith Ranch or in larger urban areas in sectors further from Smith Ranch. Detailed demographic information for the area surrounding Smith Ranch is provided in Section 3.10 of the ER.

2.2.4 Historic, Scenic and Cultural Resources

Several detailed cultural resource surveys have been conducted on Smith Ranch and adjacent areas. The surveys and referenced addenda are included in separate volumes to ensure confidentiality as required under 43 CFR 7.8, "Confidentiality of archaeological resource information". Information contained in the addenda is exempt from public disclosure under 10 CFR 9.17(a) (3). A summary of the confidential archaeological surveys that have been conducted at Smith Ranch are included in Section 3.8 of the ER. An updated affidavit to withhold cultural resource information from public disclosures is being submitted as part of this LRA.

A total of 13 archaeological sites are located within the Reynolds Ranch Satellite license area. Six of the sites were deemed historic and seven were deemed to be prehistoric. Eighteen isolated artifacts were recorded. All of the sites are considered ineligible for inclusion into the National Register of Historic Places and no further work was recommended for any of these sites. Assessment of the potential impacts to the Bozeman Trail and other historical sites within the Reynolds Ranch Satellite license area was conducted in 1997. The assessment included a 5 kilometer (3 mile) segment of the Bozeman Trail known as the Holdup Hollow segment (T36N, R74W, Sections 3, 10, and 15), as well as 4 kilometers (3 miles) of trail just north of the Reynolds Ranch Satellite area. The Holdup Hollow segment is listed in the National Register of Historic Places.

Recommendations from the archaeological assessment discussed that no ground disturbing activity of any kind associated with ISR activities should occur within the recognized boundaries of the Holdup Hollow segment, as well as no exploratory drilling. As a result of this recommendation, the sections of land in which the Holdup Hollow segment is located have been excluded from the Reynolds Ranch Satellite.

In addition to the Bozeman Trail, three historic period dry-land homesteads were recorded and evaluated. All of these sites were considered to be ineligible for listing in the National Register of Historic Places, and a determination of No Effect has been recommended by the SHPO. If any previously unidentified historical or cultural finds are discovered on the property, they will be protected and the appropriate state and/or federal officials notified.

2.2.5 Meteorology, Climatology and Air Quality

Wyoming's elevation results in relatively cool temperatures. Much of the temperature variations within the state can be attributed to elevation with average values dropping 1 to 2°C (2 to 4°F) per 300 meters (1,000 feet). Summer nights are normally cool although daytime temperatures may be quite high. Fall, winter, and spring can experience rapid changes with frequent variations from cold to mild periods. Freezes in early fall and late spring are typical and can result in long winters with a short growing season. In the mountains and high valleys, freezes can occur any time in the summer. During winter warm spells, nighttime temperatures can remain above freezing. Valleys protected from the wind by mountain ranges can provide pockets for cold air to settle and temperatures in the valley can be considerably lower than on nearby mountainsides.

The official weather station closest to Smith Ranch is located at the Natrona County International Airport near Casper. Mean annual precipitation for the license area is approximately 30 centimeters (12 inches). The bulk of the annual precipitation is received from moisture laden easterly winds, particularly during spring months. Most precipitation is in the form of rain, although occasional heavy wet snowfalls in spring months are not uncommon. Summer precipitation is almost exclusively from thundershower activity.

Wyoming ranks first in the United States for wind with an annual average speed of 6 meters/second (13 miles/hour). During winter, Wyoming frequently experiences periods where wind speed reaches 13 to 18 meters/second (30 to 40 miles/hour) with gusts to 22 to 27 meters/second (50 or 60 miles/hour). At Smith Ranch, wind speed data from the National Oceanic and Atmospheric Administration (NOAA) indicate that southwesterly winds dominate throughout the year. The mean annual wind speed is 6 meters/second (13 miles/hour), with averages during December and January of approximately 7 meters/second (16 miles/hour). Wind often coincides or follows snowstorms and can form snow drifts several meters deep. Snow can accumulate to considerable depths in the high mountains. The data indicate that the climatology in the SUA-1548 license area is consistent with the climatology of the area presented in the previous renewal. A detailed discussion of the regional and site meteorology, climatology, and air quality for Smith Ranch is provided in Section 3.6 of the ER.

2.2.6 Geology and Seismology

Smith Ranch is located in the Powder River Basin. The Powder River Basin is a late Cretaceous to early Tertiary age structural asymmetrical syncline, with its axis oriented in a general northwest-southeast direction along the western margin of the basin. East of the axis, the sedimentary rock strata are exposed at the surface and gently dip at approximately 1 to 2 degrees to the west. West of the axis, the strata dip more steeply (as much as 20 degrees) to the east. No major faults or folds in the bedrock occur within the permit area. However, a series of sub-parallel anticlines and synclines with relief ranging from 3 to 6 meters (10 to 20 feet) were identified in the northeast portion of the Smith Ranch permit area.

The basin incorporates a sedimentary rock sequence that has a maximum thickness of approximately 4,600 meters (15,000 feet) along the synclinal axis. The sediments range in age from Recent (Holocene) to early Paleozoic (Cambrian) (500 to 600 million years ago) and overlie a basement complex of Precambrian-age (more than a billion years old) igneous and metamorphic rocks.

Of particular interest are the Tertiary-age deposits of the Wasatch and Fort Union Formations. The uranium-bearing sandstones lie within the upper Fort Union and lower Wasatch Formations. As many as 10 separate potentially uranium-bearing sandstone units have been identified within the license area. Individual sandstone units may be discontinuous in some areas or merge with over or underlying sandstone units. Historically, the sandstone units within the Highland area have been identified from bottom to top as the 0, 10, 20, and 30 through 120 Sands. Within the Smith Ranch and Reynolds Ranch Satellites, the same sandstone units are identified from bottom to top as the K, M, O, and Q through W Sand. Above the School Coal Seam, the sandstone units are identified from bottom to top as the E and G Sands. The O Sand is the principle uranium ore zone sand member and ranges in thickness locally from 12 to over 90 meters (40 to 300 feet). Individual sandstone units are separated by confining units that are as much as 60 meters (200 feet) thick.

A variety of surficial materials layer the Wasatch and Fort Union Formations within Smith Ranch. They include residual soils, slopewash formed by the downslope movement of soils and weathered rock fragments, playa deposits, and stream-deposited alluvium.

Historic seismic events for Converse County have been documented by the US Geological Survey (USGS) (Case and others, 2002, 2003). Twelve magnitude 3.0 and greater earthquakes have been recorded in Converse County. Seismic activity is summarized as follows:

- *April 14, 1947*: Intensity of V felt near LaPrele Creek southwest of Douglas.
- *August 21, 1952*: Intensity IV approximately 13 kilometers (8 miles) north-northeast of Esterbrook.
    - Three additional earthquakes occurred in the same area.
        - *September 2, 1952*: No associated magnitude or intensity.
        - *January 5, 1957*: Intensity III.
        - *March 31, 1964*: Intensity IV.
- *January 15, 1978*: Magnitude 3.0 occurred approximately 5 kilometers (3 miles) northeast of Esterbrook.
- *November 15, 1984*: Magnitude 3.0 occurred approximately 24 kilometers (15 miles) northeast of Casper.
- *December 5, 1984*: Magnitude 2.9 occurred in the Laramie Range, southern Converse County.
- *June 30, 1993*: Magnitude 3.0 located approximately 24 kilometers (15 miles) north of Douglas.
- *July 23, 1993*: Magnitude 3.7 occurred approximately 21 kilometers (13 miles) north-northwest of Toltec.
- *December 13, 1993*: Magnitude 3.5 occurred approximately 13 kilometers (8 miles) east of Toltec.
- *October 19, 1995*: Magnitude 4.2 approximately 24 kilometers (15 miles) northeast of Casper.

Seismic events were minor and did not cause damage. There are no known exposed active faults with a surficial expression in the vicinity of Smith Ranch. Consequently, no fault-specific analysis can be generated for this location. A detailed discussion of the regional and site geology and seismology for Smith Ranch is provided in Section 3.3 of the ER.

2.2.7 Hydrology

The Smith Ranch license area consists of approximately 16,200 hectares (40,000 acres) and is located in the southern portion of the Powder River Basin. Within the Powder River Basin, Smith Ranch is situated within the Sage Creek drainage of the North Platte River drainage system and the Box Creek, Duck Creek, Willow Creek, and Brown Springs Creek drainages of the Cheyenne River drainage system. Topography in the permit area is characterized by gently rolling upland areas and broad stream valleys that are dissected by numerous draws with relatively steep slopes and rounded ridge crests. All streams are ephemeral and flow in response to snow melt and heavy thunderstorms that account for approximately 305 millimeters (12 inches) of precipitation annually.

Currently, no regulated gauging stations exist within Smith Ranch drainages; therefore flow rates are not quantifiable for this area. A considerable area encompassed by the license area is internally drained to playas, which naturally store runoff during periods of abundant precipitation. Sage Creek runs through the southwest portion of Smith Ranch. The USGS maintained a stream gage near Orpha, approximately 2.6 kilometers (1.6 miles) southeast of Smith Ranch (USGS Gage No. 06648780) from 1965 to 1984. Resulting data indicate that Sage Creek is highly variable as annual peak flow rates range from 0 to 7 meters^3/second (229 feet^3/second). Sage Creek is also ephemeral, as 5 out of 19 years of record were dry. Refer to Section 3.6 of the ER for a detailed discussion of the climatic data for this area.

Land along Box Creek and the Middle and East Forks of Willow Creek is predominantly rangeland. Stock ponds have been constructed in many of the ephemeral streams draining the area. Ponds collect some runoff for watering livestock; however, these ponds are dry much of the time. Most surface water rights are limited to these creeks and associated small stock ponds. Waters collected in the stock ponds meet Wyoming livestock use suitability standards (Class III) and are considered suitable for stock and wildlife consumption.

Hydrogeologic units include the following: Holocene-age alluvial deposits, Eocene-age Wasatch Formation, Paleocene-age Fort Union Formation, and Cretaceous-age Lance and Fox Hills Formations. Individual sandstones within these units may be classified as aquifers depending on their hydrologic characteristics and potential yield to wells and/or springs.

The potential for future development of alluvial groundwater supplies within Smith Ranch is considered very poor since only small amounts of precipitation infiltrate the alluvium to provide recharge. The Wasatch Formation is one of the more important aquifers in the Powder River Basin and within Smith Ranch generally yields between 19 to 57 liters/minute (5 to 15 gallons/minute) to wells. Another important aquifer in the Powder River Basin is the Fort Union Formation, which contains nearly all of the Smith Ranch injection and production wells. While most of the wells are designated for yields between 19 and 114 liters/minute (5 and 30 gallons/minute), wells completed in the Fort Union Formation are reported to have produced as much as 2,120 liters/minute (560 gallons/minute). The Lance and Fox Hills Formations underlie the Fort Union Formation and yields from these formations are not expected to exceed 400 liters/minute (100 gallons/minute), with limited groundwater reserves. Little is known of the hydrologic characteristics of the Lance and Fox Hills Formations as only one well has been completed in these aquifers in the vicinity of the permit area. The location of this well is south of the southwest mine unit. A detailed discussion of the regional and site hydrology including surface water and groundwater rights and water quality for Smith Ranch is provided in Section 3.4 of the ER.

2.2.8 Ecology

The Smith Ranch license area has been extensively surveyed for vegetation resources. Woodward-Cycle Consultants completed field surveys and vegetation inventories in the western portion of the license area in 1976, 1978 and 1979. Beartooth Environmental conducted additional plant survey work in the summer of 1990, and a final Baseline Vegetation Assessment was prepared by BKS Environmental Associates, Inc. in 1997. Hayden-Wing and Associates, LLC (HWA) was contracted to complete an updated vegetation survey in the spring of 2011. In short, the 1979 vegetation studies indicated that the study area was primarily grassland, with sagebrush/grassland vegetation present throughout the affected area.

Smith Ranch is located in the western part of the Great Plains within a region referred to as the short-grass prairie. Numerous animal species are associated with the short-grass prairie of eastern Wyoming. Pronghorn antelope, mule deer, coyote, prairie dog, badger, deer mouse, horned lark, and meadowlark are abundant in this environment. However, during the past century, some animal populations have changed as a result of increased human settlement. For example, the bison (or buffalo) and the gray wolf, which preyed primarily on the bison, were both formerly abundant on the short-grass prairie. Today, the pronghorn antelope is the dominant big game species of the prairie, and more antelope occur in Wyoming than in any other state.

An updated wetlands survey was completed in August of 2011 at Smith Ranch by HWA. Nineteen potential wetland locations were surveyed because they exhibited wetland qualities. Eleven of the 19 sites that were surveyed were deemed to be wetlands. Four of the 11 locations exhibited weak indicators. Wetland vegetation varied within the surveyed sites. Common observed vegetation species included *Juncus balticus* (Baltic rush), *Veronica* sp. (speedwell), and *Eleocharis* sp. (spikerush). Any disturbances that will encroach on these locations will require a USACE review and clearance.

Between 1976 and 1990, several wildlife and wildlife habitat studies were performed for the Smith Ranch license area. Grouse Mountain Environmental Consultants and HWA were contracted to complete an updated wildlife survey in the spring and summer of 2011. Proposed wildlife species to be surveyed during 2011 included: wintering bald eagles, greater sage grouse, raptors, mountain plover, prairie dogs, swift fox and burrowing owls. Monthly wetland/pond surveys will also be conducted to monitor any use by wildlife. Vegetation species surveyed in 2011 include: blowout penstemon, Ute ladies'-tresses, invasive/noxious weeds, and general vegetation. A detailed discussion of the ecological resources of Smith Ranch is provided in Section 3.5 of the ER.

2.2.9 Background Radiological Characteristics

Baseline gamma surveys and soil sampling were performed on the western portion of the license area on a mine unit-by-mine unit basis. Three separate surveys were performed in 1985, 1988 and 1989 on lands covering the eastern portion of the license area. A background radiological survey of the Reynolds Ranch Satellite area was conducted by SMC as part of their efforts to develop a state mine permit application for the area in 1989 and 1990. Surface gamma levels determined during this survey are consistent with surface gamma surveys conducted previously for the western and eastern portions of the license area. Cameco considers these surveys representative of baseline conditions for this LRA for those mine units and the Reynolds Ranch Satellite.

Additional baseline radiological surveys are provided with the mine unit hydrologic data packages as they are developed. Further detailed discussion of the baseline radiological surveying is provided in Section 3.11 of the ER.

2.2.10 Background Non-Radiological Characteristics

The remote location of Smith Ranch is characterized by sparse population settlements with the predominant land uses associated with agriculture and energy development. The region does not have any industrial activities that constitute a major source of chemical generation. Chemicals associated with an ISR operation include $C0_2$, hydrochloric acid (HCL), hydrogen peroxide (H_20_2), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH). Emission rates for these chemicals are well below the threshold that would trigger a permit. With respect to fugitive dust, the same can be said; the levels are too low to warrant a permit. In conclusion, because emissions are all below permitting action levels, the concentrations are considered protective of the public.

2.3 North Butte Remote Satellite

2.3.1 Location and Layout

The North Butte Remote Satellite is located in the southern Powder River Basin in southwest Campbell County. Location of the site is approximately 80 kilometers (50 miles) by road from the City of Gillette and 64 kilometers (40 miles) from the town of Wright. The license area contains approximately 409 hectares (1,010 acres) and includes portions of Sections 18 and 19 in T44N, R75W and Sections 13, 23, 24 and 25 in T44N, R76W. **Figure 1.10** shows the general location of the North Butte Remote Satellite. Access to the site is from State Highway 50, Van Buggenum Road, Christensen Road, and an existing oil field road owned by T-Chair Ranch. In the eastern and southern portions of the license area, the topography is fairly level although moderately dissected by ephemeral stream channels. In the northern and western portions, the slope of the topography increases and the drainages become more incised due to the proximity of North Butte. The surface elevations range from about 1,500 meters (4,900 feet) in the extreme south to approximately 1,700 meters (5,700 feet) above sea level near the flank of North Butte.

2.3.2 Uses of Adjacent Lands and Waters

The North Butte Remote Satellite occupies only private land surfaces. The surrounding area is composed of predominantly private land, although there are parcels of state, and federal (BLM)-owned land near the license boundary. Lands within 5 kilometers (3 miles) of the North Butte Remote Satellite are 2% owned by BLM, 6% owned by the State of Wyoming and the remaining 92% are private. Private landowners control access to the federal and state parcels of land and limit access for recreational purposes. Hunting of antelope and mule deer are permitted by landowner consent only. Sage grouse are also hunted to a very limited extent.

Cattle and sheep ranching is the major land use within and surrounding the North Butte Remote Satellite. Approximately 94% of the land in the Powder River Basin is classified as rangeland. Native rangeland vegetation provides the majority of the livestock forage in the region. Livestock production was the leading industry of Campbell County prior to mineral development. There is no prime farmland located within the North Butte Remote Satellite license area.

Development of several uranium projects is ongoing in the Powder River Basin in the vicinity of the North Butte Remote Satellite. Nichols Ranch is located southwest of the project site and Willow Creek (Christensen Ranch and Irrigary) is located northwest of the site. The Moore Ranch ISR uranium project is southeast of the North Butte Remote Satellite.

The top 10 producing coal mines in the United States are located in Campbell County making it the nation's prime source of domestic coal production. These mines produce over 36% of the nation's coal used for electrical generation (Campbell County Natural Resource and Land Use Plan, 2007). The closest coal mining operation to the North Butte Remote Satellite is the Jacobs Ranch coal mine located approximately 52 kilometers (32 miles) east.

In 2007, the Powder River Basin CBM fields produced 12.5 billion meters^3 (442 billion feet^3) of gas, making the region the third largest source of natural gas in the United States. **Figure 2.1** shows the CBM development in the Powder River Basin as of 2004. Developed for a presentation by the Energy Information Administration, **Figure 2.1** details CBM development within the Powder River Basin and depicts the facilities associated with SUA-1548. CBM activities have continued to develop since 2004 in Sheridan, Johnson and Campbell Counties. However, the pace of development has slowed in response to economic factors.

As of the end of 2004, CBM wells were present immediately south and northwest of the North Butte Remote Satellite. Lands near the North Butte Remote Satellite have been developed by the Anadarko Petroleum Corporation (Anadarko) in conjunction with their CBM Willow Creek Plan of Development. Anadarko's CBM wells began dewatering processes in the fall of 2010 and will continue over the next 1 to 2 years. Active life of the CBM wells will be 7 to 15 years from the initiation of dewatering. Completed wells in the Big George Coal seam are at a depth of approximately 472 meters (1,550 feet).

Cameco has a Surface Use Agreement with Anadarko that establishes how CBM activities will be integrated with ISR activities, including joint surface use. North Butte Remote Satellite acreage in Section 13, T44N, R76W, has not been developed for CBM from the Big George Coal Seam. There are no other prospective CBM target formations in the vicinity of the North Butte Remote Satellite.

Known new CBM development in the vicinity of the North Butte Remote Satellite is limited to two wells in Section 13, T44N, R76W, which have not yet been drilled in the Big George Coal Seam. CBM activities over the next 10 years will include continued dewatering and gas production from the nine existing CBM wells operated by Anadarko and one well by Lance Oil and Gas (a subsidiary of Anadarko). After their useful life, CBM wells will either be plugged and abandoned in accordance with Wyoming Oil and Gas Conservation Commission rules and regulations or transferred to the surface owner for other beneficial uses, such as groundwater supply.

The limited surface water supplies within and adjacent to the permit area are used for livestock and wildlife watering. Even in the wet years, Willow Creek only flows for a couple of months. In dry years there is essentially no flow over the entire 12 month period. Stock reservoirs in the area provide additional sources of water for livestock and wildlife. There are 16 adjudicated surface water rights located within a 5 kilometer (3 mile) radius of the license boundary. All 16 surface water rights are for either reservoirs or stock reservoirs. There are no surface water rights for diversion of direct flows from Willow Creek or its tributaries within a 5 kilometer (3 mile) radius of the North Butte Remote Satellite license boundary.

Excluding Cameco-owned monitoring wells, there are three non-industrial water wells (with pumps) on North Butte Remote Satellite lands. All three wells are utilized by the T-Chair Land Company for stock watering. There are five permitted domestic wells located within 5 kilometers (3 miles) of the site. Three are located northwest, one is located northeast, and one is located southeast of the North Butte Remote Satellite. There is one non-permitted domestic well located at the Pfister Ranch (Beck Well) that is used for lawn and stock watering. Water for household consumption is trucked in. There are 31 additional wells within this radius that are permitted for stock watering. Additional details of water rights and usage in the vicinity of the North Butte Remote Satellite are presented in Section 3.4 of the ER.

2.3.3 Population Distribution

The nearest communities to the North Butte Remote Satellite are Wright, a small Campbell County incorporated town located northeast of the satellite area on State Highway 387, and the Towns of Edgerton and Midwest, which are located in Natrona County southwest of the satellite on State Highway 387. Other nearby towns are Kaycee, located in Johnson County west of the satellite at the junction of State Highway 192 and I-25, and the City of Gillette, located in Campbell County northeast of the satellite at the junction of State Highway 59 and Interstate 90 (I-90). The largest growth rates in the four-county region since 2000 occurred in Campbell, Converse, and Johnson Counties, primarily because of ongoing mineral resource development in the Powder River Basin. The total current population within the 80 kilometer (50 mile) radius from the North Butte Remote Satellite is approximately 34,900 people. Detailed demographic information for the area surrounding the North Butte Remote Satellite is provided in Section 3.10 of the ER.

2.3.4 Historic, Scenic and Cultural Resources

Plans for uranium recovery in the area developed in the 1970s and later. CBM development in the Powder River Basin resulted in two episodes of large-scale cultural resource studies in and around the North Butte Remote Satellite. Sixteen archaeological sites are present at the North Butte Remote Satellite. Two sites have been determined eligible for the National Register of Historic Places. The remaining 14 sites are not eligible.

Pumpkin Buttes is an extremely large, discontinuous historic property that takes in the tops and sides of the physiographic features making up the Pumpkin Buttes – Dome Butte, North Butte, North Middle Butte, South Middle Butte, Indian Butte, and South Butte. Studies have determined that the Pumpkin Buttes are eligible for the National Register of Historic Places under Criteria A (associated with events that have made a significant contribution to our history), Criteria B (associated with the lives of significant persons), and Criteria D (have yielded information important in history). Interviews, ethnographic, and ethnohistoric data have also led to the determination that the Pumpkin Buttes qualifies as a traditional cultural property (TCP). ISR restrictions and mitigative actions will be negotiated with interested parties during the NRC "Section 106" review process that will take place concurrently with the review of this LRA. Cameco has developed a Section 106 Plan that can be used for gathering information of religious and cultural significance to Indian tribes that may be affected by ISR activities at the North Butte Remote Satellite. This plan is included as **Appendix A, North Butte Section 106 Plan**.

The report from the Office of the Wyoming State Archeologist states that archeological clearance is recommended with the stipulation that, if subsurface cultural remains are found during construction activities, the appropriate state and federal agencies will be contacted immediately. Cameco will fully comply with this stipulation. Additionally, License Condition 9.9 of SUA-1548 requires that if any unanticipated cultural resource is found during development or operations at any of the licensed areas, all work will cease until the artifacts have been inventoried and evaluated in accordance with 36 CFR Part 800. No disturbance will occur within the unanticipated discovery area until Cameco has received authorization from the NRC to proceed. Detailed information of the scenic, historic, and cultural resources is contained in Section 3.8 of the ER.

2.3.5 Meteorology

In November of 2010, Cameco installed an on-site meteorological station at the North Butte Remote Satellite. Collected data are obtained on a continuous basis and include wind speed, temperature, relative humidity, precipitation, and solar radiation. Section 3.6.3.1 of the ER contains detailed information relating to this meteorological station.

Climate at the North Butte Remote Satellite is generally classified as semi-arid and cool. The region is characterized by cold harsh winters, hot dry summers, relatively warm moist springs, and cool autumns. Climate in the area is rather dry since the Cascade, Sierra Nevada, and Rocky Mountains serve as an effective barrier to moisture from the Pacific Ocean when winds are from the west and northwest. Mountain ranges in the west-central portion of the state are perpendicular to the prevailing winds west of the mountain ranges. These ranges tend to restrict the passage of storms and restrict precipitation in the eastern part of Wyoming. Average annual precipitation in the region is approximately 33 centimeters (13 inches).

Temperatures in the North Butte Remote Satellite area range from -31°C (-25°F) in the winter to 38°C (100°F) in the summer. The average maximum temperatures during the summer months of June, July and August range from 27 to 29°C (80 to 85°F). During the winter months of December, January, and February, the average minimum temperatures range from -11 to -7°C (13 to 19°F).

The mean annual precipitation is approximately 34 centimeters (14 inches) with precipitation ranging from 31 to 41 centimeters (12 to 16 inches) based on data from the 10 meteorological stations. The average number of days throughout the year with 0.03 centimeters (0.01 inch) of precipitation is approximately 81, most of which occur during the spring and summer months. Consequently, the absence of cumulonimbus clouds results in bright days with considerable sunshine throughout the winter season.

The bulk of the annual precipitation is received from moisture laden easterly winds, particularly during spring months. Most of this precipitation is in the form of rain, although occasional short-lived, heavy, wet snowfalls during spring months are not uncommon. Summer precipitation is almost exclusively from thundershower activity. Under normal conditions, these thundershowers provide sufficient moisture to maintain growth of rangeland grasses.

Wind data obtained for the Gillette Campbell County Airport indicate the predominant wind direction is south and southwest more than 35% of the time. Surface winds in the region tend to be high year-round with wind velocities ranging from 4 to 6 meters/second (8 to 13 miles/hour) more than 28% of the time. The average wind speed in the North Butte Remote Satellite area is approximately 5 meters/second (11 miles/hour) and the maximum average wind speed is approximately 26 meters/second (57 miles/hour). Wind directions in the area are highly variable and are strongly influenced by local topography and general weather patterns. Detailed climatological data, including site-specific data and analysis, are presented in Section 3.6 of the ER. Once 12 months of data have been collected at the on-site meteorological station, they will be analyzed and compared to the regional climatological data to determine representativeness of the regional data to site conditions. This updated report will be submitted to NRC as a supplement to this LRA.

2.3.6 Geology and Seismology

The overall topography of the North Butte Remote Satellite is that of flat to gently sloping terrain. Slopes increase in the western portion of the site. Surficial deposits consist of alternating sands and sandy clays and silts in a repeating Wasatch facies environment. Let-down material is minor except in the northwest portion where there is extensive slide material present from the erosion of North Butte. Surficial geology consists of upper Wasatch Formation and lower White River Formation materials which form the walls and cap rock of North Butte, respectively.

The structural attitude of the beds is nearly horizontal in the Basin with only a slight dip of 0.5 to 1.5 degrees to the northwest. Evidence of structural instability at the North Butte Remote Satellite such as faulting, has not been observed either by field observations or through drill hole correlation. The closest known faulting and/or significant folding occur approximately 26 kilometers (16 miles) to the west of the site.

The North Butte Remote Satellite area is underlain by the Eocene Wasatch Formation off the southeast flank of North Pumpkin Butte. Mineralized sand members occur in the lower part of the formation, at an approximate average depth of 150 to 200 meters (500 to 650 feet). The "C", "B", and "A" Sands are the primary mineralized members in the North Butte Remote Satellite ore sand. The "C" Sand is the upper most unit of the "C-B-A" Sand package, ranging in thickness from 0 to approximately 40 meters (130 feet). The "B" Sand is the middle unit and primary ore-bearing member of the "C-B-A" ore Sand. Thickness of the "B" Sand is variable, ranging from approximately 15 to 50 meters (50 to 160 feet), but stratigraphically continuous across the project. Where the "CB" Shale is absent, the top of the "B" Sand is in contact with the base of the "C" Sand. The "A" Sand is the lower most unit of the "C-B-A" Sand package. The "A" Sand ranges in thickness from approximately 6 to 46 meters (20 to 150 feet) and is fairly uniform in the project area. However, on the northwest and south ends of the project, there are locations where this unit thickens. Locally the "A" Sand splits into an upper and lower unit. Either the entire sequence or the upper or lower unit may be present locally; however the unit does occur across the entire project area.

Historic seismic events for Campbell County including the North Butte Remote Satellite have been documented by the USGS (Case and others, 2002, 2003). Seismic activity is summarized below.

Five magnitude 2.5 and greater earthquakes have been recorded in Campbell County.

- *May 11, 1967*: Magnitude 4.8 earthquake centered in southwestern Campbell County approximately 11 kilometers (7 miles) west-northwest of Pine Tree Junction.
- *February 18, 1972*: Magnitude 4.3 earthquake occurred approximately 29 kilometers (18 miles) east of Gillette.
- *May 29, 1984*: Magnitude 5.0, intensity V earthquake occurred approximately 39 kilometers (24 miles) west-southwest of Gillette. Felt in Gillette, Sheridan, Buffalo, Casper, Douglas, Thermopolis, and Sundance.
- *October 29, 1984*: Magnitude 2.5 earthquake occurred approximately 40 kilometers (25 miles) west-northwest of Gillette.
- *February 24, 1993*: Magnitude 3.6 earthquake occurred in southeastern Campbell County approximately 16 kilometers (10 miles) east-southeast of Reno Junction.

Reports of damage from the above seismic events were minimal if not non-existent. There are no known exposed active faults with a surficial expression in the vicinity of the North Butte Remote Satellite. As a result, no fault-specific analysis can be generated for this location. More detailed information on the geology and seismology of the North Butte Remote Satellite license area is provided in Section 3.3 of the ER.

2.3.7 Hydrology

The North Butte Remote Satellite is located in the Willow Creek drainage basin. Willow Creek and its North Butte area tributaries are classified as ephemeral streams. Overall size of the Willow Creek drainage basin above the Dry Willow Creek confluence is approximately 35 kilometers^2 (14 miles^2). The short reach of the Willow Creek channel within the license boundary is at an elevation of 1,500 meters (4,900 feet). The gradient of the stream channel within the license area is approximately 19 meters/kilometer (100 feet/mile), and the active stream channel averages 4 meters (14 feet) in width. The length of the Willow Creek reach within the satellite is approximately 660 meters (2,165 feet).

Most of the ephemeral conveyances within this basin originate at the North Butte itself and flow to the south and southeast. Eventually, all of these drainages converge with Willow Creek on the south end of the permit area. Channel gradients range from 0.012 to 0.068. Tributaries may flow intermittently in the spring and early summer, but generally remain dry for the majority of the year. Ephemeral drainage channel bottoms are generally grass lined and narrower than Willow Creek. Typical ephemeral draw (drainage) surveyed side slopes range from 1.5 to 5:1 (H:V). A hydrologic curve number of 76 is assumed for the upper reaches of several of the basins, while an average curve number of 70 is assumed in the lower, downstream sub-basin areas. Peak discharges were calculated and are provided in Section 3.4 of the ER.

Aquifers of interest are sand members within the Eocene Age Wasatch Formation, a fluvial deposit containing alternating layers of sands and shales. Recharge to the sands of the Wasatch occurs mainly at outcrop locations, with some influx of groundwater from vertical movement through adjacent aquitards. Flow in aquifers generally moves to the north along paleodrainage trends, with a small portion of the groundwater regionally discharging to streams. Aquifer properties are highly variable due to large variations in local lithologies. Reported transmissivities within the Wasatch Aquifer range anywhere from 0.01 to 62 meters^2/day (1 to 5,000 gallons/day/foot).

The hydrogeologic units that occur within the North Butte Remote Satellite are alluvium; the Wasatch Aquifer, Fort Union Aquifer, and Lance and Fox Hills Aquifer. Section 3.4 of the ER provides a detailed description of these hydrogeologic units. Cameco conducted a field investigation of the alluvial deposits along Willow Creek during August 2011. Results of the 2011 alluvial/shallow aquifer investigation indicate sand and gravel deposits are discontinuous and range between 0 and 2 meters (6 feet) thick within the channel of Willow Creek. Small amounts of precipitation infiltrate the alluvium during part of the year and intermittent flows across the alluvium may provide some recharge locally. Between November 1 and 2, 2011, a hydrogeologic investigation was conducted to determine if an alluvial aquifer exists within Willow Creek and if a shallow aquifer exists between the surface and the F Sand, considered the overlying aquifer at the North Butte Remote Satellite. Two sites were selected within the channel of Willow Creek, and exploratory drilling was conducted. Borehole WC #1 was drilled to a depth of 32 meters (105 feet). No alluvium or water producing sands were encountered between the surface and the F-Sand. Borehole WC #2 was drilled to a depth of 24 meters (80 feet). Alluvium consisting of dry gravelly sand was encountered between 4 and 5 meters (14 and 18 feet) below ground surface at this location. Alluvium, where it is present in Willow Creek, is laterally discontinuous. No other potential water producing sands were encountered between the alluvium and the F -Sand. Although no water was encountered in the alluvium, it was determined that the alluvium could become saturated during spring runoff. See Section 3.4 of the ER for more information pertaining to this analysis.

2.3.8 Ecology

The North Butte Remote Satellite license area supports four vegetative community types including sagebrush-grassland, grassland, bottomland and juniper-sagebrush. Juniper (*Juniperus* spp.) woodland is found along the slopes of North Butte. Scattered cottonwoods (*Populus deltoids*) grow along the Willow Creek drainage, and isolated trees are found in smaller drainages.

Original vegetation sampling was conducted at the North Butte Remote Satellite in 1979. In 2010, Real West Natural Resource Consulting (Real West) was contracted to update the vegetation section of the license. Based on examination of all the available license application information, it was concluded that no additional sampling would be required for this 2011 license update. Revisions and supplemental information compiled by Real West for the update included:

1. Preparation of a new vegetation map.
2. Update of the plant species list.
3. Identify any wetlands in the license area.
4. Identify the potential for any threatened or endangered (T&E) plant species to occur on the license area.

In 2010, HWA was contracted to create a Wildlife Monitoring Plan that would set forth protocols and schedules for monitoring the status of wildlife species identified by the WGFD and the USFWS as species of concern that may occur in or proximal to the license area. The plan has been tailored to meet the specific wildlife monitoring needs of the North Butte Remote Satellite area. HWA conducted field surveys for the 2010 survey season for the following species: mountain plover, black-tailed prairie dog, swift fox, greater sage grouse, burrowing owl and raptors.

In 2011, Wildlife Resources was contracted to update and continue monitoring the status of wildlife within the project site in accordance with Cameco's Wildlife Monitoring Plan. More detailed information on the North Butte Remote Satellite ecology is presented in Section 3.5 of the ER.

2.3.9 Background Radiological Characteristics

A background gamma radiation survey on portions of the North Butte Remote Satellite license area was conducted during 2010. A total of 423 gamma readings were recorded in four selected areas. The satellite and mine unit portions were surveyed on an approximate 15 meter (50 feet) transect interval, the proposed roadway at 46 meter (150 feet) intervals in the road center, and the additional license area was covered by 15 to 168 meter (50 to 550 feet) transect intervals. No specific features were encountered showing elevated gamma readings, including sandstone outcrops and drainages. Generally, it is concluded that the 2010 verification field gamma survey data agree with the data collected in the mid-1980s. Radionuclide analyses of soil samples collected in 2010 from the top 15 centimeters (6 inches) were low and consistent with historical data. Additional data will be collected from the area near the satellite and pond locations prior to construction at the site. Additional information pertaining to background radiological data is contained in Section 3.11 of the ER.

2.3.10 Background Non-Radiological Characteristics

As with the Smith Ranch site, the location of the proposed North Butte Remote Satellite operation is characterized by sparse population settlements, and the predominant land uses are agriculture and energy development. The region does not have any industrial activities that constitute a major source of chemical generation. Chemicals associated with the North Butte Remote Satellite operation include sodium bicarbonate ($NaHCO_3$) CO_2, HCL, O_2, and NaOH. As with Smith Ranch, emission rates for these chemicals are anticipated to be well below the threshold that would trigger a permit. With respect to fugitive dust, the same can be said; levels are anticipated to be too low to warrant a permit.

2.4 Gas Hills Remote Satellite

2.4.1 Site Location and Layout

The Gas Hills Remote Satellite site is situated approximately 105 kilometers (65 miles) due west of Casper within Fremont and Natrona Counties. In proximity to the Smith Ranch Site, the Gas Hills Remote Satellite is situated 151 kilometers (94 miles) to the west. The permit area comprises approximately 3,440 hectares (8,500 acres) and includes: Sections 1, 2 and 11 and portions of Sections 3, 10 and 12 in T32N, R90W (Fremont County); Sections 21, 22, 27, 28, 29, 32 and 33 and portions of Sections 31 and 34, T33N, R89W (Fremont County); and a portion of Section 6, T32N, R89W (Natrona County). The general layout of the proposed project site, including the five mine units and the surface facilities, is shown on **Figures 1.11** and **1.12**.

2.4.2 Uses of Adjacent Lands and Waters

Land within the Gas Hills Remote Satellite and surrounding area (radius of 8 kilometers [5 miles]) is comprised of predominantly federal (BLM) land (85 %). Interspersed within this area are parcels of land owned by the State of Wyoming (7%) and privately-owned (8%). Other small parcels of privately and state-owned land are also located in the proximity of the proposed facility.

In addition to agriculture, the area surrounding the Gas Hills Remote Satellite has been used for a number of other purposes. In particular, the Gas Hills Uranium District is considered to be one of the major uranium-producing regions in the United States. As such, this area has seen a history of endeavoring to obtain its uranium reserves. Resource allocation from these activities has produced more than 50,800 metric tons (50,000 tons) of ore over the last 40 years. Of the approximately 3,440 hectares (8,500 acres) within the license boundary, approximately 15%, or 518 hectares (1,281 acres), have been previously disturbed by underground and/or surface mining activities.

At least 14,000 exploration boreholes have been drilled within the Gas Hills Remote Satellite area since the 1950s. Estimated impacts from previous drilling disturbed approximately 105 hectares (260 acres), or 27% of the total area contained within the five proposed ISR mine units, approximately 393 hectares (972 acres).

Approximately 14 historical open-pit or underground mining operations were located within and adjacent to the license area. Additional activities in the area include oil and gas production, although there is currently no production of oil and gas within 3 kilometers (2 miles) of the proposed facility boundary. Aside from energy production, the area is also used for recreational activities, including hunting, and is an important wildlife habitat for mule deer and pronghorn antelope.

In general, surface water sources in the Gas Hills Remote Satellite are acceptable for wildlife and livestock consumption. Surface water quality in the area varies greatly with the type of water body. As of November 2011, surface water rights within 2 kilometers (1 mile) of the Gas Hills Remote Satellite totaled eight according to the WSEO records. All but one of the surface water rights are for stock watering or wildlife purposes. One surface water right is permitted for industrial purposes and is associated with the B-Spoils Reservoir. There are 177 groundwater rights on file with the WSEO within and adjacent to the Gas Hills Remote Satellite. The vast majority of these groundwater rights are for wells installed for hydrologic monitoring or industrial purposes. Seven groundwater rights associated with wells installed for livestock watering exist. No groundwater rights for domestic use exist within 0.3 kilometers (0.5 miles) of the Gas Hills Remote Satellite according the WSEO.

The nearest PWS in the vicinity of the Gas Hills Remote Satellite is the Wyoming Transportation Department Waltman Rest Area (5600964), located 37 kilometers (23 miles) northeast of the site.

Refer to Section 3.4 of the ER for more details pertaining to the uses of lands and waters adjacent to the Gas Hills Remote Satellite.

2.4.3 Population Distribution

The nearest larger communities to the Gas Hills Remote Satellite include Riverton, Arapahoe, and Shoshoni (all in Fremont County), which are located approximately 60 to 80 kilometers (37 to 50 miles) west and northwest. The largest growth rates in the four-county region surrounding the Gas Hills Remote Satellite, since 2000, occurred in Fremont, Natrona, and Sweetwater Counties. The total current population within the 80 kilometer (50 mile) radius from the center of the Gas Hills Remote Satellite is approximately 13,500 people. For a more detailed discussion of demographics for the Gas Hills Remote Satellite area, please refer to Section 3.10 of the ER.

2.4.4 Historic, Scenic and Cultural Resources

A Class III Cultural Resources Inventory was performed over most of the Gas Hills Remote Satellite in 1992. Thirty potential sites were identified and only five of these sites were determined to be potentially eligible for listing on the National Register of Historic Places. A follow-up to this survey was performed in May of 1997 on 1,149 hectares (2,840 acres), not previously inventoried. Based on this survey, one prehistoric site was assigned a cultural affiliation. Prior to these studies a survey of portions of the Gas Hills Remote Satellite was conducted in 1980.

Of the total Gas Hills Remote Satellite area, approximately 1,797 hectares (4,440 acres) have been surveyed for archaeological sites. Recorded sites from the 1980 survey were required to be re-examined. Of the re-examined sites, two sites were considered eligible for listing on the National Register of Historic Places. An additional seven sites from this survey require further testing to determine their eligibility status. Until further clarification is made, these sites will be treated as eligible. A portion of proposed Mine Unit 5 may require a Class III inventory prior to commencement of mining related activities. For a more detailed summary of historic, scenic and cultural resources, refer to Section 3.8 of the ER.

2.4.5 Meteorology

Climate in the area surrounding the Gas Hills Remote Satellite is considered semi-arid and cool. Meteorological and climatic data for the Gas Hills Remote Satellite are collected from the Gas Hills 4E National Weather Service (NWS) Station, located at the Gas Hills Remote Satellite. Supplemental data are gathered from the Casper NWS station located at the Natrona County International Airport near Casper.

Data from the Gas Hills 4E weather station indicate that July is considered to be the warmest month of the year while January is the coldest. The mean maximum and minimum temperatures for the project site are 28°C and 12°C (83°F and 54°F), respectively in July and -2°C and -12°C (29°F and 11°F), respectively in January. Temperature extremes (highest and lowest) recorded in this area are 36°C and 37°C (96°F and -34°F), respectively.

Mean annual precipitation, based on data from the Gas Hills 4E station, is approximately 23 centimeters (9 inches). Half of the mean annual precipitation is estimated to occur between April and June, while less than a third occurs from October through March. Snow commonly falls as early as October and often as late as May. Estimated annual snowfall in the area is 200 centimeters (79 inches) with no measurable snowfall amounts observed in July and August. Monthly snowfall amounts are fairly uniform from November through February, but typically increase slightly during March and April spring storms.

Annual-average relative humidity in the area ranges from 64 to 71% during evening and overnight hours and from 43 to 46% for daytime hours. Data gathered from Pathfinder Reservoir, located 97 kilometers (60 miles) from the Gas Hills Remote Satellite, suggest annual mean lake evaporation is roughly 107 centimeters (42 inches). The estimated evapotranspiration rate for the project site is 56 centimeters (22 inches).

Wind data collected by the EPA in Casper for the period of 1984-1992 shows the average wind speed is about 21 kilometers/hour (13 miles/hour). Dominant wind direction is from the southwest at an average speed of about 28 kilometers/hour (18 miles/hour). Refer to Section 3.6 of the ER for a more detailed climatological discussion for the Gas Hills Remote Satellite.

2.4.6 Geology and Seismology

Geologic formations that crop out within the Gas Hills Remote Satellite are the Miocene Split Rock Formation, Oligocene White River, and Eocene Wagon Bed Formations. The Split Rock Formation crops out along the south and caps the Beaver Divide and is both stratigraphically and topographically higher than the Wind River Formation and consists of arkosic sands and conglomerates. The White River Formation consists of tuffaceous bentonitic mudstone with local lenses of arkosic sandstone and conglomerate. The Wagon Bed Formation consists of variegated mudstone, tuffaceous sandstone, and several ledge forming rhyodacite breccia flows and conglomerates. Quaternary alluvium occurs along Fraser Draw and West Canyon Creek and consists of unconsolidated sand, silt and clay.

Target production sands are comprised of the Eocene Wind River Formation and are subdivided into a series of sand and shale units (30 Sand, 40 Sand, etc.). Sandstones and conglomerates typically coalesce along the axes of the alluvial fan systems present in the Gas Hills Remote Satellite area. Along the margins of the fans, alternating series of coarse channel sands and conglomerates with fine grained overbank deposits are typical.

Stratigraphic interpretation within the Gas Hills Remote Satellite is complicated by extensive intertonguing of various strata, members and beds, and by post-depositional faulting. To better illustrate the site conditions, a summary of the site geology on a mine unit-by-mine unit basis is provided below. A geologic map and detailed cross sections of the Gas Hills Remote Satellite are provided in Appendix D-5 of the WDEQ Permit.

- *Mine Unit No. 1 (Muskrat Deposit)*: Located in the west-central part of the Gas Hills Remote Satellite. The production zone consists of the 70 Sand and is a well-defined single sandstone bed that ranges in thickness from 6 to 24 meters (20 to 80 feet). Confining units consist of shales, claystones, and siltstones. The upper unit ranges from 17 to 46 meters (55 to 150 feet) in thickness. The lower confining unit ranges from 6 to 15 meters (20 to 50 feet) in thickness.
- *Mine Unit No.2 (Bountiful Deposit)*: Located in the east-central portion of the Gas Hills Remote Satellite. The production zone is located within the 40-50-60-70-80 Sand horizons. The individual sandstones range in thickness from pinchout to 30 meters (100 feet). Production sands typically are separated vertically by confining units which can range up to 6 meters (20 feet) thick. The upper confining unit consists of siltstone and claystone 23 to 122 meters (75 to 400 feet) in thickness. The lower confining unit is the Triassic Chugwater Formation which is approximately 300 meters (1,000 feet) thick.

- *Mine Unit No. 3 (Peach Deposit)*: Located in the western portion of the Gas Hills Remote Satellite. The production zone is located within the 30-40-50 Sands. Individual sands range in thickness from pinchout to 15 meters (50 feet). Production sands are separated by confining claystones and siltstones which can range up to 9 meters (30 feet) in thickness. The upper confining unit is a claystone, 2 to 12 meters (5 to 40 feet) in thickness.
- *Mine Unit No. 4 (Buss Deposit)*: Located in the eastern portion of the Gas Hills Remote Satellite. The production zone is located within the 50-60-70-80 Sands. Individual sandstones within this area range in thickness from 9 to 30 meters (30 to 100 feet). An upper confining unit overlies the uppermost 90 Sand throughout the mine unit south of the Buss Fault and ranges from 3 to 30 meters (10 to 100 feet) in thickness. South of the Buss Fault, a thinner, 3 to 12 meters (10 to 40 feet) thick locally continuous confining bed overlies the 80 Sand. The confining unit north of the Buss Fault overlies the 60 Sand since the 70-80 Sands are generally unconfined. The confining unit overlying the 60 Sand ranges in thickness from 3 to 6 meters (10 to 20 feet). The confining unit below the 50 Sand ranges from 2 to 9 meters (5 to 30 feet) thick.
- *Mine Unit No. 5 (Pix Deposit)*: Located in the northeastern portion of the Gas Hill Remote Satellite. The production zone is located within the 50 Sand and ranges in thickness from 15 to 21 meters (50 to 70 feet). The upper confining unit ranges from 6 to 12 meters (15 to 40 feet) thick and the confining unit below ranges from 6 to 12 meters (20 to 40 feet) thick.

Historically, Central Wyoming has had a moderate level of seismic activity compared to the rest of the State. A discussion on historical earthquakes in the surrounding areas (Atlantic City, Lander, and Sand Draw/Gas Hills Areas,) is presented below.

The Atlantic City Area is located about 100 kilometers (62 miles) southwest of the Gas Hills Satellite:

- *December 10, 1873*: Intensity III, near Atlantic City in southern Fremont County.
- *December 12, 1923*: Intensity V earthquake reported from Atlantic City.
- *October 30, 1925*: Intensity III
- *August 22, 1959*: Intensity IV.
- *February 23, 1963*: Magnitude 4.3, Intensity V 48 kilometers (30 miles) west, northwest of Atlantic City.
- *November 3, 1984*: Magnitude 5.0, Intensity VI 16 kilometers (10 miles) northwest of Atlantic City. This earthquake was one of the strongest recorded in the southwestern quarter of the State.

The Lander Area is located approximately 100 kilometers (62 miles) west of the Gas Hills Satellite:

- *January 22, 1889*: Intensity of III-IV.
- *November 21, 1895*: Intensity IV.
- *November 23, 1934*: Intensity V 32 kilometers (20 miles) northwest of Lander. Cracks were found in buildings in two business blocks and the brick chimney of the Fremont County Courthouse was moved 5 centimeters (2 inches) away from the building. August 17, 1950: Intensity IV.
- *January 12, 1954*: Intensity II.
- *December 13, 1955*: Intensity IV event near Lander.
- June 14, 1973: small earthquake 13 kilometers (8 miles) east northeast of Lander. This event has since been interpreted as a probable explosion.

- *January 31, 1992*: Magnitude 2.8 32 kilometers (20 miles) northwest of Lander.
- *October 10, 1992*: Magnitude 4.0, Intensity III 35 kilometers (22 miles) east of Lander.

Sand Draw/Gas Hills:

- *August 11, 1916*: Intensity III 10 kilometers (6 miles) south of Jeffrey City.
- *April 22, 1973*: Magnitude 4.8, Intensity IV 19 kilometers (12 miles) north of Jeffrey City.
- *March 25, 1975*: Magnitude 4.8, Intensity III 29 kilometers (18 miles) northwest of Jeffrey City. A mobile home 56 kilometers (35 miles) southeast of Riverton was moved 3 centimeters (1 inch) off its foundation.
- *December 19, 1975*: Magnitude 3.5 40 kilometers (25 miles) northeast of Jeffrey City.
- *August 16, 1985*:,Magnitude 4.3, Intensity IV 40 kilometers (25 miles) northwest of Jeffrey City.
- *June 1, 1993*: Magnitude 3.8, Intensity III near Baroil, about 32 kilometers (20 miles) southeast of Jeffrey City.

Additional seismic reports for Natrona County are summarized in Section 3.3 of the ER. Reported damage from earthquake activity was minimal to non-existent.

There are three exposed active faults in the vicinity of the Wind River Basin and the Gas Hills Remote Satellite. Of these faults, the Green Mountain segment of the South Granite Mountain Fault System was analyzed deterministically to estimate the ground motion at the Gas Hills Remote Satellite. This fault was the only one analyzed because it is closer to the site than the other faults, its recurrence interval is shorter, and it can produce a maximum credible earthquake for the area. For the site, which is located about 45 kilometers (28 miles) from the nearest segment of the Green Mountain Fault, the expected horizontal ground acceleration at the site would be about 6% the acceleration of gravity for a magnitude 6.75 earthquake (Campbell, 1987). For a more detailed summary of the Gas Hills Remote Satellite Geology and Seismology, see Section 3.3 of the ER.

2.4.7 Hydrology

Surface water drainage within the Gas Hills Remote Satellite is primarily to West Canyon Creek, with lesser amounts draining to Fraser Draw. West Canyon Creek has its headwaters at the Beaver Divide in the southern portion of the site. Tributaries drain approximately 70% of the area. West Canyon Creek is tributary to Canyon Creek, then to Deer Creek, and subsequently to Poison Creek. Fraser Draw and its tributaries drain approximately 25% of the southwest portion of the Gas Hills Remote Satellite. Fraser Draw is tributary to Muskrat Creek. Both Poison Creek and Muskrat Creek are within the Wind River Basin. Only a minor portion (less than 2%) of the area lies within the West Sage Hen Creek drainage in the Sweetwater River Basin.

Many of the basin areas have been disturbed by previous surface and underground mining activities. Disturbances include total blockage of channels by spoil piles, stream capture by mine pits, and surface disturbance by exploration activities. Gully erosion and headcutting are actively occurring adjacent to pit highwalls and oversteepened reaches near the basin divide. Sedimentation and ephemeral ponding occurs where drainages are impounded by spoil piles.

Drainages in the Gas Hills region are generally ephemeral. With the exception of isolated spring-fed reaches, channels are dry for the majority of the year. Channels are generally above the local water table except at a few locations where springs or seeps may exist. Discharge from these springs can create a limited reach of perennial flow.

Post-Wind River Formations that crop out within the Gas Hill Remote Satellite area are the Quaternary Alluvium, the Miocene Split Rock, Oligocene White River, and the Eocene Wagon Bed Aquifers. Aquifers include the Wind River Aquifer (uranium host and aquifer of primary importance within the Gas Hills Remote Satellite), Cloverly and Nugget Aquifers, Tensleep Aquifer (a very good aquifer and in places contains water hot enough to provide a geothermal energy source).

Transmissivity for the Wind River Aquifer within the Gas Hills Remote Satellite area varies from 6.5E-2 to 89.7 meters^2/day (4.9E-4 to 6.7E-1 feet^2/minute). Horizontal hydraulic conductivities range from 0.01 to 3 meters/day (2.4E-5 to 6.7E-3 feet/minute). In Mine Unit 3 where the highest hydraulic conductivities were reported, the values are believed to be influenced by proximity to faults which were acting as recharge boundaries. Hydraulic conductivities generally increase from east to west across the Gas Hills Remote Satellite Area corresponding to coarsening texture of the Wind River sediments. Calculated storage coefficients range from 8.5E-5 in Mine Unit 4 to 1.3E-3 in Mine Unit 2. A more detailed description of the Gas Hills Remote Satellite surface and ground water hydrology can be found in Section 3.4 of the ER.

2.4.8 Ecology

The majority of the lands in and around the Gas Hills Remote Satellite are shrub lands intermixed with pockets of herbaceous grasslands, evergreen trees and barren land. Woodlands are located along the southern boundary of the Gas Hills Remote Satellite.

Five native vegetation types occur within the Gas Hills Remote Satellite. These include mixed sagebrush grassland, rough breaks, bottomland sagebrush, upland grassland, and wetlands. Studies have shown no federally listed plant species were observed during surveys of the area.

Approximately 11 hectares (28 acres) of potential wetlands were identified and mapped based on the presence of potential wetland vegetation. Most of this observed wetland vegetation exists along and within the stream channel of West Canyon Creek. Furthermore, wetland vegetation also occurs along the margins of Cameron Spring Reservoir and several small seeps which originate from the base of the Beaver Divide near the southern boundary of the license area. Wetland species on the site include creeping spikerush (*Eleocharis palustris*), bulrush (*Scirpus pungens*), sedges (*Carex* spp.), and rushes (*Juncus* spp.). A small stand of willows (*Salix* spp.) occurs in the upper portion of West Canyon Creek.

Wildlife surveys for the Gas Hills Remote Satellite area included big game, upland game birds, raptors, small mammals and migratory birds of high federal interest (MBHFI). Detailed information for the Gas Hills Remote Satellite ecology is presented in Section 3.5 of the ER.

2.4.9 Background Radiological Characteristics

Much of the land at the Gas Hills Remote Satellite has been previously disturbed by mining activities. A baseline radiological survey was performed to both establish pre-mining radiological conditions and to document areas exhibiting high radiation resulting from previous conventional mining activities. Baseline data were also collected on radiological characteristics of soil, air, groundwater and surface water.

Gamma readings averaged 20 µR/hour across the Gas Hills Remote Satellite area, which are comparable to other Wyoming sites. Higher readings were observed in areas previously disturbed by mining activity. Areas exhibiting the highest gamma readings are those containing ore and waste rock piles that remain from previous conventional mining activities in addition to conventional mine ore haul roads (i.e., the Carol Shop Road). A second evaluation of baseline radiological characteristics was completed in 2008 to satisfy Condition 9.13 of SUA-1548. The evaluation took place at four areas designated as Study Areas A, B, C and D. Direct radiation measurements taken in Study Area A had an average of 22 μR/hr. Study Area B had an average of 40 μR/hr, Study Area C had an average of 17 μR/hr., and Study Area D had an average of 22 μR/hr.

Soil sampling results corroborate gamma survey results in that the areas containing high background concentrations of radionuclides are those that have been previously disturbed by conventional mining activities.

A pre-operational air monitoring program was established at four locations across the Gas Hills Remote Satellite for ambient gamma exposure and radon concentrations. Measurements resulted in average gamma exposure rates of approximately 170 mrem/year and average radon concentration of 1.6 pCi/liter/year. High volume air samplers have been ordered and will be installed in January 2012 to collect baseline air particulate samples pursuant to Regulatory Guide 3.14

Groundwater samples show uranium concentrations are relatively low in all monitoring wells, including the ore zone wells. Radium is in equilibrium with uranium in the aquifer with higher concentrations found near existing and mined-out uranium deposits. Outside the ore bodies, radium levels are significantly lower. Up-gradient from these deposits, Ra-226 is typically less than 5 pCi/liter. Down-gradient values are higher, but still less than 50 pCi/liter. Ra-226 in surface waters shows significant variation without regard to the mine disturbances. Values are typically less than 5 pCi/liter but elevated levels have been observed. A more detailed discussion of the baseline radiological conditions is contained in Section 3.11 of the ER.

2.4.10 Background Non-Radiological Characteristics

Similar to the other remote satellite locations, the Gas Hills Remote Satellite is characterized by sparse population settlements with predominant land uses geared primarily towards agriculture and energy development. The region does not have any industrial activities that constitute a major source of chemical generation. Chemicals associated with operating the Gas Hills Remote Satellite will be the same as the other remote satellite locations except for the addition of H_2SO_4 that may be used during the yellowcake precipitation process.

2.5 Ruth Remote Satellite

2.5.1 Site Location and Layout

The Ruth Remote Satellite facility is located in southeast Johnson County, about 84 kilometers (52 miles) north of Casper. The facility is about 21 kilometers (13 miles) southwest of the North Butte Remote Satellite. Encompassing approximately 572 hectares (1,414 acres), the Ruth Remote Satellite includes portions of Sections 13, 14, 23, 24, 25, and 26 of T42N, R77W.

2.5.2 Uses of Adjacent Lands and Waters

Located in the southern portion of the Powder River Basin, the Ruth Remote Satellite and surrounding area measured within an 8 kilometer (5 mile) radius is predominately comprised of private land (88%). Interspersed within private ownership are parcels of state (6%) and federal (BLM) lands (6%). Recreational activities, such as hunting, within this area are limited by access within private lands.

The majority of the lands in and around the Ruth Remote Satellite are grasslands similar to the North Butte Remote Satellite. Pockets of shrub land, both within the license boundary and within an 8 kilometer (5 mile) radius, are present. Scattered areas of woody wetlands run along a north-south line through the middle of the license boundary and extend out into the 8 kilometer (5 mile) radius to the southeast.

As with the North Butte Remote Satellite, cattle and sheep ranching comprises the major land use in the region surrounding the Ruth Remote Satellite with approximately 94% of the land in the Powder River Basin classified as rangeland. Native rangeland vegetation provides the majority of the livestock forage in the region. Major native forage species are blue grama grass, western wheatgrass, needlegrasses, prairie junegrass, and numerous forbs. Surface water within and adjacent to the Ruth Remote Satellite is used for livestock and wildlife watering. Surface water flow also contributes to the riparian vegetation along the Dry Fork of the Powder River. As of November 2011 there are 32 surface water rights adjudicated for this area according to WSEO records. All but one of the surface water rights are for stock watering purposes. One surface water right is permitted for industrial purposes and is associated with the Ruth Remote Satellite ISR retention reservoir. The Ruth Remote Satellite ISR retention reservoir consists of a two-celled solar evaporation pond located off-channel in the Dry Fork of the Powder River drainage (NENE, Section 14, T42N, R77W).

There are 125 groundwater rights on file with the WSEO within and adjacent to the Ruth Remote Satellite. The vast majority of these groundwater rights are for wells installed for CBM development. For livestock water consumption, 22 groundwater rights exist. There are three monitoring wells remaining at the Ruth Remote Satellite that were installed by Uranerz in the 1980s. One dual use domestic and stock groundwater right exists approximately 0.5 kilometers (0.5 miles) southeast of the Ruth Remote Satellite.

The nearest municipal water source is located at the unincorporated community of Linch, located approximately 8 kilometers (5 miles) west of the Ruth Remote Satellite. Linch does not have an EPA PWS number. See Section 3.3 of the ER for a more detailed discussion of the uses of lands and waters within and adjacent to the Ruth Remote Satellite.

2.5.3 Population Distribution

The Ruth Remote Satellite is located in southeastern Johnson County, approximately 10 kilometers (6 miles) southwest of the North Butte Remote Satellite. Because the Ruth Remote Satellite is so close to the North Butte Remote Satellite, both of these locations share the same four counties that lie within an 80 kilometer (50 mile) radius from the site, as well as the same nearby communities. The total current population within the 80 kilometer (50 mile) radius from the center of the Ruth Remote Satellite is approximately 7,300 people. See Section 3.10 for a more detailed discussion on the population distribution at the Ruth Remote Satellite.

2.5.4 Historic, Scenic and Cultural Resources

In June of 1980, members of the Office of the Wyoming State Archeologist conducted an archeological survey of 16 hectares (40 acres) within the Ruth Remote Satellite. In addition to the survey, a file search was conducted through SHPO in May of 1980. No surveys had previously been conducted in the area nor were any previously recorded sites known.

Results from the survey showed that no cultural resources were located within the study area during the 1980 survey. An archaeological clearance was recommended with the stipulation that if subsurface cultural remains were found, the appropriate state and federal agencies would be contacted immediately. Further information regarding this survey can be found in Section 3.8 of the ER.

2.5.5 Meteorology, Climatology and Air Quality

Currently, there are no meteorological stations in operation at the Ruth Remote Satellite. The Ruth satellite is 19 kilometers (12 miles) southwest of the North Butte Remote Satellite. At this time, the contemporary dataset most relevant to the Ruth Remote Satellite is at the North Butte Remote Satellite.

See Section 3.6 of the ER for site-specific data collected at the North Butte Remote Satellite from December 21, 2010 through June 2, 2011. Cameco will establish a meteorological station at the Ruth Remote Satellite and collect 12 months of data in support of future licensing activities at the site.

The most recent presentation of meteorological or climatological data for the Ruth Remote Satellite is included in the Ruth Supplemental Report (1988). Pertinent information from this report is described below.

- Cleveland-Cliffs operated a meteorological data collection program from 1978 to 1979 23 kilometers (14 miles) northeast of the Ruth Remote Satellite in the Pumpkin Buttes. Parameters measured include wind speed and direction, temperature, relative humidity and particulate concentrations. Sounding balloons were also used to determine atmospheric stability.
- Data from both the Cleveland-Cliffs meteorological data collection program and regional stations in Kaycee, Midwest, Casper and one additional station 29 kilometers (18 miles) southeast of Gillette were used to describe meteorology and climate conditions at the Ruth Remote Satellite. Sections 8.2 through 8.8 in Volume 1 of the Ruth Supplemental Report presents the results of the compilation of the most recently analyzed data associated with the Ruth Remote Satellite. The following data are presented in the Ruth Supplemental Report:
    1. Table 8.1 – Maximum snowfall amounts.
    2. Table 8.2 – Average relative humidity.
    3. Tables 8.3 to 8.6 – Regional monthly precipitation.
    4. Table 8.7 – Mean sky cover.
    5. Tables 8.8 to 8.11 – Regional monthly temperature.
    6. Figures 8.2 and 8.3 – Wind rose diagrams.

For a more detailed discussion related to climatology of the Ruth Remote Satellite, see Section 3.6 of the ER.

2.5.6 Geology and Seismology

The Ruth Remote Satellite is characterized by flat to gently sloping terrain. Surface geology consists of sands, sandy clays and silts in a repeating facies type environment. Let down material consisting primarily of manganese nodules is abundant on the knolls and high areas but much less apparent in the lowland areas.

Target sands at the Ruth Remote Satellite are units of the Eocene Wasatch Formation. Beginning with the uppermost sand unit, the units of interest are the B Sand, B-A Shale, A Sand, A-1 Shale, and the 1 Sand. The primary production sand is the A Sand having a production zone typically 15 meters (50 feet) thick with an average depth of 163 meters (535 feet) below the surface. The production zone is bounded above and below by confining layers averaging about 9 meters (30 feet) thick. The upper and lower confining beds are composed of shales, silty shales, and shaley lignite interbeds. Evidence of structural instability at the Ruth Remote Satellite such as faulting has not been observed either by field observations or through drill hole correlation. The closest known faulting and/or significant folding is present approximately 7 kilometers (4 miles) to the west of the site along Pine Ridge.

Historic seismic events for Johnson County, including the Ruth Remote Satellite have been documented by the USGS (Case and others, 2002, 2003). Relevant seismic activity is summarized below.

The USGS documents eight occurrences of magnitude 2.5 and greater earthquakes recorded in Johnson County.

- *October 24, 1922*: Intensity IV to V located approximately 13 kilometers (8 miles) east of Sheridan.
- *September 6, 194*3: Intensity IV epicenter 5 to 6 kilometers (3 to 4 miles) south-southwest of Buffalo.
- *June 3, 1965*: Magnitude 4.7 centered approximately 19 kilometers (12 miles) south of Kaycee.
- *April 12, 1966*: No specified magnitude/intensity detected 40 kilometers (25 miles) southwest of Buffalo.
- *September 2, 1976*: Magnitude 4.8, Intensity IV-V 53 kilometers (33 miles) northeast of Kaycee.
- *September 7, 19*84: Magnitude 5.1, Intensity V 53 kilometers (33 miles) east-southeast of Buffalo.
- *February 22, 1992*: Magnitude 2.9 recorded approximately 29 kilometers (18 miles) east of Buffalo.
- *August 30, 1992*: Magnitude 3.6, Intensity IV centered near Maynworth, approximately 35 kilometers (22 miles) west-northwest of Kaycee.

For a more detailed description of the geology and seismicity of the Ruth Remote Satellite, see Section 3.3 of the ER.

2.5.7 Hydrology

The Ruth Remote Satellite is located in the Dry Fork of the Powder River drainage which is a tributary of the Powder River located approximately 35 kilometers (22 miles) upstream of the confluence of Dry Fork and the Powder River. The Powder River is tributary to the Yellowstone River, which is part of the Missouri River Drainage Basin. Dry Fork flows in a northerly direction through the center of the Ruth Remote Satellite. The Dry Fork of the Powder River is classified as an intermittent stream and mainly flows in response to snow melt and large convective rainstorms. The alluvium is partially saturated and supports cottonwood trees and willows.

The size of the drainage area above the Ruth Remote Satellite is approximately 156 kilometers^2 (60 miles^2). The Dry Fork channel has a gradient of about 7 meters/kilometer (15 feet/mile); an active channel width of 2 meters (7 feet); and a length of approximately 6 kilometers (4 miles) through the Ruth Remote Satellite.

No stream gauging stations are currently located on the Dry Fork of the Powder River. The mean annual flow of Dry Fork at the Ruth Remote Satellite is estimated to be 0.1 meters^3/second (4.8 feet^3/second). Basin characteristics, rainfall depth, and results of hydrologic calculations are presented in Table 10.16 of Volume I (Ruth Supplemental Report).

The Ruth Remote Satellite is located on the outcrop of the Wasatch Formation, which is a fluvial deposit. At the Ruth Remote Satellite, the Wasatch Formation is approximately 443 meters (1,350 feet) thick. The major sands can be correlated for miles and are the basis for regional aquifers in the Powder River Basin. Aquifer properties are locally variable due to large variations in local lithologies. Recharge to the Wasatch Formation is mainly by exposure to outcrops with some influx of groundwater from vertical movement through adjacent aquifers. Regionally, the Wasatch Formation combined with the underlying Fort Union Formation is developed extensively for shallow domestic and stock wells in the area.

The A and B Sands are saturated, but due to their discontinuous lithology and limited size, they cannot be considered aquifers. Over most of the Ruth Remote Satellite, the B-A Aquitard is vertically continuous and not compromised by sand lenses. The A-1 Aquitard consists of two unequal shale layers separated by a thin coal seam. This is not expected to significantly affect the ability of the A-1 Aquitard to prevent lixiviant migration to the underlying 1 Sand during ISR operations.

The A Sand in this area exhibits an average transmissivity of 1 meter^2/day (110 gallons/day/foot) and a horizontal permeability of 0.1 meter/day (0.3 feet/day). The A Sand is a confined aquifer with a storage coefficient of 8.0E-5. Groundwater flows towards the northwest. Groundwater gradient in the area is 0.005 meters/meter with a movement rate of 0.4 centimeters/day (0.01 feet/day) from an average permeability of 0.1 meters/day (0.3 feet/day) and an effective porosity of 0.1.

See Section 3.4 of the ER for more details pertaining to surface and groundwater characterization.

2.5.8 Ecology

The Extended Reference Area (EXREFA) concept was used in describing vegetation at the Ruth Remote Satellite. A vegetation map, discussion of the communities and species present along with a comparison of vegetation studies previously conducted in the region were prepared in conjunction with this study. Original baseline data were collected by NUS Corporation and baseline verification was performed by Applied ECOsystems in the summer of 1988.

Vegetation types present at the Ruth Remote Satellite were delineated into one of four mapping units:

1. Drainage Bottomland
2. Sprayed Sagebrush-Grassland
3. Sagebrush-Grassland
4. Grassland

Descriptions and photographs of the four mapping units can be found in Section 12.2 of the Ruth Supplemental Report. No rare or endangered plant species were identified.

The baseline wildlife study at the Ruth Remote Satellite is a composite of work initiated in the fall of 1987 and supplemented by earlier work. The wildlife study area included the license area plus a buffer of 2 kilometers (1 mile) for raptors and 1 kilometer (0.5 mile) for all other wildlife. Field investigations for big game, mammalian predators, small and medium-sized mammals, raptors, game birds, passerine birds, reptiles, and T&E species were completed on the Ruth Remote Satellite area and adjacent habitats.

No big game migration routes or critical habitat are known to exist within the Ruth Remote Satellite. No nesting or other significant use by raptor species is expected. At the time of the 1989 Ruth Supplemental Report, three T&E species had the potential to occur at the site; the bald eagle, the peregrine falcon, and the black-footed ferret. The bald eagle was occasionally sighted in the winter; no sightings of the peregrine falcon or the black-footed ferret were reported. Refer to Section 3.5 of the ER for a more detailed discussion of the ecological resources of the Ruth Remote Satellite.

2.5.9 Background Radiological Characteristics

Components of the pre-mining environmental radiological sampling program at the Ruth Remote Satellite include the following; vegetation, soils, sediment, gamma survey, thermoluminescent dosimetry, atmospheric Rn-222, groundwater (Ra-226), and surface water (Ra-226). Results from the sampling program are detailed in Volume 2 of the Ruth Supplemental Report.

A gamma survey was completed on a 60 meter (200 foot) grid overlying the ore body. Continuous and fixed point readings ranged from 9 to 14 μR/hour with an average of 11 μR/hour and a standard deviation of 1 μR/hour.

Radium-226 values from collected groundwater samples ranged from <0.06 to 175 pCi/liter with an average of 16 pCi/liter. Elevated Ra-226 levels are typical in groundwater where the aquifer shows significant uranium mineralization.

Surface water quality samples were collected at two locations on the Dry Fork of the Powder River. One sample was collected at SWS-U (upstream of the Ruth Remote Satellite) and four samples were collected at SWS-L (downstream of the Ruth Remote Satellite). Refer to Section 3.11 of the ER for more information pertaining to sampling, sampling results, and background radiological characteristics.

2.5.10 Background Non-Radiological Characteristics

Similar to the other remote satellites, the proposed Ruth Remote Satellite is exemplified by sparse population settlements with predominant land uses geared towards agriculture and energy development. The region does not have any industrial activities that constitute a major source of chemical generation. Chemicals associated with the Ruth Remote Satellite will be the same as those to be used at the North Butte Remote Satellite.

2.6 References

Campbell County Natural Resource and Land Use Plan. 2007. Adopted August 21.

3.0 Description of Proposed Facilities and Operations

Section Summary: This section describes various components of the project relative to operating characteristics including the orebodies, mine units, and the injection/extraction circuits. The project sites under the Source and Byproduct Materials License SUA-1548 are described in Section 3.2.

Section 3.3 provides a description of the orebodies at Smith Ranch and the North Butte, Gas Hills and Ruth Remote Satellites. The Smith Ranch orebody description remains largely unchanged but, the reserve estimates have been revised to include Highland and Reynolds Ranch satellite facilities. Additionally, Section 3.3.1.3 includes an updated schedule of mine unit development at Smith Ranch. The orebody descriptions have also been updated at the North Butte, Gas Hills and Ruth Remote Satellite facilities.

Section 3.4 provides an updated discussion related to geologic and hydrologic assessments of mine unit wellfields, including a commitment to provide the hydrologic testing packages to NRC for review.

Section 3.5 discusses mine unit design, construction and operations. Smith Ranch still employs the same mine unit pattern configurations, but a seven-spot and line drive pattern description has been added in Section 3.5.1.1. Monitoring well spacing and placement (Section 3.5.1.2) also has not changed. The basic well completion techniques described in Section 3.5.2 for well installation have been modified slightly to account for improvements such as centralizer spacing, and changes to well bore annulus requirements. Additionally, a description of alternative completion methods and well recompletion techniques employed for production and injection wells is discussed in Sections 3.5.2.4, 3.5.2.5 and 3.5.2.6. Drill hole site preparation and hole abandonment in Sections 3.5.2.8 and 3.5.2.9 have been revised to be consistent with State of Wyoming requirements. The abandoned drill hole count has been updated as provided in Section 3.5.2.10. This section also provides a revised discussion on how potentially leaking old exploration drill holes will be handled. Section 3.5.2.11 provides the Cameco well stimulation (well workover) program. Section 3.5.3.8 provides a discussion related to special operational considerations for the Gas Hills Remote Satellite wellfields.

Section 3.6 provides the facility layout, equipment, processing circuit and waste water management for Smith Ranch (including Highland and Reynolds Ranch) as well as the North Butte, Gas Hills and Ruth Remote Satellites. Sections 3.6.1 reference new figures and maps for the Smith Ranch main office, CPP and Highland CPF. The Smith Ranch satellite facilities discussed in Section 3.6.2 have been updated to incorporate new and proposed satellite facilities in addition to new floor plan figures and maps for the facilities. Treatment of waste water at Smith Ranch, Section 3.6.1.3 includes information regarding the new Class I UIC deep disposal wells installed. Instrumentation and controls in header houses have continually improved over the renewal period and a revised discussion is provided in Section 3.6.1.4. The selenium treatment facility is introduced in Section 3.6.1.4. Sections 3.6.3 through 3.6.5 provide information on the remote satellite facilities relative to facility layout, uranium processing circuits, waste water management and instrumentation.

Section 3.7 discusses access roads which have not changed except for the addition of the roads at the remote satellite facilities. A new section describing construction quality assurance is found in Section 3.8.5.

Section 3.9 discusses the updated project schedules and water balance for Smith Ranch and each of the remote satellite facilities.

Section 3.9 discusses potential impacts of operations on surrounding waters, primarily spills and excursions with information and related data provided in Section 3.9.1.1. Section 3.9.1.2 provides an updated spill history section. Information regarding excursions by mine unit and corrective actions is provided in Section 3.9.2. Section 3.9.3 provides an update discussion related to leakage at the lined ponds and the purge storage reservoirs.

3.1 Background

Since purchasing the Smith Ranch properties from RAMC in 2002, Cameco has operated Smith Ranch and the Highland Uranium Project (Highland) as one integrated property. Shortly after the acquisition, Cameco combined and consolidated the facilities and work force and relocated all staff to the Smith Ranch facilities. The Highland CPF was placed on standby status in 2003 and has not processed uranium since that time. Cameco plans to refurbish the CPF during the next renewal period and operate it again as an IX resin and yellowcake processing facility.

In March 2003, Cameco requested an amendment from NRC to combine the Highland Source and Byproduct Materials License SUA-1511, the North Butte license (SUA-1540), the Ruth license (SUA-1539), and the Gas Hills license with the Smith Ranch license SUA-1548. On August 18, 2003, NRC issued Amendment No. 5 to SUA-1548 reflecting the consolidation of the licenses and establishing the Smith Ranch CPP complex as the main processing facility with Highland, North Butte and Ruth properties as satellite facilities. NRC Staff did not approve the inclusion of Gas Hills with this amendment as their review of the 1998 request to amend the Gas Hills as a satellite to Highland had not yet been completed. Gas Hills was subsequently amended into SUA-1548 with Amendment No. 6 dated January 29, 2004.

In December 2004, Cameco requested an amendment to SUA-1548 to add the Reynolds Ranch satellite area. Reynolds Ranch is north of and contiguous with the Smith Ranch portion of the Smith Ranch Project (SUA-1548). The amendment would allow the construction of an additional IX satellite facility and mine units. NRC approved the request through Amendment No. 11 to SUA-1548 on January 31, 2007. WDEQ approval of the Reynolds Ranch amendment is still pending as of January 2012.

Future operations under the Source and Byproduct Materials License SUA-1548 will consist of continued mine unit installation and operation at Smith Ranch and Highland production areas as well expansion to Smith Ranch (Reynolds Ranch) and the remote satellite areas North Butte, Gas Hills and Ruth. The development schedule is discussed in more detail later in this section.

The major components of the Smith Ranch Project (SUA-1548) are:

- The orebody at Smith Ranch, Highland, Reynolds Ranch Satellite, North Butte Remote Satellite, Gas Hills Remote Satellite, and Ruth Remote Satellite;
- The mine units;
- The lixiviant injection circuit;
- The uranium extraction circuit;
- Uranium precipitation, drying and packaging at the Smith Ranch CPP (and in the future at the Highland CPF);
- Waste water management systems; and
- Aquifer restoration, decommissioning and surface reclamation.

Descriptions and operating characteristics of these components and processes are provided in detail in the following subsections. Waste water management systems and aquifer restoration/surface reclamation are described in detail in Sections 4.0 and 6.0, respectively.

3.2 Site Description and Facilities Layout

3.2.1 Smith Ranch

The main office complex and the CPP are approximately 35 kilometers (22 miles) northeast of the town of Glenrock and 40 kilometers (25 miles) northwest of Douglas (see **Figure 1.3**). **Figure 1.3** also shows the general project location, access to the Smith Ranch license area, the location of process areas including satellite buildings, mine units, pipelines, impoundments, major roads, and the main office complex. As of January 2012, five satellite facilities and two processing plants are currently located at Smith Ranch. As discussed in Section 3.6.3.1, an additional satellite and associated wellfields is planned for the Reynolds Ranch area. **Figures 1.4 through 1.8** provide greater detail of the mining areas depicted on **Figure 1.3**. The Highland main office and CPF complex is located in the NE/NW Section 29, T36N, R72W.

The Reynolds Ranch Satellite (shown on **Figure 1.9**), when constructed, will be located in the SE1/4, Section 35, T37N, R74W. The building will occupy approximately 2,044 meters^2 (22,000 feet^2). The satellite will serve all mine units planned for the Reynolds Ranch Satellite area. The satellite will be designed with a maximum through-flow of 22,680 liters/minute (6,000 gallons/minute) during production operations. The original license amendment for Reynolds Ranch specified a maximum flow rate of 17,034 liters/minute (4,500 gallons/minute) and Cameco requests that the maximum flow rate be increased to 22,712 liters/minute (6,000 gallons/minute) through this LRA. The satellite equipment will include 1,890 liters/minute (500 gallons/minute) of reverse osmosis (RO) capacity for groundwater restoration purposes.

3.2.2 North Butte Remote Satellite

The North Butte Remote Satellite facility is located in southwest Campbell County, Wyoming. The site is approximately 80 kilometers (50 miles) from the City of Gillette and 64 kilometers (40 miles) from the Town of Wright. The permit area contains approximately 408 hectares (1,010 acres) and includes portions of Sections 18 and 19 in T44N, R75W and Sections 13, 23, 24 and 25 in T44N, R76W.

The surface facilities at the North Butte Remote Satellite will include the mine units, header houses, buried pipelines, overhead and buried power lines, access roads, laydown yard, surge ponds, Class I UIC disposal wells, and the satellite IX building. The locations of the satellite building and associated facilities are shown on **Figure 1.10**. The satellite building will house IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, disposal well equipment, RO units and bioremediation materials for groundwater restoration, a laboratory area, offices, and an employee break room. **Figure 3.1, North Butte Remote Satellite Floor Plan** shows the equipment layout for the proposed satellite building. The building will occupy approximately 1,560 meters^2 (16,800 feet^2) and will be designed to operate with a maximum flow of 22,680 liters/minute (6,000 gallons/minute) during operations. The original license amendment for North Butte specified a maximum flow rate of 17,010 liters/minute (4,500 gallons/minute) and Cameco requests that the maximum flow rate be increased to 22,712 liters/minute (6,000 gallons/minute) through this LRA. The original plant design in the license amendment had a smaller building dimension than stated above (see Change No. 6, NRC Application, Page1-6, Section 1.4.2 dated March 27, 1992).

The North Butte uranium orebody has been divided into five proposed mine units. Preliminary geologic and hydrologic information has been developed by Uranerz and PMC and is presented in Appendices D5 and D6 of the North Butte WDEQ permit which accompany this LRA. Detailed geologic and hydrologic information of the individual mine units such as isopach maps, potentiometric surface maps and monitor well locations will be submitted as part of each mine unit hydrologic testing package.

3.2.3 Gas Hills Remote Satellite

As shown on **Figure 1.1**, the Gas Hills Remote Satellite is located in Fremont and Natrona Counties, approximately 105 kilometers (65 miles) due west of Casper. The permit area contains approximately 3,440 hectares (8,500 acres) and includes: Sections 1, 2 and 11 and portions of Sections 3, 10 and 12 in T32N, R90W (Fremont County); Sections 21, 22, 27, 28, 29, 32 and 33 and portions of Sections 31 and 34, T33N, R89W (Fremont County); and a portion of Section 6, T32N, R89W (Natrona County). The general layout of the proposed project site, including the five mine units and the surface facilities, is shown on **Figure 1.11** and **Figure 1.12**.

The surface facilities at Gas Hills will include the mine units, header houses, buried pipelines, overhead and buried power lines, access roads, evaporation ponds, and the satellite IX buildings. The locations of the satellite facilities and evaporation ponds are shown on **Figure 1.11**. The current plan is for the main office, one of the (IX) facilities and main water treatment facility to be located in the existing Carol Shop. No additional surface disturbance at the Carol Shop is anticipated to accommodate the planned operational and parking facilities. Depending on the interior condition of the Carol Shop, a new process/administration building may be necessary. This building would be constructed on previously disturbed land within the Carol Shop complex. The satellite buildings will house IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, disposal well equipment, RO units and bioremediation materials for groundwater restoration, a laboratory area, offices, and an employee break room. An additional satellite may be constructed at one of the two locations shown on **Figure 1.12** and will disturb approximately 1 hectare (2 acres), including parking and all ancillary facilities. **Figure 3.2, Carol Shop Floor Plan** shows the equipment layout for the Carol Shop satellite building. The process equipment in the Carol Shop building will occupy only a portion of the building and will be designed to operate with a maximum flow of 51,030 liters/minute (13,500 gallons/minute). However, the current plans are to operate the Carol Shop at only 34,020 liters/minute (9,000 gallons/minute).

An additional alternative remote satellite facility at Gas Hills will be installed as a remote IX, resin loading and unloading facility, and future restoration RO at one of the two locations shown on Gas Hills WDEQ Permit Plate OP-1W. Bleed and restoration reject fluids from the associated wellfields will be transferred through pipelines to the central water treatment facility at the Carol Shop for treatment and disposal. The alternative remote satellite will have an installed flow capacity of approximately 17,010 liters/minute (4,500 gallons/minute) of produced fluids. The layout for the satellite is shown on **Figure 3.3, Alternative Satellite Floor Plan**.

3.2.4 Ruth Remote Satellite

The Ruth Remote Satellite facility is located in southeast Johnson County, Wyoming, about 84 air kilometers (52 miles) north of Casper (**Figure 1.1**). The facility is about 21 air kilometers (13 miles) southwest of the North Butte Remote Satellite. The Ruth Remote Satellite includes portions of Sections 13, 14, 23, 24, 25, and 26 of T42N, R77W. The Ruth site has approximately 572 hectares (1,414 acres). All existing facilities at the Ruth site are non-operational and on stand-by status. Currently, three buildings (process building, generator building, and warehouse), two evaporation ponds, and three monitoring wells remain on the property. An abandoned wellfield (0.3 hectares or 0.8 acres) and two topsoil storage areas also remain on the site. Topsoil Storage Pile #1 contains 13,587 meters^3 (17,771 yards^3) and Topsoil Storage Pile #2 contains 2,356 meters^3 (3,081 yards^3). Cameco does not have plans to extract uranium at Ruth within the next 10 years, and an operations plan that details the mine unit wellfield layout, elution circuit, and other process details has yet to be developed. The license area for the Ruth Remote Satellite is shown on **Figure 1.13**.

3.3 Description of the Orebodies

3.3.1 Smith Ranch

3.3.1.1 Smith Ranch Orebody

The uranium ore deposits at Smith Ranch occur at depths of 61 to 366 meters (200 to 1,200 feet) below surface. The ore is hosted in fluvial, arkosic sandstones of the Paleocene Fort Union and Eocene Wasatch Formations. The Fort Union and Wasatch Formations are locally separated by a laterally prevalent coal seam known as the School Coal. Individual host sand units have been correlated and named, and are separated by semi-continuous, confining layers usually composed of shale or claystone. The Tertiary sediments dip gradually toward the basin syncline (generally 0 degrees to 5 degrees). Faulting in these Tertiary sediments is rare.

In cross section, reduction-oxidation (redox) fronts, also called roll fronts, generally form C-shaped rolls, concaving toward the oxidized side of the roll front. In plan view, mineralization occurs in sinuous redox fronts within the host sandstones. The best ore accumulations typically occur where the redox fronts are the most sinuous. Hematite and limonite coatings on sand grains are prevalent on the oxidized side of the front, and feldspars have been totally or partially altered to kaolinite. Sands on the oxidized side of the front are generally orange to red to brown in color. There is nominal uranium on the oxidized side of the roll front and there may be a false radiometric uranium signature resulting uranium series decay elements.

On the reduced side of the roll front, the feldspars are unaltered. Reductants such as carbonaceous materials (lignite) and reduced mineral forms such as pyrite may also be present. The host sands on the reduced side of the roll front are usually gray to green-gray in color. The economically recoverable uranium mineralization is concentrated on the reduced side of the roll front, which at Smith Ranch typically results in uranium ore thicknesses of between 2 and 8 meters (5 and 25 feet).

The two most common uranium ore minerals are uraninite (UO_2) and coffinite [$U(SiO4)_{1-X}(OH)_{4X}$) and occur as precipitated coatings on sand grains. These minerals both contain uranium in the +4 valence (or reduced) state. The chemical reduction of the uranium during ore emplacement is accomplished by the interaction of the oxidized ore-bearing groundwater with organic carbon and pyrite that were naturally present within the sandstones near these redox boundaries.

3.3.1.2 Smith Ranch Reserve Estimates

Smith Ranch currently has 18 mine units in a production, pre-restoration or restoration phase. For 2010, Cameco produced 817 metric tons (901 tons) of uranium (U_3O_8). The following table provides the official reserve and resource numbers (metric tons) reported by Cameco in 2010 for Smith Ranch and the associated satellites (Highland and Reynolds Ranch).

Proven Reserves	Probable Reserves	Measured Reserves	Indicated Resources	Inferred Resources
1,415 (1,560)	2,224 (2,452)	2,235 (2,464)	8,005 (8,824)	2,976 (3,280)
All units are in metric tons with tons given in parentheses.				

During the installation of each mine unit, it is very likely that the reserves will be slightly changed based on the results of final delineation drilling and pilot hole drilling for the mine unit pattern areas. The final outlines of the mine units will depend on the reserves encountered during the delineation drilling of each mine unit.

3.3.1.3 Smith Ranch Mine Unit Locations

Table 3-1, Mine Unit Development Schedule lists all current and proposed mine units for Smith Ranch and their status as of January 2012. **Table 3-1** shows the proposed production sequence for the mine units. The CPP IX facility currently serves Mine Units 1, 2, 3 and 15/15A. Satellite 2 serves Mine Units C, D, D-Extension, F, E, H, and I. The Satellite No. 2 facility is designed to operate with a maximum flow of 3,200 gallons/minute during production operations. As of January 2012, Mine Units C and D-Extension are undergoing groundwater restoration. Mine Units H and I are in production. Mine Unit D-Extension is out of production and is being prepared for groundwater restoration. Satellite No. 3 serve Mine Units F, J and K. Satellite 3 may also serve additional mine units that are currently being geologically evaluated for future expansion in the western portion of the original Highland license area (i.e., west of Satellite No. 3). Satellite SR-1 serves Mine Units 3, 4, 15 and 15A. SR-1 may also serve additional mine units (i.e., Mine Units 7 and 8) being evaluated for future expansion. The southwest Satellite, SR-2, serves Mine Unit 9 and will serve planned mine units in the southwest area, including Mine Units 10, 11, and 12. The Reynolds Ranch Satellite will serve Mine Units 21 through 28. Further details related to the Smith Ranch CPP and associated satellite operations are provided in Section 3.6.

3.3.1.4 Smith Ranch Mine Unit Flow Rate Predictions

Flow rates for the Smith Ranch mine units were estimated during the hydrological assessment of the mine unit wellfields, and this information is provided in the Mine Unit Hydrologic Test Documents for each mine unit. A Hydrologic Test Proposal will be developed for each of the Reynolds Ranch Satellite mine units and submitted to LQD for approval and NRC for review. The hydrologic testing program will be completed and the results presented along with final mine unit development plans, monitoring requirements, and baseline groundwater quality determinations in the Mine Unit Hydrologic Test Document.

3.3.2 North Butte Remote Satellite

The North Butte Remote Satellite and associated mine units will be operated as a remote satellite IX uranium extraction facility. Only IX uranium recovery, water treatment and disposal activities will occur at the North Butte Remote Satellite. Proposed facilities are described in more detail in subsequent sections. The proposed mine plan for the North Butte orebody is to extract the economically recoverable uranium from approximately five mine units, beginning with Mine Unit #1. The license area and facilities layout are shown on **Figure 1.10**.

3.3.2.1 North Butte Orebody

The uranium mineralization is present as coffinite, a black uraniferous silicate mineral. The host sandstones are composed of quartz, feldspars, and rock fragments with locally occurring carbon fragments. Grain size ranges from very fine-grained to small granules. The sandstone is weakly to moderately cemented and friable. Occasional occurrences of pyrite and calcite as cementing materials can be observed. The uranium is deposited on individual detrital sand grains or on and within authigenic clays in the interstices. The interstitial clays present are primarily montmorillonite with lesser amounts of kaolinite and smectite. Hematite is a common oxidation product of pyrite within the host rock, along with minor limonite. Accessory biotite and muscovite are also present.

In 2010, Cameco conducted a detailed mineralogical study on two North Butte cores at the Cameco Research Center at Port Hope, Ontario. The new mineralogical studies confirmed that the predominant mineral in the formation is coffinite.

Mineralogical characterization of the North Butte ore was done using bulk energy dispersive X-ray analysis (EDX), X-ray diffractometry (XRD) and microscopy of polished sections of unbroken ore pieces, and porosimeter measurements.

The XRD results indicated that quartz, albite, the K-feldspars microcline and orthoclase as well as the phyllosilicates chlorite and muscovite/illite are the primary gangue minerals. XRD results confirmed the arkosic nature of the sandstone.

The Scanning Electron Microscope/EDX work showed the trace mineral content to be highly variable. The occurrence of unoxidized heavy minerals such as ilmenite and magnetite as well as leucoxene and limonite indicates that overall, the sandstone was not strongly affected by weathering and diagenetic alteration. This conclusion is also supported by the relatively high amount of unaltered feldspar in the rock and some delamination and alteration of micas. Trace amounts of elemental selenium and ferroselite were identified as selenium-bearing minerals, and in one sample, trace amounts of nickel-arsenic-bearing pyrite were identified.

Thorium minerals were present in both drill cores and may have influenced some of the radiometric drill hole logging data. The uranium mineralization is fine grained and predominantly within the sandstone matrix. It often forms coatings on the sandstone detritus above or below layers of clay minerals that appear to be commonly of chloritic to montmorillonitic composition. Other than clay and regular detritus, uranium mineralization was also associated with iron-titanium minerals, pyrite, zircon, calcite and carbonaceous material. The predominant uranium mineralization is coffinite associated with tyuyamunite with a minor component of uraninite associated with tyuyamunite.

3.3.2.2 North Butte Reserve Estimates

The North Butte Remote Satellite has five proposed mine units. Each mine unit will contain reserves ranging from 455 to 817 metric tons (502 to 901 tons) of uranium. The following table provides the official reserve and resource numbers (metric tons) reported by Cameco in 2010 for North Butte.

Proven Reserves	Probable Reserves	Measured Reserves	Indicated Resources	Inferred Resources
0	3,723 (4,104)	620 (683)	2,714 (2,992)	408 (450)
All units are in metric tons with tons given in parentheses.				

During the installation of each mine unit, it is very likely that the reserves will be slightly changed based on the results of final delineation drilling and pilot hole drilling for the mine unit pattern areas. The final outlines of the mine units will depend on the reserves encountered during the delineation drilling of each mine unit.

3.3.2.3 North Butte Mine Unit Locations

Detailed information on the individual mine units will be submitted in each mine unit hydrologic testing package. Approximate mine unit locations are shown on **Figure 3.4, Mine Unit Location Map** and the site layout map, **Figure 1.10**. **Figure 3.5, Mine Unit 1 Location Map** shows the configuration of Mine Unit 1. As additional mine unit delineation drilling occurs, the shape and configuration of these mine units may change to some degree.

3.3.2.4 North Butte Mine Unit Flow Rate Predictions

Hydro-Engineering Inc. (1992) performed a wellfield flow modeling study on the then proposed Mine Unit 1 which simulated the anticipated wellfield pattern configuration at various bleed and well flow rates to determine whether flow paths would cross the original permit boundary. This study is provided in **Appendix B, North Butte Wellfield Modeling Study**. The model simulations indicate that solution containment within the original permit boundary is possible with the planned operational bleed rate of approximately 1%, with the specific mine unit pattern configuration used in the study (injection/production wells located as close as 37 meters (120 feet from the license boundary). A bleed rate of 0.5 to 1.5% was also used in the model prediction to produce an even more significant buffer zone between the patterns and the license boundary. This is due to the aquifer properties of the "B" sand in the area of proposed Mine Unit 1 and the fact that the license boundary in the area of interest is in an upgradient direction from the proposed mine unit pattern activity. A cumulative impact analysis has been performed for the North Butte Remote Satellite to predict potential drawdown effects from other operations in the area as well as effects of North Butte operations on other groundwater users in the area. This analysis is discussed in Section 4.4 of the ER.

Because the exact mine unit pattern configuration is not presently known, and will not be known until delineation drilling is completed, the simulations will be re-run after the mine unit planning has been completed to confirm and assure that normal bleed rates will, in fact, contain the lixiviant within the production pattern areas during the production phase. This simulation will be included with the mine unit hydrologic data package for Mine Unit 1 which will be submitted to LQD for approval and NRC for review.

3.3.3 Gas Hills Remote Satellite

The Gas Hills Remote Satellite and associated mine units will be operated as an IX uranium recovery and yellowcake slurry production facility. Loaded IX resin and yellowcake slurry will be transported in DOT-approved containers to either the CPP or the CPF for final processing. Proposed facilities are described in more detail in subsequent sections. The proposed mine plan for the Gas Hills orebody is to extract the economically recoverable uranium from five mine units, beginning with Mine Unit 1. The five mine units correspond to the following deposits: Muskrat, Bountiful, Peach, Buss, and Pix, respectively. Cameco's goal is to extract sufficient uranium from the Gas Hills mine units to yield as much as 1,134 metric tons (1,250 tons) of yellowcake per year over a production period of 20 years or longer.

3.3.3.1 Gas Hills Orebody

The Gas Hills uranium ore deposits are found within the Puddle Springs Arkose Member of the Eocene Wind River Formation. Alluvial fans were formed when high energy bed load streams with headwaters in the Granite Mountains deposited sedimentary loads on an incised erosional surface. After deposition and burial, uranium-bearing, oxidized groundwater solutions migrated down the permeable fluvial axes of the fans. Lobes of alteration spread parallel to the axes, and uranium was deposited at an oxidation-reduction interface (roll front) in a tongue-like geometry. Faulting and folding of the surface then complicated the geological picture. The NRC Staff has reviewed this information in an amendment to SUA-1548 as it pertains to the proposed operations at the Gas Hills Remote Satellite.

The Gas Hills area is comprised of four distinct Eocene Wind River Formation alluvial fans and roll front systems. These are (from east to west): Deer Creek, Canyon Creek, Coyote Creek, and Muskrat Creek. The Gas Hills Remote Satellite production area lies within a large segment of the Canyon Creek system and the eastern margin of the Coyote Creek system. The uranium mineralization is contained in a series of Wind River Formation sand and shale units. The sand units are numbered by even increments of ten starting with the deepest sand unit designated as the 10 Sand.

The uranium orebodies within the Gas Hills Remote Satellite license area are contained within channel sandstones and conglomerates of the Wind River Formation. The orebodies, which occur as roll fronts, are typically as much as 48 meters (156 feet) thick and vary in width from a pinch out to 30 meters (100 feet). The fronts are anisotropic with the bulk of the high grade ore being contained within a few feet of the oxidation/reduction contact and the balance of the ore grading out from the contact point.

The two most common uranium ore minerals are uraninite, UO_2, and coffinite, (Frondel, 1967), with both minerals occurring as intimate intergrowths (Ludwig and Grauch, 1980; King and Austin, 1966; Hazen, 1996). These minerals both contain uranium in the 4+ valence state, which is the reduced oxidation state for uranium. The chemical reduction of the uranium during ore emplacement was accomplished by the interaction of groundwater with organic carbon and pyrite. This has resulted in an intimate association of the uranium minerals with carbon, an association which has been verified by electron microprobe analysis (Ludwig and Grauch, 1980; Hazen, 1996).

3.3.3.2 Gas Hills Reserve Estimates

Cameco's goal is to extract sufficient uranium from the Gas Hills Remote Satellite ore to yield as much as 1,134 metric tons (1,250 tons) of yellowcake per year over a production period of 20 years or longer. The initial annual production rate will be approximately 454 metric tons (500 tons) of yellowcake. The following table provides the official reserve and resource numbers (metric tons) reported by Cameco in 2010 for Gas Hills.

Proven Reserves	Probable Reserves	Measured Reserves	Indicated Resources	Inferred Resources
0	8,611 (9,492)	1,530 (1,687)	1,029 (1,134)	585 (645)
All units are in metric tons with tons given in parentheses.				

During the installation of each mine unit, it is very likely that the reserves will be slightly changed based on the results of final delineation drilling and pilot hole drilling for the mine unit pattern areas. The final outlines of the mine units will depend on the reserves encountered during the delineation drilling of each mine unit.

3.3.3.3 Gas Hills Mine Unit Locations

The ore deposits contained within the mine units are vertically stacked, and multiple completion well installations will be utilized (see Section 3.5). The Gas Hills orebody geology is complex, and in some cases uranium will be extracted from multiple vertical zones within the same production area. Therefore, a detailed discussion of each mine unit is provided below to provide an understanding of the Gas Hills stratigraphy and the need for multiple well completions. The locations of the mine units are shown on **Figures 1.11** and **1.12**.

Mine Unit 1

Mine Unit 1 is located in the west central portion of the Gas Hills Remote Satellite license area. Uranium deposits within this mining unit are contained within what is locally called the 70 Sand. The 70 Sand is part of the Coyote Creek Fan System, within the Wind River Formation. This is a single sand layer with no identified traceable faults, and typically has several hundred feet of hydrostatic head (confined water pressure).

The 70 Sand consists of medium to very coarse grained arkosic sandstone. This sand ranges in thickness from 6 to 24 meters (20 to 80 feet), and is generally underlain and overlain by continuous claystone and siltstone beds that act as confining layers for groundwater within the unit. The upper confining unit is continuous throughout the region and ranges in thickness from 17 to 46 meters (55 to 150 feet). It separates the 70 Sand from several thin layers of discontinuous sandstones. The lower confining unit ranges in thickness from 6 to 15 meters (20 to 50 feet) and separates the 70 Sand from the 50 Sand (sand units are not necessarily continuous throughout an area - e.g., in this case, the 60 Sand is not encountered beneath the 70 Sand as anticipated).

The 70 Sand in Mine Unit 1 is separated from underlying formations by as much as 61 meters (200 feet) of Wind River Formation sediment. The underlying Pre-Tertiary units are Triassic in age. The Jasper Fault and the HBow Fault lie to the south of Mine Unit 1. There has been no previous mine development within the production area of Mine Unit 1.

Mine Unit 2

Mine Unit 2 is located in the east central portion of the Gas Hills Project site. Uranium deposits contained within this mine unit are roll fronts within multiple sands (40, 50, 60, 70, and 80 Sands) which in this area are part of the Canyon Creek Fan System. This mine unit contains two traceable faults. Considerable attention will be given to mapping, hydrological testing, and pattern planning in the vicinity of these faults and where discrete sand units come together in order to evaluate impacts to mining operations (see Section 3.5.3.8).

The proposed area of pattern development would cross two traceable faults, the Bountiful and the Uranium Point Zone (UPZ) Fault. The Bountiful Fault has a displacement of 12 to 15 meters (40 to 50 feet). The UPZ Fault has up to 15 meters (50 feet) of displacement. Prior to mine development in this area, the faults will be hydrologically tested to determine their potential impact on mining.

The Mine Unit 2 sands consist of medium to very coarse arkosic sandstones with cobble and boulder conglomerate interbeds. The individual sandstones within this area range in thickness from a pinchout to 30 meters (100 feet). The sands are typically separated vertically by confining units of shale that can be up to 6 meters (20 feet) thick. In the planned vicinity of ore development, the confining units tend to be continuous. East of the planned development area, the shale interbeds disappear. The upper confining unit for the 70 Sand consists of siltstone and claystone. It is continuous throughout the east central portion of the site and has a thickness that ranges from 23 to 122 meters (75 to 400 feet). The confining unit below the 40 Sand is the Triassic Chugwater Formation. This formation is predominantly composed of shale and siltstone, and is not considered to be an aquifer (i.e., it would not yield significant quantities of groundwater). The total thickness of the Chugwater Formation is about 305 meters (1,000 feet). Between the sand layers of the Mine Unit, there are shale layers that range from 2 to 6 meters (5 to 20 feet) thick.

Previous mining has occurred in the vicinity of Mine Unit 2. The UPZ mine shaft is located on the southern edge of Mine Unit 2. Federal American Partners commenced construction of this shaft in 1979. Construction was halted in 1983, at which time, the TVA poured a concrete floor in the bottom of the shaft and allowed it to flood. At the end of construction, the shaft was 268 meters (880 feet) deep. Pump stations were installed at 76 and 151 meters (250 and 495 feet) and the shaft is concrete lined. The shaft was reclaimed in 1991 and filled with materials removed from the shaft during its construction, as well as broken concrete from the reclaimed surface facilities, and capped with concrete. Impacts of prior mining operations will be evaluated during hydrologic testing as discussed in Section 3.4.

Mine Unit 3

Mine Unit 3 is located in the western portion of the Gas Hills Remote Satellite. The uranium production zones in this mine unit are roll fronts within multiple sands (30, 40, and 50 Sand) that are part of the Coyote Creek Fan System. This orebody is a southern extension of the Pathfinder Lucky Mc open pit mine. Dewatering of the Lucky Mc open pit over the years has lowered the potentiometric surface within the northern portion of the mine unit (i.e., water levels have been reduced because water was drained from the sand unit). Because of insufficient water pressure, the upper geologic section of this unit may be excluded from development. This mining unit has two traceable faults as well as the abandoned Atlas underground mine. In order to develop this mining unit, additional mapping and hydrological testing will be required for pattern design as discussed in Section 3.4.

The 30, 40, and 50 Sands consist of medium to coarse grained arkosic sandstones. The individual sands range in thickness from a pinchout to 15 meters (50 feet). Within the planned development area, the sands are generally separated by confining claystones and siltstones that can be up to 9 meters (30 feet) thick. The 30 through 70 Sands coalesce along the northwest side of Mine Unit 3 and form a single hydrostratigraphic unit.

The upper confining unit to the 70 Sand is a claystone that is continuous throughout the proposed development area. This claystone ranges from 2 to 12 meters (5 to 40 feet) in thickness. The confining unit immediately below the 30 Sand is composed of claystones and mudstones of the Wind River Formation or shales of the Pre-Tertiary Formations.

Mine Unit 3 is underlain by the Morrison, Cloverly, Thermopolis, Muddy, Mowry, and Frontier Formations. The Morrison, Thermopolis, and Mowry Formations are not considered to be aquifers. The Cloverly Formation, which is considered to be an aquifer, is separated from the proposed production sand by confining units within the Wind River Formation. There are no aquifers within the Muddy Formation, and there is very little aquifer potential within the Frontier Formation.

The proposed development area for Mine Unit 3 would intersect the traceable PCH Fault. Hydrological testing would be performed to determine its potential impact on the proposed mining. The Peach pump test, performed in 1996, indicates a zone of higher transmissivity near the Jasper Fault. In addition, water level data collected from wells in the area indicate that the Lucky Mc Fault located north of the planned development, may represent a hydrological barrier.

The Atlas Underground Mine was developed in the area of Mine Unit 3 in the 1960s and was reclaimed in the 1980s. It is located in the western portion of the site. This mine developed ore in the 30, 40, and 50 Sands. Impacts of previous mining activities will be evaluated during hydrologic testing as discussed in Section 3.4.

Mine Unit 4

Mine Unit 4 is located in the eastern portion of the Gas Hills Remote Satellite license area. The uranium production targets in this mine unit are roll fronts located in the 50 through 90 Sands. These sands are part of the Canyon Creek Fan System. The Buss open-pit mine is located in the northeastern portion of the planned development area. It was reclaimed in 1995. The mine extracted ore from the 60, 70, 80, and 90 Sands. Prior dewatering of the open pit has lowered the groundwater level surface within portions of this mining unit. Roll fronts in the higher part of the section near the open pit mine may be excluded from development because of insufficient water pressure.

The mine unit will intersect at least one known traceable fault, the Buss Fault. This fault has a vertical displacement of about 15 meters (50 feet). A hydrological testing program will be used to determine the potential impact of this fault on ISR development. The sand units of Mine Unit 4 consist of medium to very coarse grained arkosic sandstones with cobble and boulder conglomerate interbeds. The individual sandstones within this area range in thickness from 9 to 30 meters (30 to 100 feet. The sands can be separated vertically by mudstone or siltstone interbeds which can range from pinchouts to 5 meters (15 feet) thick. These confining units are not always continuous and frequently disappear allowing the sand units to coalesce.

An upper confining unit overlies the uppermost uranium-bearing sandstone (90 Sand) throughout the production area south of the Buss Fault. It has a thickness that ranges from 3 to 30 meters (10 to 100 feet). A thinner (3 to 12 meters), locally continuous confining bed overlies the 80 Sand south of the Buss Fault. The confining unit north of the Buss Fault is shale on top of the 60 Sand (the 70 and 80 Sands are generally unconfined - the top surface of the groundwater is at atmospheric pressure). The shale on top of the 60 Sand has a thickness that ranges from 3 to 6 meters (10 to 20 feet). The confining unit below the 50 Sand ranges from 1.5 to 9 meters (5 to 30 feet) in thickness and is continuous throughout the production area. This confining unit separates the 50 Sand from the underlying East Canyon Conglomerate.

Mine Unit 4 is underlain locally by a lower confining unit and over 91 meters (300 feet) of East Canyon Creek Conglomerate which either rests on the Wind River Formation shale or unconformably overlies the Jurassic Sundance Formation.

Mining and reclamation of the Buss open pit mine has affected the overall water quality in the vicinity of Mine Unit 4. In addition, upper ore zones (80 and 90 Sands) were mined in the Two States and Blackstone Pits. An underground drift was developed south of the Two States Pit. Other open-pit mines in the area include the Cap, Bengal, and Mars Pits, which have been backfilled above the water table. Impacts of these previous operations on future mining activities in this mine unit will be evaluated during hydrologic testing, discussed in Section 3.4.

Mine Unit 5

Mine Unit 5 is located in the northeastern portion of the Gas Hills Remote Satellite license area. The mine unit is near several open-pit mines, such as the Veca mine, and several hundred acres of Abandoned Mine Land Program (AML), Umetco, and TVA reclamation. In addition, the Rox and Thunderbird underground mines, which are located within the Thunderbird Graben and within Mine Unit 5, were abandoned in the 1960s and reclaimed in the 1980s. The uranium production areas in this mine unit are roll fronts within the 50 Sand of the Canyon Creek Fan System. The 50 Sand in the vicinity of Mine Unit 5 consists of medium to very coarse grained arkosic sandstones with interbeds of cobble and boulder conglomerate. The thickness of the 50 Sands in this area ranges from 15 to 21 meters (50 to 70 feet). Because of the complexity of the sand layers in the vicinity of Mine Unit 5, and the lack of detailed geologic information, no isopach map has been prepared for the 50 Sand. Isopach maps will be prepared after additional delineation drilling has been performed and prior to submittal of a hydrologic test proposal.

An upper confining unit overlies the 50 Sand throughout the Mine Unit 5 area and ranges from 5 to 12 meters (15 to 40 feet) thick. The confining unit below the 50 Sand ranges in thickness from 6 to 12 meters (20 to 40 feet). This confining unit separates the 50 Sand from the underlying East Canyon Conglomerate. The mine unit is underlain by a lower confining unit and 76 meters (250 feet) of East Canyon Conglomerate which unconformably overlies the Jurassic Sundance Formation.

Mine Unit 5 will intersect one traceable fault, marking the southern side of the Thunderbird Graben which is characterized by two parallel striking faults. The stratigraphic section between these two faults is downthrown by about 46 meters (150 feet).

Historic open pit mining has affected water quality in the vicinity of Mine Unit 5. The Thunderbird/Rox Mine is located within the northern portion and is likely to affect operations in the area. The Mine Unit 5 hydrological testing program will address the potential impacts of previous mine development, including the potential downgradient movement of high total dissolved solid (TDS) water from the abandoned mine reclamation. The movement of high TDS water in reference to future ISR operations is further discussed in Section 3.5.3.8.

3.3.3.4 Gas Hills Mine Unit Flow Rate Predictions

To estimate the flow rates expected during production at the Gas Hills Remote Satellite, flow models have been developed and run for each of the first four mine units, where there is adequate data to effectively model the hydrology. These estimated flow rates will assist with production planning and groundwater restoration programs, because they simulate the natural limits of the hydrogeologic system, which must be known to effectively plan and control the operation. Where estimated flow rates are low, due to low permeability and/or low available hydraulic head, the economics of ISR can be impacted to the point that the uranium mineralization may be unrecoverable. In addition, the estimated flow rates have been used to determine the production and groundwater restoration schedules. Therefore, the model estimates of this section are important to the overall planning of the Gas Hills Remote Satellite operations, but are still only model estimates, which will be modified as the property is developed and additional data are accumulated.

A discussion of the modeling used for the Gas Hills Remote Satellite is included as **Appendix C, Gas Hills Groundwater Modeling**. The following is a summary of the flow model results.

Simulation Method

An analytical groundwater model was used to predict maximum flow rates for the Gas Hills Remote Satellite. The model, PATH v.5.0, was developed for the ISR industry and allows the input of numerous wells and well patterns. Superposition is used to simulate the additive effects of varying flow rates from multiple wells. The final predicted flow rate is based on the available injection or production pressure, the aquifer characteristics and fluid properties, and the geometry of the patterns.

A total of five areas of differing geology and hydrogeologic conditions were identified for analysis: Mine Unit. 1, Mine Unit 2, Mine Unit 3 south of the Atlas Mine, Mine Unit 3 north of the Atlas Mine, and Mine Unit 4. Mine Unit 5 has not yet been adequately defined for hydrologic modeling purposes. Three geometric patterns were used to analyze each area:

1. "Single row 5 spot" - single row of connected 5-spot patterns with the injectors located on the outside and the producers located on the pattern interior;
2. "Double row 5 spot" - two connected rows of single row 5 spots. This can be extended to a block 5 spot pattern by adding rows of 5-spots; and
3. "Groundwater sweep" - single or double row of production wells.

Figure 3.6, Modeled Pattern Configuration shows these three pattern configurations and **Figure 3.7, Simulation Index Map** shows the areas modeled. The aquifer and fluid properties were determined from pump test analyses and reflect reasonable estimates of the anticipated hydrogeologic conditions within each mine unit. Model sensitivity analysis supports the selection of aquifer permeability within the observed range of pump test data. The ore thickness, depth to the static water level (SWL) and the depth from the SWL to the center of the ore were obtained from the potentiometric surface map and geologic cross sections of the five analyzed areas.

The following model input data was constant for all of the five analyzed areas.

Porosity	0.27
Viscosity	1.0 centipoise
Compressibility	2.8 E-5
Ore thickness	6 meters (20 feet)
Spacing between like wells	24 meters (80 feet)

A discussion of the input data is included in Gas Hills WDEQ Permit Addendum OP 2.

Flow Rate Results

The estimated flow rates that result in a pressure differential match for each analyzed area and pattern configuration are summarized in **Table 3-2, Gas Hills Flow Rate Estimates**. In each modeled area, the single row 5-spot pattern exhibited the highest flow rate, and the groundwater sweep pattern exhibited the lowest flow rate. The estimated flow rates during production and groundwater restoration have been used to determine the project schedule, and to design the water treatment facilities.

As can be seen from **Table 3-2**, maximum production flow rates for the double row 5-spot patterns should range from 34 to 76 liters/minute (9 to 20 gallons/minute) per production well, which are acceptable for economic recovery of the uranium reserves. However, due to the limited static water level above the ore zone in the Gas Hills (limited static head), pumping rates during groundwater sweep, when there is no re-injection, are estimated to be 8 to 38 liters/minute (2 to 10 gallons/minute) per pumped well after one year. During the reverse osmosis phase of groundwater restoration, when 75 to 95% of the produced fluids are re-injected back into the ore zone, sustainable flow rates are estimated to be from 15 to 76 liters/minute (4 to 20 gallons/minute) per pumped well. These flow rates represent the ability of the aquifer, given the existing available heads, to yield water. These flow rates will be the physical limitation on both the rate of recovery and the rate of groundwater restoration which can be achieved at the Gas Hills Remote Satellite.

Mine Unit Simulations of Groundwater Flow Paths

The movement of groundwater near previously conventionally mined areas, both reclaimed open pit mines and underground mines, was investigated to determine the impact of the mined out areas on the proposed ISR operations, to improve pattern design, and to account for the hydrologic gradient. PATH V.5.0. was used to simulate flow rates and pathlines in areas of interest at the Project. Simulations were conducted for five areas:

1. Mine Unit 1;
2. Mine Unit 2;
3. Mine Unit 3, south, located south of the Atlas underground mine workings;
4. Mine Unit 3, north, located north of the Atlas underground mine workings and south of the Pathfinder Mines Corporation reclaimed pit; and
5. Mine Unit 4 near the reclaimed Buss pit.

The simulation areas are shown on **Figure 3.7**. The purpose of the simulation was to estimate injection and production rates which will control flow at the margins of the patterns, and prevent the migration of high TDS water associated with previously mined areas from migrating toward the ISR operation.

Simulation Methods

The planned mine unit geometry, geology, and hydrology were used to estimate the achievable flow rates for the areas to be developed by ISR. These estimated flow rates are based on a calibration of injection and production pressures as discussed in Section 3.3.3.4. Pathlines showing the direction of groundwater flow, were modeled based on, (1) estimated flow rates; (2) the wellfield pattern; (3) the sand thickness, porosity and permeability; and (4) the potentiometric surface elevations.

Output from the model is displayed as pathlines of groundwater movement in two modes. The Injection Mode (forward tracking) shows the pathline of a particle of water that was injected through an injection well into the aquifer. The Extraction Mode (backward tracking) shows the pathline that a particle of water in the aquifer would travel to reach and be produced from a production well. The Injection Mode is important in tracking the flow of lixiviant and to ensure that lixiviant does not migrate away from the production area. The Extraction Mode indicates the degree of dilution that can be expected during production and will be important in tracking the migration of groundwater from previously mined areas toward the mine unit area. If an initial simulation showed migration to or from an area of concern, such as a previously mined area, then the wellfield pattern and/or the injection and production rates could be adjusted to reduce the outward migration of lixiviant (flare) or the inward migration of groundwater (sweep).

Simulation Results

The estimated model input data and the results for each simulation case are summarized in **Table 3-3, Summary of Groundwater Flow Path Simulation**. A Production Plot (Injection Mode), a Production Plot (Extraction Mode), a Groundwater Sweep Plot (Extraction Mode), the input formation data, and the final adjusted production and injection rates for each simulation case are presented in **Table 3-3**. The model results for each mine unit indicate the following:

1. Injection and production rates can be modified to meet the site-specific hydrologic conditions such that lixiviant control is assured at the Project with the existing hydrologic conditions;
2. The 1% bleed rate, which is used in the waste water handling section of this application, will be adequate to maintain the necessary control in each mine unit which has been modeled; and
3. The areal extent of the "flare" during mining has been used to model the volume of affected groundwater which must be recovered and treated during groundwater restoration.

3.3.4 Ruth Remote Satellite

At stated in Section 3.2.4, all existing R&D facilities at the Ruth Remote Satellite are non-operational and on stand-by status. Currently, three buildings, two top soil stockpiles, two evaporation ponds and three monitoring wells are all that remain on the property. Cameco has plans to extract uranium at Ruth within the next ten years, but an updated operations plan that details the extraction and production plans, including mine units, satellite layout and other details have yet to be developed. Cameco anticipates that the existing evaporation ponds and building structures that were used in the R&D operation will also be used in the commercial operation. The Ruth Remote satellite and associated mine unit(s) will be operated as a satellite IX uranium extraction facility to the Smith Ranch CPP or Highland CPF. Only IX uranium recovery, water treatment and disposal activities will occur at Ruth.

3.3.4.1 Ruth Orebody

The uranium mineralization at Ruth occurs in the Wasatch Formation. The ore sand is approximately 163 meters (535 feet deep and generally 15 meters (50 feet) thick and is called the A sand. The unit existing above the A sand is called the B Sand and an aquitard of approximately 12 meters (40 feet) of shale exists between the A and B Sands. A thinner aquitard exists below the A sand and above the next underlying aquifer termed the 1 Sand. In the Ruth ore deposit the uranium mineralization is present as amorphous uranium oxide or sooty pitchblende, with some subordinate carnotite. The host sandstones are composed of quartz, feldspars, and rock fragments with locally occurring carbon fragments. Occasional occurrences or pyrite and calcite as cementing materials can be observed. The uranium is deposited upon individual grains or upon and within authigenic clays in the interstices. The interstitial clays present are primarily montmorillonite with less amounts of kaolinite. Biotite and muscovite are also present.

3.3.4.2 Ruth Reserve Estimates

The Ruth Remote Satellite facility has three proposed mine units. The following table provides the official reserve and resource numbers (metric tons) reported by Cameco in 2010 for Ruth.

Proven Reserves	Probable Reserves	Measured Reserves	Indicated Resources	Inferred Resources
0	0	0	1,850 (564)	76 (23)
All units are in metric tons with tons given in parentheses.				

During the installation of each mine unit, it is very likely that the reserves will be changed based on the results of final delineation drilling and pilot hole drilling for the mine unit pattern areas. The uranium orebody will be divided into three mine units comprising in total about 58 hectares (142 acres). The mining units are designated as Mine Unit I (19 hectares or 47 acres), Mine Unit II (16 hectares or 41 acres) and Mine Unit III (22 hectares or 54 acres). Detailed information on the individual mine units will be submitted in each mine unit Hydrologic Testing Document.

3.3.4.3 Ruth Mine Unit Flow Rate Predictions

During the Uranerz Ruth R&D project, the groundwater flow from each production well was approximately 57 to 95 liters/minute (15 to 25 gallons/minute). The total flow rate from all of the mine units will be approximately 3,780 liters/minute (1,000 gallons/minute).

Because the exact mine unit pattern configuration is not presently known, and will not be known until drilling is completed, groundwater simulations will be completed after the actual installation of wells within Mine Unit I to confirm and assure that anticipated bleed rates will, in fact, contain the lixiviant within the production pattern areas. This simulation will be included with the mine unit Hydrologic Testing Document for Mine Unit I which will be submitted to LQD for approval and NRC for review.

3.4 Detailed Geologic and Hydrologic Assessment of Wellfields

3.4.1 General

WDEQ Permit Appendices D-5 and D-6, respectively, contain baseline geologic and hydrologic information pertaining to the Smith Ranch Project SUA-1548 facilities including Smith Ranch, North Butte, Gas Hills, and Ruth Remote Satellites. Prior to developing individual mine unit wellfields, detailed geologic and hydrologic information is collected and assembled so that pattern areas can be defined, geologic and hydrologic parameters quantified, hydrologic monitoring programs developed, and groundwater quality adequately defined in advance of production.

To accomplish the above, a multi-step program is conducted which includes submittals to NRC for review. The following sections contain a detailed description of the data that is collected for new mine unit wellfields, and the reports that will be submitted to NRC.

3.4.2 Hydrologic Testing Proposal

Prior to installing monitor wells in a new mine unit, a Hydrologic Testing Proposal is developed and submitted to LQD for review and comment. Cameco will approve the hydrological test plan/results through the ORC/SERP process and will provide a copy to the NRC for review. The proposal typically contains the following:

1. A map showing the general location of the proposed production pattern areas and all proposed monitor wells.
2. Information supporting the proposed monitor well spacing and location for all monitor wells for the mine unit.
3. Isopach maps of the proposed production zone sand, overlying confining unit and underlying confining unit.
4. Geologic cross sections and cross section location maps which show geologic conditions of the proposed mine unit. Geophysical logs used to develop the cross sections will either be shown on the cross sections or provided in an appropriate scale and format to allow direct overlay of the logs onto the cross sections.
5. Information describing proposed pump test procedures including the well(s) to be pumped and monitored, estimated pumping rate(s) and the expected duration of pumping. The primary objective of the pump test will be to demonstrate hydraulic connection between the ore zone and the "M" monitor wells and to determine the degree of isolation of the ore zone from overlying and underlying zones, the "MO" or "MS" and "MU" or "MD" monitor wells. The secondary objective will be to determine aquifer properties, including transmissivity, permeability, storage coefficient, and anisotropy. These aquifer properties can be used in hydrologic modeling to simulate production activities.
6. Wetlands information and/or mitigation plans, if applicable.

Additional objectives will be determined for each mine unit to address specific geologic and hydrologic conditions including the position and hydraulic properties of any faults or discontinuities within a particular mine unit. Potential impacts of past surface and underground mining and reclamation activities will be evaluated along with anticipated differences in water quality due to previous mining activities.

Following review and comment of the Mine Unit Hydrologic Testing Proposal by NRC and LQD, the pump test(s) is conducted according to the proposal. Water quality data will also be collected at this time to allow determination of the groundwater Class of Use and the calculation of Upper Control Limits (UCL) and RTV.

3.4.3 Hydrologic Testing Document

Following completion of the field data collection, data reduction and interpretation, a Hydrologic Test Document will be prepared and submitted to LQD for review and comment. Cameco will approve the hydrological test plan/results through the ORC/SERP process and will provide a copy to the NRC for review. Injection of lixiviant will not occur until the agencies have reviewed and commented on this document.

Prior to performing the Mine Unit Hydrologic test, Cameco will have completed delineation drilling in the proposed mine unit area and will generate very detailed geological maps/cross sections within the proposed hydrologic unit test area. Using this geological information, Cameco will evaluate the presence and continuity of aquifers, aquitards, and any other potential geological structure or discontinuity that could impact the hydrologic test and the proposed mine unit resource recovery plan.

Should the mine unit hydrologic test indicate communication between the production zone and any adjacent aquifer, Cameco will investigate the source(s) of the leakage and take appropriate action, prior to initiating injection, to ensure that vertical excursions will not occur during production of the mine unit. The investigation will address subsurface geology, the presence or absence of faults, possible leaking drill holes or wells and other potential discontinuities. For example, should the pump test results show significant drawdown in an overlying monitor well, and no natural discontinuities, such as faults, or other natural discontinuities, have been identified, focus will be directed to bad pump test data or improperly abandoned drill holes and wells. If no problems are identified with the pump test data, information from the abandoned drill hole map will be used to locate the holes on the ground. Additional mini pump tests may also be performed in the area of interest to further refine the location of possible old holes. Vegetation and soil will then be stripped from the area in an effort to visually identify old abandoned drill holes in the area of the pump test anomaly. Each visually identified abandoned hole will be reentered and sealed from the bottom of the hole to the surface. Additionally, during startup of injection in a new wellfield area, a visual ground survey will be performed to look for surface leakage expressions and/or significant water level changes in adjacent aquifer monitor wells. Should leakage be identified, injection will be halted until the leaking drill holes have been found and sealed.

Each Hydrologic Test Document will contain:

1. A description of the mine unit wellfield areas.
2. A map(s) showing the wellfield pattern areas and locations of all monitor wells.
3. Revised geologic cross-sections and cross-section location map incorporating the new monitor well data. Geophysical logs of the monitor wells will either be shown on the cross sections or provided separately in an appropriate scale and format to allow direct overlay of the logs onto the cross sections.
4. Revised isopach maps of the production zone sand and overlying and underlying confining units utilizing the monitor well data.
5. Discussion of how the hydrologic test(s) was performed, including well completion records.
6. Discussion of the results and conclusions of the hydrologic test(s) including raw test data, pressure (drawdown) curves and analysis, potentiometric surface maps, water level graphs, drawdown maps and, where appropriate, directional transmissivity data and graphs.
7. Information verifying that the monitor wells are placed at adequate distances and elevations to serve their intended functions.
8. Potential impacts from faulting, surface and underground mining and reclamation activities, and potentially leaking abandoned boreholes will be discussed if located in or near planned production areas, including proposed actions to mitigate potential impacts.
9. Baseline groundwater quality data, calculated UCL and RTV.
10. Any other information pertinent to the tested mine unit.

3.4.4 Baseline Water Quality Determination

Baseline water quality conditions will be determined from water samples collected from wells installed in the production zone and in the aquifers overlying and underlying the production zone, where present. In accordance with accepted procedures and the guidance provided in LQD Guidelines No. 4 and 8, the samples will be analyzed for the parameters listed in **Table 3-4, Baseline Water Quality Parameters** and **Table 3-5, Baseline Parameter Short List**. The groundwater quality data are used to determine the groundwater class of use and calculation of UCL and RTV for each new mine unit. Established procedures and methods will be used for sample collection, preservation and quality control.

The general procedure for determining the baseline groundwater quality of each proposed mine unit will be as follows:

1. Water quality samples will be obtained and analyzed from all monitor wells utilizing accepted sampling and analytical procedures.
2. Two separate samples will be collected from each monitor well at least two weeks apart. Each sample will be analyzed for the parameters listed in **Table 3-4**.
3. Two additional samples will be collected for each well, at least two weeks apart, and will be analyzed for the parameters listed in **Table 3-5**.

For the purpose of groundwater classification and calculation of RTV, the production zone monitor wells (MP wells) baseline analytical data will be averaged over the mine unit. The M, MO, and MU wells will be classified by averaging all of the analyses for each parameter on a well-by-well basis. The variability of the data will also be calculated. Statistical outliers will be determined using accepted statistical methods and the guidance provided in LQD Guideline No. 4.

3.4.5 Statistical Assessment of Baseline Water Quality Data

Baseline water quality is determined by averaging the data collected for each parameter, for each zone that is monitored on a mine unit basis. The variability of the data is also calculated. Outliers are determined using accepted statistical methods. Values determined to be outliers are not used in the baseline calculations. If a majority of the baseline values for a well are excluded as outliers, a separate UCL will be established for that well.

Where wells are not uniformly distributed, the average may be determined by weighting the data according to the fraction of area, or water volume, represented by the data. Baseline conditions are determined as follows:

1. Mineralized Zone (Production Pattern) Wells - Data for each parameter are averaged. If the data collected for the entire mine unit indicate that waters of different underground water classes (WQD Rules and Regulations, Chapter 8) exist together, the data are not averaged together, but treated as sub-zones. Data within specific sub-zones are averaged. Boundaries of sub-zones, where required, are delineated at half-way between the sets of sampled wells which define the sub-zones.
2. Ore Zone (Monitor Well Ring) Wells - Data for each parameter are averaged. As with the mineralized zone wells, if sub-zones are present which differ in underground water classes, data within the specific sub-zones are averaged separately.
3. Overlying Aquifer - Data for each parameter are averaged.
4. Underlying Aquifer - Data for each parameter are averaged.

Outliers in the baseline data are eliminated for the purpose of determining UCL using the following statistical method:

1. UCL parameter water quality data are treated as a group. For example, if 40 wells are sampled and analyzed three times each for chloride, the 120 samples are treated as a group.
2. A tolerance test (see Loftis et al., 1987) is applied in which x = kS, where x is the mean of the group of samples, and S is the standard deviation of the group sampled, and k is the tolerance limit factor. The values for k are provided in Appendix A of LQD Guideline No. 4.
3. Samples falling outside the tolerance limits, as defined by the above test are considered anomalous outliers and are eliminated from use in determining the UCL.
4. If all samples from an individual well are eliminated by the above process, discrete UCL values are determined separately for this well.

To ensure that the UCL determined from the baseline data are accurate, the monitoring data collected at the onset of the operational monitoring program (at least the first two samples) will be compared with the appropriate UCL and baseline data. In the event that the data collected at the onset of the operational monitoring program show that the baseline water quality data and UCL are not consistent with previously determined baseline values and UCL, additional baseline water quality data will be collected and alternative UCL will be proposed to LQD.

3.4.6 Upper Control Limit Determination

Monitor ring wells are installed within the production zone around the pattern area and within overlying and underlying aquifers to document that the lixiviant and production fluids are not leaving the defined production zone. The bleed (wellfield purge), in combination with production activities (pumping and injection rates), assist in keeping production fluids within the production zone.

The UCL are based on the baseline water quality data and LQD Guideline No. 4 and are determined as follows:

1. Chloride UCL - baseline mean plus five standard deviations, or the baseline mean plus 15 mg/L, whichever is greater.
2. Bicarbonate or Total Alkalinity UCL - baseline mean plus five standard deviations.
3. Conductivity UCL - baseline mean plus five standard deviations.

3.4.7 Restoration Target Value Determination

As discussed earlier, MP wells are installed and sampled to determine the baseline water quality of the production zone so that RTV can be established. As discussed in Section 6.1.2, the MP well baseline data for each mine unit are evaluated over the mine unit on a parameter-by-parameter basis. RTVs are established for each mine unit as the baseline mean plus two standard deviations.

3.5 Mine Unit Design, Construction and Operation

3.5.1 Mine Unit Design

3.5.1.1 General Well Pattern Types and Spacing

The geometrical configuration of the mine unit boundaries as well as the wellfield patterns within the mine unit is subject to several governing factors. The outline of the ore, the grade and thickness of the ore, the number of ore intercepts of economic viability, the permeability of the sand units, and the location of the edges of the economic ore are all considered when determining the type of patterns employed and their spacing. The primary mine unit pattern design is a five-spot configuration. In areas of lower permeability a seven-spot configuration may be employed. Five-spots, alternating line drives, staggered line drives, and other configurations may be employed as conditions warrant. The spacing within the patterns will vary from 15 to 37 meters (50 to 120 feet) between injection and production wells, once again depending on the aforementioned governing factors.

The five-spot configuration is common in ISR, especially in areas of good permeability. In a five-spot pattern, four injection wells surround a central recovery well in a rectangular or square configuration. In an actual mine unit pattern area of repeating five-spot patterns, each injection well services four recovery wells and each recovery well is serviced by four injection wells. An example of the five-spot pattern is shown in **Figure 3.8, Typical 5-Spot Pattern.**

The seven-spot pattern configuration is typically utilized in areas of lower permeability. In a single isolated pattern, six injection wells in a hexagonal configuration are employed with a central recovery well. Solutions enter the ore zone through the injection wells and are recovered from the recovery well. In a large array of patterns, each injection well services three recovery wells and each recovery well is serviced by six injection wells. The exception to this is along the boundary of the mine unit pattern area where a slightly higher injector to recovery well ratio is required. An illustration of the seven-spot configuration is depicted in **Figure 3.9, Typical 7-Spot Pattern.**

In both the five-spot and seven-spot patterns, the spacing of the wells will vary, but the completion of each well will be similar allowing each well to be used as either an injector or recovery, depending on the configuration of the ore and economic considerations.

Line drives, whether alternating or staggered, will be used to exploit narrow portions of the orebody where five or seven-spot configurations are impractical. Line drives consist of alternating injection and recovery wells. The offset placement of injectors and recovery wells yields a staggered line drive. As in the five and seven-spot patterns, the role of each well may be reversed as required. The spacing and distance between wells is controlled by the width of the ore. An example of the line drive and staggered line drive patterns is provided in **Figure 3.10, Line and Staggered Line Drive Patterns**.

3.5.1.2 Monitor Well Spacing and Placement

As many as five types of monitor wells may be used. The actual density, spacing and location of monitor wells vary from mine unit to mine unit and will be determined during the orebody delineation and defined in the Hydrologic Testing Proposal document for each mine unit. "M" wells are installed in the ore sand aquifer, laterally from the production zone, to detect lateral movement of lixiviant from the ore zone. In accordance with LQD Rules and Regulations Chapter 11, Section 6(h)(iv) and LQD Guideline 4, Section C. 5. B. and Attachment II of Guideline 4, the location and spacing of these wells will be determined by a technically sound method which may include, but not be limited to, hydrologic modeling, delineation drilling data, gradient consideration, dispersivity of recovery fluids, the calculated operational flare and calculated excursion recoverability within 60 days. The density and spacing of M wells is determined for each mine unit during the detailed geohydrologic assessment of each mine unit.

"MO" wells are installed in the next overlying aquifer to detect vertical migration upward of lixiviant from the ore zone. One MO well is installed for each hectare (3 acres) of proposed pattern area.

"MU" wells are installed in the next underlying aquifer, if existent, to detect vertical migration downward of lixiviant from the ore zone. One MU well is installed for each hectare (3 acres) of proposed pattern area.

"MP" wells are installed in production zone pattern areas to characterize the baseline quality of the groundwater within the ore zone. One MP well is installed for each hectare (3 acres) of proposed pattern area. Class of Use and RTVs are established for the MP wells using the baseline water quality data as described in Section 3.4.4. Detailed discussions of the production zone geology and hydrogeology for each mine unit is provided in WDEQ Permit Appendices D-5 and D-6 for Smith Ranch, North Butte Remote Satellite and Gas Hills Remote Satellite.

"MT" wells, although optional, may be installed near pre-existing conventional mine workings or areas where it is known that the adjacent groundwater quality will be significantly different from what is present in a particular Mine Unit. This type of well can also be used as an early warning of a potential excursion. For this purpose, MT wells are typically located between the pattern edge and the "M" wells. Water quality data from these wells is not reportable to the agencies. The use of these wells is a preventative measure to allow greater operational control of recovery fluids and to decrease the possibility of an excursion reaching a reportable monitor well.

The actual density, spacing and location of monitor wells will vary from mine unit to mine unit at each facility and will be determined during the hydrologic testing and assessment of each mine unit.

3.5.1.3 Monitor Well Installation

In determining the number, location and construction of monitoring wells and the frequency of monitoring, the following criteria is considered:

1. The pre-ISR groundwater use for all affected or potentially affected aquifers.
2. The proximity of the ISR operation to points of non-ISR water use.
3. The local geology and hydrology.
4. The operating pressures and whether a negative pressure gradient is being maintained in the production zone.
5. The nature and volume of the injection fluids, recovery fluids, formation water, and process byproducts.
6. The injection well density.

Monitor wells are installed using the procedure described in Section 3.5.2.3 to ensure that they are constructed in compliance with state and federal requirements. All monitor wells having a diameter of 10 centimeters (4 inches or more will be permitted through the WSEO.

3.5.2 Well Construction and Completion Techniques

3.5.2.1 General

Several types of wells are installed at the Smith Ranch Project SUA-1548 license areas. These include injection wells, production wells and monitor wells. All wells are constructed in such a manner to ensure that the well annulus is sufficiently sealed to prevent communication from the production zone to overlying and underlying aquifers that have been penetrated by the well. All wells will be constructed in accordance with WSEO, WQD and LQD rules and regulations. Multiple completion zone wells will be installed at Smith Ranch and the Gas Hills Remote Satellite.

In June 2011, the WSEO revised Part III, Chapter 3, Section 2(c)(ii) to state: "All wells shall be constructed with at least a 5 centimeter (2 inch) annular space surrounding the outermost casing and extending not less than 6 meters (20 feet) below ground surface (bgs)". Additionally, LQD Rules and Regulations Chapter 11, Section 6(c)(i) states: "The drill hole shall be of sufficient diameter for adequate sealing and, at any given depth, at least 7 centimeters (3 inches) greater in nominal diameter than the diameter of the outer casing at that depth". Cameco ensures that the annular space of all wells drilled meets the above requirements. **Figure 3.11, Typical Injection Well, Figure 3.12, Typical Production Well**, and **Figure 3.13, Typical Monitor Well** are schematic drawings showing construction details of each type of well.

3.5.2.2 Well Construction Materials

The typical well casing used is rigid PVC Standard Dimension Ratio 17 (SDR-17) with a nominal 13 centimeters (5 inches) outside diameter (Certainteed or similar). However, should a larger pump size be required, larger diameter casing may be utilized. Each joint of PVC casing typically has a length of approximately 6 meters (20 feet) and a wall thickness of 0.7 centimeters (0.3 inches). The pipe is rated for 1.1 MPa (160 pounds/inch^2) maximum internal pressure (i.e., working pressure including safety factor) and 2 MPa (224 pounds/inch^2) for resistance to hydraulic collapse (i.e., external pressure where the casing fails). The maximum working pressure is the pressure rating for the pipe and does not take into consideration the cement backing in the well. The collapse pressure is important during well cementing and development. Once the grout has cured around the annulus of the casing, the collapse pressure caused by the slurry is eliminated. The current casing is joined mechanically using pipe threads or a water tight O-ring seal with a high strength nylon spline. Metal screws, *although used in the past*, are not used to support the joining of casing sections. Alternative casing materials, such as fiberglass or steel, may also be used as long as they meet applicable standards of the American Society for Testing and Materials (ASTM) and American Petroleum Institute (API) specifications for well casing and are found suitable for the required service.

Well siting and construction are in accordance with LQD Rules and Regulations Chapter 11, Section 6(b) through (g). The top of each well casing ends above grade, and where possible, above any known high water conditions of flooding from runoff or ponded water. The immediate area around each well collar slopes away from the well to direct surface runoff away from the well. Wells are not located in the channel or floodplain of any perennial or intermittent drainage. If wells must be located in ephemeral drainages, they are not located in the flow course. Precautions will be taken during installation to minimize damage to the channel from erosion and sedimentation, protect the well from damage due to erosion, and prevent surface runoff from entering the well. This is typically ensured by keeping well locations several feet away from the streambed and utilizing appropriate best management practices (BMP) to prevent sedimentation into the channel and erosion. A temporary channel diversion may be required. The primary sediment/erosion control measure is to re-establish a vegetative cover as soon as possible after well completion using a temporary seed mix followed by interseeding with the permanent seed mix. Until a vegetation cover has been established, temporary sediment and erosion control measures are implemented. These temporary measures may include silt fences, rock check dams, sediment traps, contour ditches, mulch, geotextile fabric or other BMPs as deemed appropriate for the particular situation.

When not in use, each well is covered with a well cap to prevent the introduction of undesirable materials into the well. Injection and production wells utilize insulated hard covers to protect the well head during inclement weather conditions. Wells are clearly marked as to their identification. The surrounding area of each well head is kept clear of excessive vegetation and/or debris so that well identification is clearly visible.

Wells constructed near buildings or power lines are located at a distance from the building or power line to allow access for repairs, maintenance, sampling, etc. At a minimum, a well must clear any building projection by at least 1 meters (3 feet) and any power line by at least 3 meters (10 feet).

3.5.2.3 Typical Well Completion Technique

The following well completion techniques will be utilized at all SUA-1548 license areas:

1. Two completion techniques include the following: A pilot hole (nominally 13 centimeters[6 in] in diameter) will be drilled through the ore zone by use of a rotary drill and a drilling mud system. The second method employs the use of a larger bit (Polly Diamond Carbide [PDC]) that provides an annular space adequate to meet the WSEO and LQD requirements. Drift control will be maintained using weighted drill collars and close supervision during drilling. The drill holes will not be drilled into the underlying confining unit by more than 2 to 3 meters (5 to 10 feet).
2. The drill hole is then geophysically logged using tools including natural gamma, spontaneous potential, and single point resistance to determine lithology, grade, thickness and distribution of the ore. Deviation logs will be run to determine the location of the bottom of the hole.
3. Upon verification that the well location is suitable for its intended purpose, the pilot hole will be reamed to a nominal diameter that provides an annular space adequate to meet the WSEO and LQD requirements described in Section 3.5.2.1. Holes drilled with PDC do not require reaming.
4. Prior to installing the casing, the borehole will be circulated with water or drilling mud to remove loose drill cuttings, rock chips or other obstructions.
5. The hole will be cased with a nominal 11 to 15 centimeters (5 to 6 inches) diameter SDR-17 PVC well casing. Fiberglass or steel casing may also be used. The casing will extend from the top of the target zone to approximately 0.6 meters (2 feet) above ground level. Each joint of SDR-17 casing will be connected by a water tight O-ring seal which is locked with a high strength nylon spline. No glue or screws will be used with these types of well casing materials. Centralizers will be placed at a maximum spacing of one per 12 meters (40 feet to ensure there is sufficient annular space for the placement of the "sealing" grout.
6. Pursuant to LQD Rules and Regulations Chapter 11, Section 6(c)(iv), the casing will be grouted in place with a neat cement slurry, sand-cement grout, or bentonite-clay mixture as approved by the LQD Administrator. Casing may also be grouted in place with a cement-bentonite grout slurry or cement-pozzolan grout slurry as approved by the LQD Administrator. The grout slurry will be pumped down through the casing and up the annulus of the well at a rate adequate to maintain turbulent flow in the slurry to prevent channeling. The cement within the casing will be displaced with a volume of water or drilling mud sufficient to displace the cement to the surface. A wiper plug may also be used to displace the grout slurry. The well casing will be pressure sealed with the casing secured in place, and the sealing grout will be allowed to cure for approximately 24 hours. Maintaining the pressure inside the well casing ensures that the sealing material remains in the annulus until it is cured.
7. After curing, the well annulus at the surface is topped off with additional sealing material. If, during well sealing procedure, the grout slurry does not return to the surface, or settling during curing is more than 12 meters (40 feet), a tremie pipe will be used to complete the sealing to the surface to ensure that bridging does not occur. If casing is set above the production zone, the wiper plug or sealant column in the bottom of the casing will then be drilled out. If casing is set through the production zone, then the wiper plug or sealant will be left in the bottom of the casing. An under-reaming tool will then be lowered into the well

creating a cavity approximately 28 to 36 centimeters (11 to 14 inches) in diameter where the well screen will be placed.

8. The well screen will then be lowered through the casing and secured within the casing joint above the screen interval using a K packer assembly. Depending on the competency of the formation and/or the proposed use of the well, the annulus outside the well screen will either be gravel packed or left for natural well development (eg., monitor wells).
9. If gravel packed, a properly sized silica sand filter pack will be pumped from the surface through the drill pipe and out through a one-way valve, located at the bottom of the screen assembly, into the under-reamed zone to form a filter pack around the screen.
10. After well completion, casing integrity will be verified by conducting the approved MIT. If defects are found, they will be repaired. If repairs are not possible, the well will be plugged and abandoned and may be replaced with a new well.
11. The completed well will then be developed by pumping and surging formation water using methods such as swabbing and/or pumping.
12. A well construction completion report will be prepared for each well, and will be maintained on site for review by LQD.

3.5.2.4 Alternative Well Completion Techniques

In areas of overlapping multiple ore trends contained within one or more isolated stratigraphic horizons, alternative well completion techniques such as recompletions or twinning may be used to mine ore trends that occur in multiple stratigraphic horizons.

3.5.2.5 Well Recompletion Procedure

Ore trends that occur in stratigraphically multiple horizons may be reached by recompletion of wells used to produce from the initial production zone. Wells will only be recompleted after the initial ore zone and any of its adjacent stratigraphically equivalent zones have been depleted.

3.5.2.6 Well Twinning Procedure

Ore trends that occur in multiple stratigraphic horizons may be mined by installation of twinned wells and operated in accordance with this section.

3.5.2.7 Well Integrity Testing Procedures

All cased wells are tested for integrity following completion and prior to their initial use in accordance with EPA techniques to ensure there are no significant leaks in the casing and no significant movement of fluid into an unauthorized zone. The integrity of the wells is retested on a schedule of at least once every 5 years. Wells are also tested after undergoing any physical alteration from under reaming or after any workover operation involving the use of a cutting tool that may have caused casing damage. Integrity testing will also be performed on any well that may be suspected to be damaged from any operational issues that may arise, such as over-pressurization of the well. If a monitor well is converted to an injection or recovery well, it will be tested for mechanical integrity prior to the conversion and will be retested at 5-year intervals.

Only MIT techniques that have been approved for use by the EPA are used. The primary method consists of a pressure-packer system approved by the EPA for Class III ISR injection wells constructed with PVC or fiberglass casing. Alternative MIT methodologies summarized below may be acceptable only if they have been approved by the EPA, LQD and NRC.

1. The primary MIT procedure is as follows: One or two inflatable packers will be installed in the casing. The bottom packer will be set just above the well screen, and the upper packer will be set at the wellhead. Alternatively, a well cap can be used at the wellhead instead of the upper packer.
2. The packer(s) will be inflated and the casing then pressurized to 125% of the expected maximum operating pressure.
3. The well and packer system will then be "closed in", and the pressure maintained for a minimum of 10 minutes.
4. If more than 10% of the "closed in" pressure is lost during this time period, the well will be deemed unacceptable for use, and will be repaired and retested, or plugged and abandoned within 120 days.

At no time will Cameco use an injection pressure greater than 90% of the pressure rating of the casing.

Upon passing the MIT, a well will be deemed acceptable for service. Any Class III injection well failing the MIT will be retested. If the well fails the second test, the well will be repaired or plugged within 120 days of the testing which indicates a lack of mechanical integrity. If the well is repaired rather than plugged, the MIT will be repeated within 120 days after the repair has been completed. The repaired well will not be used for injection purposes until written notification has been received from the applicable regulatory agency concurring that the well demonstrates mechanical integrity.

All MIT results will be documented and maintained on file at the Project site.

3.5.2.8 New Drill Hole Site Preparation

Prior to drilling an exploration, delineation or well pilot drill hole, topsoil will be removed from the mud pit location and stockpiled on native ground at a sufficient distance to avoid impacts by drilling activities. Subsoil excavated from the mud pit will be stockpiled on native ground, separate from the stockpiled topsoil and near the mud pit (see **Figure 3.14, Typical Drill Site in Even Terrain**).

Drill sites located on steep slopes such as those proposed for the Gas Hills Remote Satellite will require excavation of a pad, and access route as well as the mud pit. Topsoil will be stripped from the pad, mud pit and access road and windrowed to the uphill side of the drill hole location. Subsoil excavated from the mud pit will be stockpiled next to the pit and downhill from the topsoil stockpile (see **Figure 3.15, Typical Drill Site in Rough Terrain**). The drill rig and water truck will then move onto the site and drill the hole.

Cameco has developed and implemented BMPs that will be used during drilling and well installation activities to minimize impacts to vegetation, topsoil and the general environment. These BMPs are summarized below.

1. To minimize vegetation and topsoil disturbance, access routes to each drill location or group of locations will be plainly marked with survey stakes or similar types of markers. Vehicles will be required to travel only on these designated access routes and existing roads and trails. Should the designated access routes become compacted from use, they will be scarified and seeded as part of the drilling reclamation program.
2. To the extent possible, crossing perennial and intermittent drainages with drill equipment and vehicles will be avoided. If it becomes necessary to cross a drainage to reach a drilling

site, a stream crossing will be constructed at right angles to the channel with adequate embankment protection and installation of properly sized culverts.

3. Mobilization of the drill rig from hole to hole during exploration and delineation drilling activities will be restricted to dry or frozen ground conditions.
4. Drill rigs will be inspected by the contractor prior to project startup and daily during the project; any leaks will be repaired prior to drilling.
5. Spill containment and cleanup equipment, such as drip pans, absorbent cloths, dams, etc., will be readily available at each drill site. In the event of a spill (not contained by the drip pan) by drilling rig malfunction(s), drilling will be suspended, all contaminants will be cleaned up before drilling resumes.
6. All petrochemicals will be stored in approved containers.
7. Site clearing and preparation will be minimized to the extent possible to avoid excessive surface disturbance. However, drilling sites located on extremely steep slopes may require excavation of a level drill pad as well as an excavated access route into the location. Stripped topsoil will be windrowed to the uphill side of the drill site and access road. Subsoil excavated from the mud pit will be stockpiled next to the pit and downhill from the stockpiled topsoil. The surface disturbance footprint for each delineation drill hole, excluding access routes, will typically be approximately 74 meters^2 (800 feet^2). Each drill hole site will have an earthen mud pit excavated with a backhoe and sized to contain the drill cuttings and drilling fluid from the proposed total depth of the hole. Topsoil will be removed from each mud pit location and stockpiled on native soil at a sufficient distance to avoid impacts by the drilling activities. Topsoil stockpiles will be cordoned off and marked with flagging or other signage. A tackifier may be applied to topsoil stockpiles rather than other control measures to prevent migration by sedimentation. Subsoil excavated from the mud pit will be stockpiled on native soil separate from the stockpiled topsoil and near the mud pit.
8. All drill hole, well sites and access roads will be located, constructed and maintained to minimize erosion. BMPs to minimize erosion and offsite sedimentation will vary with specific site conditions, such as slope, vegetative cover and proximity to surface waters of the state. BMPs may include silt fencing, straw bales, vegetation buffers, slope roughening, mulch, geotextile fabrics, and other measures designed to reduce erosion and minimize the transport of sediment from the disturbed area.
9. No drill holes or wells will be installed within 30 meters (100 feet) of the edge of any perennial or intermittent drainage without first consulting with Cameco's environmental staff to determine the specific spill and erosion protection measures to be implemented at each drilling location.

3.5.2.9 Abandoned Exploration Drill Holes

All drill holes will be abandoned in accordance with W.S. 35-11-404 and LQD Rules and Regulations Chapter 8 and Chapter 11, Section 8 using an approved abandonment material. The abandonment material will be mixed with water and circulated through the drill pipe filling the drill hole from bottom to top. The mixed abandonment fluid will have a 10 minute gel strength of at least 20 pounds/100 foot^2 and a filtrate volume not to exceed 13.5 cc. Each drill hole will be completely filled to the collar of the hole or securely capped at a minimum depth of 0.6 meters (2 feet) below either the original land surface or the collar of the hole, whichever is at the lower elevation. If capped, the cap will be made of concrete or other material satisfactory for such capping. A metal tag with the drill hole number stamped on it will be affixed to the top of the cap for future hole identification. The remaining hole above the cap will be backfilled to the original land surface. If the hole cannot be plugged immediately after probing, it will be securely covered until plugging is performed.

Following abandonment of the drill hole, the mud pit will be allowed to dry out prior to backfilling. After backfilling the pits with subsoil, the pits will be allowed to settle before applying topsoil and performing final grading. Compaction may be used to further reduce potential settling of reclaimed pits. Steep slope sites and access routes will be reclaimed using a dozer, track hoe or similar equipment to minimize the surface disturbance.

Those drill sites that will become part of a mine unit within 1- year of drilling the hole will not be seeded until wellfield construction is complete. Those sites that will not become part of a mine unit within one year will be seeded after mud pit reclamation is complete. In either case, seeding will take place during the next available seeding window, spring or fall. All seeding is completed using the approved permanent seed mixture.

3.5.2.10 Historical Drill Hole and Well Abandonment

A computer database has been generated for all Wyoming properties listing the coordinates, elevation, depth drilled, and completion date, of all known exploration and mine development drill holes completed by previous mineral owners and Cameco. More than 40,000 existing drill holes are located within the SUA-1548 license areas. Approximately 2,700 drill holes have been drilled and abandoned in the North Butte license area between 1967 and 2010. North Butte and Smith Ranch drill hole tabulation and maps showing the locations of all known abandoned drill holes within the Smith Ranch are provided in Section 7.0 of Appendix D-5 and for the North Butte Remote Satellite in Section 4.0 of Appendix D-5 license areas. More than 14,000 existing drill holes are located within the Gas Hills Remote Satellite area. Appendix D5 and Addendum D5-3 provide a list and location maps of all known abandoned drill holes within the Gas Hills Remote Satellite area.

From 1967 to 1983, approximately 1,120 exploration, predevelopment, development and in situ leach wells were drilled in and around the Ruth Remote Satellite area. These wells were drilled by Conoco, Kerr-McGee and Uranerz. Beginning in 1979 and continuing through 1988, about 60 cased wells were installed at Ruth. These wells were used as in situ leaching wells for the Ruth R&D project or as monitor wells in conjunction with the leaching wells. With the exception of three monitoring wells, all of the wells have been plugged and abandoned. Detailed tables and maps showing the locations of the boreholes/wells are provided in the Ruth ISL Project, Volumes I-III, Supportive Information for WDEQ Permit to Mine Application and USNRC Source Material Applications prepared by Uranerz (October 1988).

3.5.2.11 Well Stimulation Program

The well stimulation method or work over program typically utilizes well swabbing. The well swabbing program involves pulling a swabbing cup up the well, thereby lifting the column of fluid above the swab tool to the surface. This reduces the pressure beneath the swab and pulls water from the formation at the screened interval into the well, in effect "flushing", and thus cleaning the screen. The flushed fluids will be captured in an enclosed water tank and disposed of through the waste water treatment system.

3.5.3 Mine Unit Operations

3.5.3.1 Lixiviant Composition

The selection of an appropriate ISR lixiviant must take into consideration the effectiveness of the lixiviant reagents to mobilize the uranium minerals, the cost and availability of those reagents, their effect on other minerals present in the uranium orebody, and their impact on the ore sand aquifer relative to the achievement of groundwater restoration. Since the mid-1980s, virtually all uranium ISR operations in the United States have utilized a lixiviant containing oxygen gas or hydrogen peroxide as an oxidant, carbon dioxide gas or sodium bicarbonate as the uranium complexing ion, and with mineral acids or bases for pH and bicarbonate/carbonate ratio control.

The lixiviant at Cameco's Wyoming operations consists of native groundwater fortified with a carbonate complexing agent of sodium carbonate, sodium bicarbonate and/or carbon dioxide and an oxidant consisting of oxygen or hydrogen peroxide. The target concentrations of oxidant and complexing agents are typically less than 1 g/L oxygen and less than 5 g/L bicarbonate. These target oxidant and complexing agent concentrations in the lixiviant typically result in a mine unit production fluid with the following concentrations:

Parameter	Average Concentration
Na	50-200 mg/L
Cl	50-900 mg/L
HCO_3	200-1200 mg/L
TDS	500-1850 mg/L
pH	6.2-6.5 pH units
O_2	10-600 mg/L

The complexing of the oxidized uranium species with the bicarbonate in the lixiviant creates a combination of uranyl dicarbonate ions $(UO_2\,(CO_3)_2)^{-2}$ and uranyl tricarbonate ions $(UO_2\,(CO_3)_3)^{-4}$, both of which are soluble and stable species in solution. When the uranium is recovered, a small portion of the radium content is also mobilized. Depending on site conditions, trace elements such as arsenic, selenium, and/or vanadium, may also be oxidized and mobilized in low concentrations. Commercial operations at Smith Ranch have experienced minor increases of selenium concentration in the leach solution. However, no evidence of other trace elements being significantly mobilized during leaching has been identified during more than 20 years of continuous operation.

Based on extensive pilot and commercial operating experience at Smith Ranch, and pilot and laboratory studies performed on ore from the North Butte, Gas Hills and Ruth Remote Satellites, the chosen lixiviant is compatible with the ore mineralogy, as it has been shown to provide for effective uranium recovery and successful groundwater restoration. A total of four pilot operations were conducted at Smith Ranch (including Highland) to determine the commercial viability of the ore deposits and demonstrate restoration success. The initial pilot project at Smith Ranch was the Q-Sand Pilot, which operated from 1982 to 1986. Uranium recovery exceeded the forecast recovery and aquifer restoration, completed in May 1986 was deemed acceptable by the regulatory agencies, as was the completion of a one-year aquifer stability demonstration period. The second Smith Ranch pilot was conducted in the O-Sand. This pilot operated successfully from 1984 until 1998 at which time it was incorporated into the first commercial mine unit at Smith Ranch.

Two pilot projects were conducted at Highland by Exxon Minerals during the period 1972 to 1981. The first pilot project, known as the "Original R&D", was operated from 1972 to 1976. This project investigated the technical feasibility of in situ uranium mining utilizing different concentrations of sodium bicarbonate and hydrogen peroxide in the lixiviant. The second pilot project, known as the "Expanded Pilot", was conducted from 1978 to 1981. The purpose of the project was to investigate the technical feasibility of in situ mining utilizing gaseous oxygen, sodium bicarbonate and gaseous carbon dioxide within the lixiviant, and the restorability of the affected groundwater to its original use suitability.

The most significant aspects of lixiviant compatibility are clay mineralogy and chemical compatibility. The clay mineralogy at Smith Ranch is predominantly kaolinite. This clay mineral is compatible with an ISR operation in that it will not swell and by so doing damage formation permeability, nor is it aggressive in cation exchange processes, which could adversely alter the water chemistry.

Chemical compatibility of the formation mineralogy with the ISR process is important. Elevated calcium, sodium and sulfate concentrations, which often occur during ISR can result in the precipitation of calcite or gypsum in the ore sand and reduced formation permeability. Operating experience has shown that the lixiviant in use at Smith Ranch is chemically compatible with the major constituents that could cause formation damage or loss of formation permeability.

The amenability of the North Butte orebody to ISR is assured by the similarity of this ore deposit to those located in the surrounding area. Both the Ruth ore deposit to the south and the Christensen Ranch ore deposit to the west were tested using standard ISR technology and a sodium bicarbonate/carbonate, oxygen enhanced lixiviant. Both of these deposits, as well as Irigaray to the northwest, Reno Creek to the southeast, and Smith Ranch to the south have demonstrated excellent amenability to in situ extraction methods.

Mineralogy studies comparing North Butte cores to other Powder River Basin orebodies demonstrate that similar deposition mechanics occurred throughout the area which further supports the amenability of the ore to ISR technology.

As final testing of the amenability of this ore deposit to ISR technology using sodium carbonate/sodium bicarbonate/oxygen enhanced lixiviant, core material was recovered at two locations on the North Butte project during the installation of hydrologic test wells. These cores were subjected to standardized leach tests in Uranerz' (a Cameco predecessor) laboratories. The results verified that the North Butte ore is very amenable to carbonate/bicarbonate leaching.

In addition to the previous metallurgical test work, Cameco collected additional North Butte cores in 2009 and conducted mineralogy and core leach testing at the Cameco Research Center in Port Hope, Ontario. The core testing program included pressurized bottle roll leach and column leach testing programs. The core leaching program showed that recoveries as high as 85% can be achieved using a standard carbonate lixiviant of 1 g/L sodium bicarbonate. Potential metallurgical problems identified during the leach testing program included elevated vanadium content in the ore and a higher content of carbonaceous material.

Vanadium can cause leaching problems in carbonate leach solutions by co-precipitating in the formation during the recovery process as a calcium-uranium vanadate, such as tyuyamunite. The precipitation of tyuyamunite in carbonate systems is dependent on pH and carbonate content and can be controlled through proper lixiviant control. Carbonaceous material is a reductant and probably played a role in the deposition of the uranium orebody. The carbonaceous material will also act as a scavenger for the oxygen used during the production process which will result in higher oxygen consumption. Hydrogen peroxide can also be utilized in place of gaseous oxygen during uranium recovery.

The clay mineralogy at North Butte is predominantly chloritic to montmorillonitic, which can exchange ions with percolating fluids. Cameco's lab testing program has shown that the effect of sodium exchange on the clays is more profound at higher pH and sodium concentrations. Higher pHs (above 9) tend to be more prone to cause clay swelling problems. The operating pH for the North Butte Remote Satellite will be 7 to 7.5. Additionally, operating experience at Christensen Ranch, Smith Ranch Satellite SR2, and

Crow Butte Resources using a sodium bicarbonate lixiviant has shown that the projects can be successfully operated and restored without adverse effects on the formation.

The ore mineralogy at the Gas Hills Remote Satellite is similar to that at other Wyoming uranium ISR projects that utilize a carbonate/oxygen lixiviant. Because of the mineralogical similarities between these deposits and site-specific core leach studies, Cameco proposes to use a carbonate/oxygen lixiviant at the Gas Hills Remote Satellite. The carbonate will be supplied by dissolved carbon dioxide gas, sodium bicarbonate or a combination of the two agents to achieve the required carbonate concentration to complex the uranium. Results of leach studies conducted by Cameco on Gas Hills cores indicate that, in order to counteract uranium adsorption by the clays and other minerals in the host rock, bicarbonate concentrations of up to 5 g/L may be required to achieve acceptable uranium recovery results. Supplementation of sodium bicarbonate to the CO_2 lixiviant may be used as necessary to achieve target strengths for the complexing ion.

The oxidant will be supplied as gaseous oxygen supplemented with hydrogen peroxide as necessary. The oxygen concentration will be adjusted in each mine unit in a manner which will utilize all of the available head above the ore zone to maximize oxygen dissolution. The target average oxygen concentration will be 400 mg/L O_2. If the available head is inadequate to achieve acceptable oxygen concentration and uranium production rates, hydrogen peroxide may be used to fortify the lixiviant oxidant concentration.

The clay mineralogy of the Gas Hills Remote Satellite orebody is predominantly kaolinite with lesser concentrations of monovalent smectites (Hazen, 1996). Kaolinite is favorable as it exhibits limited ion exchange capacity and will neither result in clay swelling, which can damage formation permeability, nor cation exchange, which can adversely alter the water chemistry. The addition of sodium through the use of sodium bicarbonate could induce clay swelling if substantial quantities of divalent smectite clays are present, which they are not

In 1983-1984, the results of the Ruth R&D program demonstrated the technical feasibility of utilizing sodium carbonate and various oxidants for the lixiviant as well as successful restoration of the affected groundwater. Cameco will perform further leaching and lixiviant compatibility studies on Ruth cores during the satellite design phase.

Other parameters that are monitored during operations are calcium, sodium and sulfate concentrations which can result in the precipitation of calcite or gypsum in the ore sand and reduce formation permeability. Careful characterization of the mineralogy before mining and Cameco's extensive leach testing and operating experience confirms that the chosen lixiviant for the Smith Ranch SUA-1548 license areas is chemically compatible with the major constituents that could cause formation damage or loss of formation permeability.

3.5.3.2 Anticipated Geochemical Reactions

Uraninite and coffinite have been shown to be effectively mobilized during ISR by a two stage process. The first stage is the oxidation of U^{+4} to U^{+6}, which can be accomplished by any oxidizing reagent that increases the redox state from negative to positive. The second stage is the complexation of the oxidized uranium so that it can be carried in the recovered groundwater. This can be accomplished with any number of anions, including bicarbonate, chloride, and sulfate. The most common and efficient complexing anion has proven to be bicarbonate. Based on more than 20 years of operating experience, Cameco has developed an efficient and cost-effective carbonate leaching solution consisting of varying concentrations and combinations of sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), oxygen (O_2), H_2O_2, and/or CO_2 added to the native groundwater.

Uranium in the U^{+4} oxidation state is extremely insoluble in water at near neutral pH. Therefore, the first step in uranium ISR is to increase the oxidation potential of the groundwater in contact with the uranium from less than zero to greater than zero. This redox reaction is typically accomplished by adding gaseous oxygen or hydrogen peroxide.

The basic uranium oxidation step using oxygen gas can be represented by the following reaction:

$$(1)\ 2UO_2\ (s) + O_2\ (g) = 2UO_3\ (s)$$

The oxygen can also be provided by hydrogen peroxide. Hydrogen peroxide decomposes rapidly to oxygen and water by the following reaction:

$$(2)\ 2H_2O_2\ (l) + H_2O\ (l) = O_2\ (g) + 3H_2O\ (l)$$

Therefore, the choice of gaseous oxygen or liquid hydrogen peroxide is mostly based on cost. However, it should be noted that the theoretical solubility of oxygen gas in water, which is temperature and pressure dependent, is limited by the following relationship:

$$(3)\ \text{ppm } O_2 = (170\ P)(1.082 - 0.0304 \ln P)/35.5 + T$$

where P is pressure in psi (actual) and T is temperature in degrees Celsius. Where limited head (i.e., water pressure) is available above the ore to allow dissolution of adequate gaseous oxygen, hydrogen peroxide may be selected.

Following oxidation of the uranium minerals as represented by reaction (2) above, the uranium is in the oxidized U^{+6} valence state and is now soluble in water and capable of combining with a complexing anion. As discussed above, the complexing anion of choice is the bicarbonate ion. The bicarbonate ion may be introduced into the lixiviant by adding a solution of sodium carbonate into the natural groundwater. The addition of the sodium bicarbonate solution adds operational flexibility by maintaining the bicarbonate at optimal levels for the best leaching conditions. The addition of sodium bicarbonate provides a measure of operational safety by limiting the maximum possible pH of the injection solution to 8.5.

A second method for introducing bicarbonate into the lixiviant is by injection of gaseous CO_2 which causes the dissolution of carbonate from the contained formation calcite and creates a slight acidic condition in the lixiviant. If calcite ($CaCO_3$) and CO_2 are present in adequate quantities, the following reactions take place:

(4) $CO_2\ (g) + H_2O = H_2CO_3$, which lowers the pH of the lixiviant, and

(5) $CaCO_3\ (s) + H_2CO_3 = Ca^{2+} + 2HCO_3$

Bicarbonate (HCO_3) formed by the addition of CO_2 is the least expensive on a molar basis and creates minimum geochemical disturbance with no attendant clay swelling. The complexation reactions that occur between the oxidized uranium minerals and the bicarbonate complexing agent can be represented by the following reaction:

$$(6)\ UO_3 + 2HCO_3 = UO_2(CO_3)^{2-}{}_2 + H_2O,$$

which shows the dissolved oxidized uranium species to be the uranium bicarbonate ion. This oxidized species is highly mobile in water at a near neutral pH.

3.5.3.3 Mine Unit Piping, Instrumentation and Operation

Introduction

The uranium-rich groundwater is pumped from the recovery wells to the IX extraction circuit, located at the CPP, satellites and/or the remote satellite locations. Following uranium extraction, the barren fluid is refortified with oxygen and carbon dioxide and returned to the ore zone via the injection wells.

Injection fluids are transported to the mine unit wellfield areas via pumps located at the satellites, remote satellites or the CPP. Booster pumps may be installed along the mine unit trunklines as necessary to maintain required flows and pressures.

Mine Unit Piping

The facility layout and pipeline systems have been designed to facilitate production and allow restoration activities to begin as soon as production has ceased within a mine unit or a portion of a mine unit. Production and restoration flow to and from the satellite and header houses of each mine unit will be through separate but parallel pipelines. This arrangement, along with the central water treatment design, allows for minimization of groundwater use, particularly during concurrent production in one mine unit, aquifer restoration via groundwater sweep in another, and water treatment and reinjection in possibly a third. Excess water from any mine unit may be utilized in another mine unit (i.e. for RO make-up). This design also assists in the minimization of necessary disposal volumes and associated facilities.

All mine unit pipelines are constructed of high density polyethylene (HDPE). The size of the pipe varies from 5.1 to 7.6 centimeter (1.25 to 2 inch) in diameter (well to header house) to as much as 45.7 centimeter (18 inches (main trunklines to and from the satellite). All pipelines are pressure tested for leakage prior to use. The smaller diameter piping used to connect individual wells with the header houses are typically one continuous run of pipe with no field joints, which greatly reduces the potential for leakage in the burial trench. The larger diameter piping has joints that are welded together using a manufacturer approved butt fusion technique.

All buried pipelines are installed a minimum of 0.14 meter (5.5 feet) bgs to protect from freezing. Protection from vehicle vibration damage is pursuant to design guidelines provided by the Plastic Pipe Institute in their *Handbook of Polyethylene Pipe, Second Edition*. Chapter 6, Section 3 of the manual provides the criteria to be used to prevent piping damage due to vehicle loading. Utilizing the Standard Trench or Embankment Installation Category, which applies to pipes installed with between 45.7 centimeter and 15.2 meters (18 inch and 50 feet) of cover, the pipe must have a minimum cover of at least one pipe diameter or 45.7 centimeter (18 inches), whichever is greater. The Campbell County regulations will be used for the North Butte, and Ruth Remote Satellite pipeline construction. Fremont, Johnson and Converse Counties do not have specifications for buried pipelines; however Gas Hills Remote Satellite will also follow the Campbell County regulations.

There are several types of buried pipelines used for various purposes. The production and restoration pipelines (one each for injection and recovery flows) run from the satellite to the mine unit header houses, with smaller buried lines running from the header houses to the individual injection and recovery wells. During production, the injection fluid pipelines carry barren lixiviant from the satellite to the Mine Unit, and the production fluid pipelines carry pregnant lixiviant from the mine unit to the satellite for uranium recovery. During restoration, these pipelines and/or the restoration pipelines convey restoration fluids to and from the mine unit wellfield areas.

A smaller pipeline, called the cleanout line, may be used to carry waste water produced by well cleaning operations from the mine unit to the satellite for uranium removal prior to being directed to the waste treatment system. A separate pipeline may be used to carry oxidant from a centralized location in the mine unit or near the satellite to the mine unit header houses for introduction into the barren lixiviant prior to injection.

Additional pipelines may be installed during mine unit construction and/or operation to facilitate restoration and to carry carbon dioxide to the header houses during production. Finally, a buried waste water pipeline conveys groundwater treatment reject flow (RO reject) from the waste water treatment system in the satellites to the purge storage reservoir or directly to a deep disposal well.

The goal in the design and layout of pipelines is to install all the necessary pipelines in a single trench at the same time along mine unit access routes to minimize initial surface disturbance and ground re-disturbance of the same area prior to groundwater restoration. The preferred trenching method for piping less than 20.3 centimeter (8 inch) in diameter will be either a trenching machine or a spider plow. These types of excavation machines do not require topsoil segregation and reduce the overall soil disturbance footprint. Trenches excavated using a backhoe or trackhoe separate topsoil and subsoil in accordance with **Table 3-6, Topsoil/Subsoil Management**. Following pipeline installation and testing, the excavated material from the trench is returned in the reverse order it was excavated. Trench backfill is compacted to avoid future settlement.

Pipelines constructed with field welds will be cleaned and pressure tested. Pipelines that do not have field welds will be inspected for manufacturing flaws and transportation damage prior to installation. During operation, continuous service pipelines will be equipped with high and low pressure sensors and flow meters to provide safe shutdown in the event of abnormal operating conditions such as breaks or blockages.

3.5.3.4 Pattern Balancing, Injection Pressures and Flow Rates

Pattern Balancing

Flow models are often used to predict the expected flow paths of the lixiviant from the injection to the production wells, such that the pattern design can be optimized for maximum ore contact and extraction with a minimum number of wells. These same models may be used to design lixiviant control methods to prevent excursions when working near hydrologic boundaries (e.g., faults, etc.).

During the operational phase of an ISR facility, approximately 99% of the water withdrawn is returned to the ore zone. Thus, the impact on regional pressure changes, groundwater gradients and flow paths is minimal. Pressure changes are generally limited to localized gradients to control flow between injection and production wells.

The ISR process is operated as a closed system, with the injection rate to the mine unit maintained below the total production rate from the mine unit. The water which is removed from the mine unit is referred to as bleed or purge. The bleed creates a hydrologic cone of depression within the production zone which prevents the unwanted migration of lixiviant away from the production area.

The bleed is removed from the closed system after the lixiviant passes through the IX columns for uranium removal. The volume of bleed required to maintain a zone of control around a mine unit is dependent in part on the hydraulic gradient. Typically, the steeper the hydraulic gradient across the mine unit, the greater the bleed rate must be to maintain the same zone of control. The bleed rate typically varies from 0.5% to 1.5% across a mine unit, and is distributed across the mine unit based on an engineering design that considers geologic and hydrologic factors unique to each situation. Fluid volumes removed during well work-over activities also contribute to the total bleed.

At Smith Ranch and North Butte, this excess water will be disposed using deep disposal well injection and/or land application (Smith Ranch only). At Gas Hills, the excess water will be disposed of using evaporation ponds, but Cameco is also investigating the efficiency of utilizing deep deposal well injection. The disposal options at Ruth have not yet been developed but will likely be a combination of the same options being used at the current and planned operations.

Injection Pressures

Injection pressures within well casing above the ground surface as well as associated wellhead piping are typically less than 0.82 MPa (120 psi) and will always be at least 10% below the pressure rating of the casing. Because the well casing is cemented into the bore hole, downhole pressures can substantially exceed the pressure rating of the casing without adversely affecting the integrity of the casing.

Down hole injection pressures for all Class III injection wells will be maintained below the formation fracture pressure as required in LQD Rules and Regulations Chapter 11, Section 11(c)(i). Injection well pressures are typically much lower than the formation fracture pressure due to materials used and MIT limits. A commonly used formation fracture pressure gradient in the southern Powder River Basin is 4.8 KPa (0.7 psi) for every 30.5 centimeters (12 inches) of depth (Mark Pinu, Halliburton Services, personal communication, May, 1983). James Neunan (Champion Oil, personal communication, June 1983) reports a gradient of 16.5 KPa/m (0.72 psi/feet for the Manning field near the Smith Ranch. Based on sedimentary rock density data, Hubbert and Willis (AIME Petroleum Transactions, T.P 4597, 1957, page 168) report a pressure gradient of 20 KPa/m (0.87 psi/feet at shallow depths which should increase to about 23 KPa/m (1 psi/feet at 1,524 meters (5,000 feet) depth. Cameco uses the more conservative value of 4.8 KPa (0.7 psi) as the pressure gradient at the Smith Ranch SUA-1548 license areas.

To ensure that the formation fracture pressure is not exceeded, a maximum injection pressure is calculated for each header house and is posted near the injection trunk line pressure gauge. The posted maximum operational pressure is based on MIT test pressure limits and shall not exceed the maximum surface injection pressure. The pressure of the injection trunk line is monitored daily in each mine unit header house. The surface injection pressures are not allowed to exceed the maximum surface pressures posted in each header house. Average and maximum injection pressures are reported in quarterly and annual reports to the LQD. The maximum allowable surface pressures will be determined using the calculation below:

$$IPsurf = \{[FG - 0.433 psi/ft \times SG] \times (depth)\}$$

Where:

FG = the fracture gradient in units of pounds per square inch per foot (psi/feet; 0.7 formation fracture pressure Smith Ranch Project (SUA-1548)

0.433 = density of fresh water in units of pounds per square inch per foot (lb/in^2)

SG = the specific gravity

Depth = depth of the top of the injection zone (feet

The maximum allowable MIT test pressure for a given header house is the most restrictive of the calculated injection pressures.

In accordance with LQD Rules and Regulations Chapter 11, Section 4(a)(xi), the following information concerning the production zone is determined and calculated for new Class III wells or mine units where the production zone is in a receiving stratum which is naturally water-bearing:

1. Fluid injection pressure;
2. Fracture pressure; and
3. The physical and chemical characteristics of the receiving strata fluids.

Flow Rates

Production well flow rates will vary from well to well depending on screen thickness, the variable hydraulic characteristics of the ore zone aquifer, the available hydraulic head, the depth to the ore zone, the flow rates of associated injection wells, and the capacity of pumps. Production well flow rates range from 0.013 to 0.10 liters/minute (5 to 40 gallons/minute), and injection well flow rates range from 0.005 to 0.08 liters/minute (2 to 30 gallons/minute). To maximize resource extraction and to maintain hydrologic control, each mine unit is normally operated at the maximum sustainable flow for each pattern. This maximum flow rate is adjusted to maintain an adequate head on the ore zone aquifer such that the oxygen and carbon dioxide in the lixiviant remain in solution.

Injection rates vary for each well and are based on "balancing" the mine units. Balancing of the production patterns refers to keeping the injection rate minus the bleed in each pattern matched with the production rates to maintain the cone of depression. The term therefore describes a hydrologic balance in the aquifer. Balanced patterns achieve optimum pattern production and minimize the "flare" of production fluids outside of the pattern areas. Balanced patterns prevent the excursion of production fluids from the mine unit areas. Records of well flow rates and injection pressures are documented and retained on site until termination of the license. Injection rates, including the average and maximum daily rate and the volume of fluid injected are provided to LQD quarterly.

The relationship between injector flow rates and producer flow rates is established based on the maximum flow obtained by the pattern as a whole. A producer may have injection fed by one or more injection wells. The production well flow rate is the sum total of the injection feeding it. An injection well may feed one or more production wells.

Once each day the flow rates for each injection and production well is measured and recorded. These measurements are compared to targets for each well, and the rates are adjusted to maintain the mine unit pattern balance. The required flow rates are determined by the well balancing program and the actual flow rates are adjusted, if required. The adjusted flow rates are re-entered into the program and the required flow rates recalculated.

Header house flow data are recorded and delivered to the Wellfield Operations Superintendent or designee. The Wellfield Operations Superintendent is responsible for maintaining these data and the mine unit balance.

3.5.3.5 Power Transmission and Communication Lines

Electrical power is supplied to Smith Ranch by Rocky Mountain Power using established power lines in the vicinity. Electrical power supplied to Smith Ranch is through pole-supported overhead transmission lines. Powder River Energy Corporation will provide power to the North Butte and Ruth Remote Satellites through existing power lines to the site metering point.

Electrical power lines (High Plains Electric) have been installed to the Carol Shop at the Gas Hills Remote Satellite and were used when the facility was a conventional mine. In 2008 Cameco contracted with an independent power line service company to inspect and tighten the Carol Shop 69 kV power line service. This task was completed in the fall of 2008. Cameco will install the mine unit electrical distribution lines. Power lines from header houses to individual wells are buried. Whenever practicable, power lines and pipelines are located within a single right-of-way, with reasonable separation for safety, to minimize impact to the ground surface. All overhead power lines are built in accordance with the guidance provided in "Suggested Practices for Raptor Protection on Power Lines – The State of the Art in 2006," published by the Avian Power Line Interaction Committee. Secondary power transmission lines deliver power to transformers located in the mine units. The transformers step down the voltage for delivery to the header houses and downhole submersible pumps. Power lines from the transformers to the header houses and production wells are typically buried. Telephone and optical fiber communication lines are also buried.

Cameco has recently installed fiber optics lines at several of the Smith Ranch operational facilities. During 2010, fiber optics lines were installed at the following locations:

- Booster Station 7 & 8 in Mine Unit 15A to Header Houses 15-19, 15-20, 15-21, and 15-19 to 15-22, 15-22 to 15-23;
- SR1 to Bell Hole 4-SR1, Bell Hole 4-SR1 to SRHUP NO. 10 DDW, Bell Hole 4-SR1 to Booster 4;
- Satellite 2 to Morton 1-20 DDW; and.
- Vollman 33-27 DDW to Bell Hole tie-in (Mine Unit E); Bell Hole tie-in to SRHUP NI. 9 DDW.

The locations of these fiber optics lines are shown on **Figures 1.4 through 1.8**. The purpose of the installation of the fiber optics lines was to allow Cameco to more quickly detect and respond to any leaks that may occur.

Pipeline and power lines will follow access roads to the extent practicable. **Figures 1.10, 1.11** and **1.12,** depict the proposed locations of main and secondary access roads. Additional detail and wellfield access roads for Gas Hills Mine Unit 1 are shown on **Figure 3.16, Mine Unit 1 Delineation Drilling** and **Figure 3.17, Mine Unit 1 Wellfield Development**.

3.5.3.6 Mine Unit Maintenance

Each production well is protected by a flange mechanism installed on the well head and by a fiberglass or plastic well cover installed over each well. Each well house is clearly marked for ease of well identification. Debris or refuse are routinely removed from mine unit pattern areas to facilitate access by mobile equipment. Access is maintained to each well site to facilitate routine well maintenance or monitoring, including potential re-entry to a well by a drill rig.

3.5.3.7 Subsidence Risk Due to Mine Operations

The uranium which is present in the orebody represents only about 0.1 weight % of the rock, or about 0.03 volume %. The ore minerals occur between the sand grains, in the interstitial pore spaces of the rock. Because the lixiviant is specific for uranium minerals, it will not dissolve any constituents of the host rock. Because of the very low volume percentage of the uranium minerals, the leaching process does not affect the structural integrity of the host rock. Therefore, no void spaces are created by ISR, and no subsidence due to ISR is anticipated. There has never been an incidence of surface subsidence due to ISR at Smith Ranch during the more than 20 years of operation.

3.5.3.8 Special Considerations for Gas Hills Remote Satellite Wellfield Operations

Wellfield Operations near Discontinuities, Previous Mining and Mine-related Reclamation

The Gas Hills Remote Satellite has similarities to Smith Ranch in that the license area and adjacent properties have been previously disturbed by conventional uranium mining operations. Cameco is experienced at operating an ISR operation adjacent to these historic disturbances. With respect to the Gas Hills Remote Satellite, Cameco recognizes the needs for special operational considerations near discontinuities such as faults, improperly abandoned drill holes, abandoned underground mine workings, existing water-filled mine pits and existing reclamation areas or backfilled mine pits. The primary ISR concern is loss of fluids, cross communication of intercepted sands and/or mixing of different quality groundwater. This latter concern is related to Cameco's need and program to prevent loss of fluids and/or interception of different groundwater types and their need to identify and discretize groundwater changes at their monitor well ring and establish if such changes are due to their actual ISR operation or the natural movement of a groundwater front, which reflects a different quality than that established by baseline sampling.

The primary pre-planning effort to prevent loss of fluids and/or mixing of differing quality groundwater is thorough definition of existing conditions during wellfield delineation and hydrologic unit testing efforts that will allow Cameco to fully understand groundwater behavior and baseline conditions. The primary engineering controls include production pattern balancing, scheduled development near mine workings or areas of high TDS groundwater, minimum setbacks of production pattern areas from mine workings or high TDS groundwater, and groundwater monitoring. In the event that the primary engineered controls are inadequate, secondary controls such as a "water fence" may be considered. In faulted areas, the production zone may be extended to include juxtaposed overlying or underlying aquifers. These operational considerations are further discussed below.

Mine Unit Production Pattern Balancing

Production pattern balancing to maintain a consistent bleed across a production area within a mine unit has been shown to be effective for preventing production fluid excursions in areas of relatively flat groundwater gradients. Cameco will use balancing programs which incorporate the geometry, geology and hydrology within each mine unit.

Due to the groundwater gradient at the Gas Hills Remote Satellite, the designed production pattern balance may result in an uneven bleed across a mine unit. Groundwater modeling, presented in **Appendix C** indicates the anticipated adjustments to the production pattern balancing that will be required to control flare and sweep under the varying hydrologic conditions for each mine unit. For example, in Mine Unit No. 3, located south of the Atlas Mine workings, injection rates in downgradient injection wells may need to be reduced by approximately 15% of the geometrically balanced rate, while injection rates in upgradient injection wells would be increased by approximately 15%. The overall bleed from the patterns would continue to be 1%, but would not be consistently applied across the pattern area. The upgradient over- injection will push against the groundwater moving toward the wellfield and create a barrier preventing dilution of the injection fluid with natural groundwater. As the distance increases upgradient from the pattern area, a point will be reached where the injection will be equally balanced against the natural groundwater flow. The resulting flare would still be less than 24 meters (80 feet) from the pattern area. Similarly, under- injection will be needed along the downgradient side of the mine unit to prevent migration of injected fluids downgradient toward the Atlas Mine workings. The information provided in **Appendix C** shows the balanced flare that will result from the 15% over injection upgradient and the 15% under injection downgradient of the mine unit.

Modeling will be an integral part of the production pattern balancing program for each mine unit. As mine units are brought into production, the detailed hydrologic data from the pump tests will be used along with operational data and experience to continue evaluation and adjustment of the balancing program.

Production Area Setback from Old Mine Workings

Conventional mining took place within and adjacent to the Gas Hills Remote Satellite. PMC has mined and reclaimed the Central Gas Hills trend and Umetco Minerals has mined and reclaimed the East Gas Hills trend. Also present within the license area (Mine Unit 4 and 5) are numerous pre-Law properties mined by various operators that have been reclaimed by the WDEQ AML Division. Several known underground mine operations were also present and were reclaimed by AML. These include the UPZ Shaft, Atlas-Peach, Thunderbird, Rox and Buss Underground. Two such surface mine pit disturbances (Buss and Cap Pits) were reclaimed by PRI. The underground mining operations were simply capped (surface plugged) and surface facilities removed and reclaimed. The open pit operations were backfilled with area mine spoils and since reclamation have exhibited groundwater recovery. In some cases, groundwater has not fully recovered and a cone of depression remains. Once a full recovery is achieved, upgradient groundwater will enter these reclaimed mine pits, mix with interstitial groundwater and pass through to a downgradient position. The natural groundwater undergoes a change in water quality, which often results in elevated TDS, elevated sulfates, and the elevation of certain metals including Fe, Mn, Al, Se, As, U, and Ra-226. In some cases there is a local lowering of pH. As the water continues in a downgradient fashion it mixes with area groundwater and is diluted to essentially a baseline characteristic. Because of the nature of the geochemical processes within the abandoned and reclaimed mine pits, these water quality changes continue to differing degrees as additional pore volumes pass through the mine pits. Cameco's Mine Units 4 and 5 are downgradient from AML reclamation and may intercept this groundwater of variable quality. Cameco's ongoing baseline monitoring has not detected a change in water quality.

When a mine unit or a production pattern area within a mine unit is located near a previously mined and/or reclaimed area, which exhibits different groundwater quality than was established by the baseline determination of a proposed ISR mine unit, Cameco will develop special provisions for this site condition. This effort will be directed towards the prevention of any incursion of these waters into the wellfield and the monitoring of the movement of these waters. The wellfield design will not only account for a monitor well ring, but will also include trend wells to detect such an incursion. An incursion is defined as the migration of different, often poorer quality (i.e., higher TDS) groundwater into the mine unit. Incursions are most likely to occur during the groundwater sweep phase of restoration. The modeling documented in **Appendix C** also addresses sweep during restoration as well as during production. For the example (Mine Unit No. 3), the anticipated sweep that will occur at the end of three years of production is 24 meters (80 feet). In other words, over a time period of 3 years, groundwater located approximately 24 meters (80 feet) from the production area may be drawn into the production area due to a wellfield bleed of 1%. **Appendix C** shows the pathlines. Similarly, during the groundwater sweep phase of restoration over a time period of 1.5 years, groundwater is anticipated to travel 36.6 meters (120 feet) towards the production area. Therefore, locating the edge of the production area patterns 91.4 meters (300 feet) from the edge of the old mine workings or the edge of the deteriorated groundwater plume will result in a buffer zone of un-impacted groundwater between the two areas. Figure ADD2-11 of **Appendix C** shows the anticipated pathlines during groundwater sweep for Mine Unit 3 south of the Atlas Mine workings. The information provided in **Appendix C** also discusses the other production units and anticipated setback distances from previously existing mine workings.

Minimum setbacks from the mine workings to prevent excursions and incursions will be developed specifically for each mine unit based on the hydrologic data. Modeling of Mine Unit 3 - South Area, using the baseline hydrologic properties presented in this TR, supports a minimum setback of 91 meters (300 feet) from the Atlas Mine workings. Similarly, modeling of the Mine Unit 3 - North Area also supports a minimum setback of 91 meters (300 feet) from the Atlas Mine workings. The planned pattern areas for Mine Unit 3 - North Area and Mine Unit 4 are located approximately 305 meters (1,000 feet) from the Pathfinder Mines Corporation reclaimed area and the Buss Pit, respectively. According to the models for these areas, the 305 meters (1,000 feet) separation is more than adequate to hydrologically isolate the ISR operations from the previous mining operations. These minimum setbacks will be reevaluated as more detailed geologic and hydrologic and operational data is obtained. The Hydrologic Testing Proposal for each specific mine unit will contain the proposed pattern areas and information supporting the proposed monitor well locations and spacing. This document will also contain detailed information supporting the minimum setbacks from mine workings, as this will affect monitor well location and spacing.

Operational Controls to Address Conductive Faults

Several faults are located near or within all of the proposed mine units at the Gas Hill Remote Satellite. Delineation drilling will allow for accurate mapping of the faults, and the hydrologic tests will investigate the potential for conductivity along these faults. Assessment of confining unit competency near faults in the ore zone will also be addressed using geologic and hydrologic data. A decision tree for operating near faulted areas has been developed by Cameco. If geologic cross-sections show the potential for juxtaposition, production zone wells, overlying aquifer wells and underlying aquifer wells will be installed on both sides of the fault. Potentiometric surface data may be used to determine communication or isolation of the sands. However, a "fault pump test" may be required on a site-specific basis to confirm this determination. If the data indicates that a particular fault provides hydraulic communication between the production zone and the overlying and/or underlying aquifer, Cameco must decide between several operational methods including primary engineering controls, secondary engineering controls, or extension of the production zone. These three options are discussed below.

1. Primary engineering controls (production area pattern balancing, scheduling, setbacks, monitoring) can be used to isolate the ISR operations from the fault. Production area pattern balancing, wellfield development scheduling and groundwater monitoring are effective when the fault does not intersect the planned production pattern area and flare area. If the fault intersects the planned production pattern area or the anticipated flare area, minimum setbacks from the fault to the production pattern area may be determined, or the use of secondary engineering controls may be required. Economics will be a consideration in planning the use of primary or secondary controls for production. For instance, if the ore is low grade and the uranium price is low, setbacks from the fault will be assessed, and the ore near the fault may not be targeted for production and Cameco will "stay away from the problem area." If the ore is high grade and the uranium price is high, Cameco may further investigate the use of secondary controls to allow recovery of the uranium near the fault.
2. Secondary engineering controls (e.g. water fence) may be used to allow ISR operations in close proximity to a fault. A "water fence" is formed by a line of injection wells that inject clean water into the production zone. This forms a high pressure ridge which prevents migration of fluids across the fence from either direction. The "water fence" is temporary and will only block groundwater flow while injection is ongoing. This option would be

considered when clean water for injection is plentiful and aquifer conductivity is low to moderate. Secondary controls may also be needed near faults or mine workings during the groundwater sweep phase of restoration to prevent incursions.

3. In the unlikely event that primary controls have failed and an excursion cannot be retrieved, the use of secondary controls will be evaluated to control the excursion. While a water fence is not planned for a specific location at this point in time, the use of this and other engineered barriers near mine workings or faults will be continually evaluated on a site specific basis.
4. Under certain geologic conditions, it may be preferable to extend the production zone definition to include the juxtaposed aquifers above or below the ore zone sand. The overlying and/or underlying aquifers may be operated as portions of the production sand thus requiring restoration. The second overlying and/or underlying aquifer, if present, may require testing and monitoring. This option may necessitate bonding adjustments to account for the additional impact to the groundwater. Geologic conditions that may warrant this operational method include low conductivity faults of limited extent. The overlying/underlying aquifer impact would be relatively small and easily restored.

The Hydrologic Testing Document for each Gas Hills Remote Satellite mine unit will include a detailed fault assessment, evaluation of abandoned drill holes in the area, evaluation of abandoned mines and underground workings as this information is required for wellfield design including monitor well spacing and placement.

Operational Controls to Address Areas Where Previous Mining and Mine-related Reclamation has Occurred

As discussed above the impact of previous mining and mine-related reclamation will be assessed prior to development of a mine unit. Operational setbacks will be the primary means of addressing concerns that different water quality from an offsite source may impact wellfield production (due to ISR bleed) and restoration. In addition Cameco will consider engineered controls as previously discussed including pattern balancing, scheduling, monitoring or secondary controls such as water fences.

In some instances and in advance of the recovery operations, different groundwater quality may be moving through a mine unit due to the natural groundwater gradient. Cameco will continue to update their baseline data collection and will address this condition. For example Cameco recently (October 2011) completed another round of baseline data collection at the Gas Hills Remote Satellite to supplement the WDEQ/LQD permit- even though baseline had been established for the state permit. This information has been incorporated into the NRC license. If the natural pre-ISR groundwater movement and its inherent change in water quality can be well established within a mine unit, then it would be inappropriate to use engineered controls to keep the differing quality groundwater separate. In this case, the high TDS groundwater would be used to establish the UCL and RTV concentrations, with the concurrence of the NRC.

Cameco has developed a decision tree that outlines the process for investigating the movement of variable groundwater quality (high TDS example) into a mine unit. The decision tree indicates that engineered controls will be planned when high TDS groundwater intersects a mine unit due to ISR operations.

3.6 Uranium Recovery Processing Facilities

3.6.1 Smith Ranch

3.6.1.1 General Facility Layout

The Smith Ranch main office and CPP are located in the NE/NW Section 36, T36N, R74W (see Figure 1.3 Smith Ranch General Location Map). The CPP complex occupies approximately 16.2 hectares (40 acres) and is located in the area of the reclaimed Kerr McGee Bill Smith underground mine complex. The current complex consists of several buildings, impoundments, chemical storage areas, and an office building. A security fence surrounds the CPP site.

The northern end of the CPP houses IX facilities; the remainder of the building contains resin transfer, elution, yellowcake processing, and drying/packaging facilities. The CPP IX facilities currently serve Mine Unit 1, Mine Unit 2 and Mine Unit 3. This area also includes a lined, two-celled waste water storage pond, the former O- and Q-Sand pilot plant building, construction and maintenance shops, warehouse facilities and the" boneyard" storage area. **Figure 3.18, CPP Site Map** shows the plan view of the CPP facilities.

The catchment basins shown on **Figure 3.18, CPP Site Map** were originally constructed by Kerr McGee for the Bill Smith Mine. They are now used as part of the storm water control process for the Smith Ranch CPP. The depression area to the west of the CPP complex was the "Sand Borrow" area used by Kerr McGee during the construction of the Bill Smith Mine. This area is now used to store wood pallets, cable spools, etc. until they are disposed during periodic permitted controlled burns.

Central Processing Plant Equipment

The CPP building contains IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, disposal well equipment, RO units and bioremediation materials for groundwater restoration, an upstairs laboratory area, offices, and employee break rooms. The principal equipment used in the yellowcake production process consists of surge tanks, elution/precipitation tanks, a thickener, vacuum drying systems, and the piping, pumps and valves required to control and move the solutions among the various process components. **Figure 3.19, CPP Floor Plan** shows the layout of process equipment in the CPP. This figure also shows the layout of the laboratory and yellowcake storage areas expansions that were completed during the last renewal period.

Highland Uranium Project Central Processing Facility

The former Highland main office and CPF complex is located in the NE/NW Section 29, T36N, R72W (see Figure 1.3 Smith Ranch General Location Map). The main office and CPF are currently on stand-by status, and all yellowcake processing occurs at the Smith Ranch CPP. The CPF building houses uranium processing facilities including the uranium extraction circuit, yellowcake precipitation, dewatering, drying and packaging equipment. The site plan of the CPF area is shown on **Figure 3.20, Highland CPF Site Map**. The current interior process equipment layout is shown on **Figure 3.21, Highland CPF Floor Plan**. Cameco plans to refurbish the Highland CPF and resume IX processing and yellowcake processing activities. This will require the replacement of the dryer equipment and the majority of the existing processing equipment. Third-party toll processing of IX resin or yellowcake slurry is also planned at the CPF once the facility is upgraded. Third party toll processing has been previously evaluated and approved by NRC in the form of license amendments.

3.6.1.2 Uranium Recovery Process

Ion Exchange/Lixiviant Makeup Circuit

The uranium-bearing solution pumped from a mine unit is piped to the CPP or satellites for extraction of the uranium by use of down flow IX columns to remove the uranium. As the solution passes through the resin in the IX column, the uranium is preferentially removed from the solution by attachment to the resin. The following IX reaction occurs when the uranium bearing lixiviant contacts the resin:

$$2RCl + (UO_2)(CO_3)_2^{2-} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$

where "R" denotes the IX resin.

Once the resin in a column is sufficiently loaded with uranium, the vessel is isolated from the normal process flow and the resin is removed from the column for elution. In the elution process, the resin is contacted with a strong sodium chloride solution, which displaces the uranium and regenerates the resin in a process very similar to regenerating a conventional home water softener. The eluted resin is then placed back in service for additional uranium recovery. The uranium rich fluid (rich eluate) is pumped to the precipitation circuit for further processing.

The barren solution leaving the IX units normally contains less than 2 mg/L (ppm) of uranium. After the barren solution leaves the IX columns, a small bleed, or purge, (averaging 0.5 to 1.5% of the total flow) is removed and sent to the waste water treatment and disposal system. This ensures that there will always be a net cone of depression within the mine unit, thereby reducing the chance of excursions. The remainder of the barren solution is refortified with carbon dioxide and/or carbonate/bicarbonate as necessary to return the carbonate/bicarbonate concentration to the desired operating level. The solution is then pumped back to the mine unit, with the oxidant (O_2 gas and/or H_2O_2) added either as it leaves the CPP or satellite, or just before the solution is re-injected into the production zone.

3.6.1.3 Elution and Precipitation Control

A chloride brine and soda ash solution is used to remove the uranium from the resin. The following chemical reaction occurs:

$$R_2UO_2(CO_3)_2{+}2NaCl{-}{>}Na_2UO_2(CO_3)_2{+}2RCl$$

The rich eluate containing the uranium is pumped to tankage in front of the precipitation circuit for temporary storage. To initiate the precipitation cycle, hydrochloric or sulfuric acid is added to the uranium bearing solution to break down the uranyl carbonate present in the solution. It is then transferred to the precipitation circuit and hydrogen peroxide is then added to the acidified eluate to effect precipitation of the uranium as uranyl peroxide. The addition of hydrogen peroxide reduces the pH of the solution. To optimize crystal growth and settling, a base (e.g., sodium hydroxide or ammonia) is added as a pH adjustment.

The uranium depleted eluate or supernate solution is removed and stored for re-use in future elutions or for disposal. Sodium chloride and sodium carbonate are added to the recycled eluate, as needed, for refortification. Storage tanks and/or lined storage ponds are used to collect and store excess process waters from this circuit, such as the excess spent eluate, prior to disposal via deep well injection.

3.6.1.4 Yellowcake Dewatering, Drying and Packaging

The resulting slurry from the elution/precipitation circuit is transferred to a thickener allowing the uranium to precipitate for maximum crystal growth and consolidation by gravity. The yellowcake slurry is dewatered as it settles and the eluate is decanted by a weir and transferred back to the elution circuit or sent to the waste water treatment and disposal system. The yellowcake slurry is routed to a filter press for washing to remove soluble contaminates followed by de-watering prior to drying. The yellowcake is dried using a rotary vacuum dryer and packaged in 208 Liters (55 gallons) steel drums for storage and shipment. With this type of dryer, the off-gases generated during drying are filtered to remove entrained particulates. The sealed vacuum system provides ventilation while the dryer is being loaded and unloaded into drums. This type of dryer eliminates airborne effluents. An enclosed, secured storage room adjacent to the yellowcake drying area, is provided for the storage of drummed yellowcake prior to shipment.

The drummed yellowcake is shipped by exclusive use transport to an offsite NRC licensed facility for further processing. During periods of inclement weather or other interruptions in product shipments, drums will be stored on site in a designated storage area. Yellowcake shipments comply with applicable NRC and DOT packaging and transportation requirements.

3.6.1.5 Waste Water Management

There are five primary process waste water streams for the Smith Ranch CPP:

1. Wellfield bleed, averaging up to 1.5% of production flow rates;
2. Groundwater restoration waste water;
3. Excess water from resin transfer, elution and precipitation circuits;
4. Well work-over water; and
5. Wash down water.

All of these waste streams are combined and treated at the CPP or satellites as follows:

1. Filtration to remove suspended solids;
2. Disposal via a Class I UIC injection well(s); or
3. Radium and selenium removal and disposal at PSR-2 Land Application Facility.

Class I Injection Wells

Smith Ranch is currently (January 2012) permitted for 10 Class I UIC injection wells to dispose of excess water generated by both mine unit and yellowcake processing operations. **Table 3-7, Deep Disposal Well Information** lists the well ID's, permits, injection rates and analysis requirements for these disposal facilities. The locations of these wells are shown on **Figures 1.4** through **1.8**. Cameco will comply with permit conditions identified within the individual UIC permits through the WDEQ/WQD.

Two wells, SR #1 and SR #2, are now approved to operate under Class I UIC Permit 99-347. Well SR #1 is located in the NE¼ of Section 35, T36N, R74W, approximately 0.8 kilometers (0.5 miles) west of the CPP. Well SR #2 is located in the NE¼ of Section 27, T36N, R74W, approximately 244 meters (800 feet) north of Satellite SR-1. Both wells are permitted to inject into the Parkman, Teapot and Teckla Formations. Deep disposal well SR #1 is used for waste water disposal at the CPP and SR #2 is used for disposal at Smith Ranch Satellite SR1. Satellite SR1 also utilizes deep disposal well SRHUP #10. Deep disposal well SRHUP #6 services Smith Ranch satellite SR2. Deep disposal wells SRHUP #7, SRHUP #8 have not yet (January 2012) been installed. The Reynolds Ranch well has been drilled but is not yet operable.

Waste Water Storage Ponds

Two small, lined storage ponds (East and West Ponds) are in operation at the CPP. These ponds were initially constructed in 1981 and authorized under the Q-Sand Pilot Project WDEQ Permit to Mine 633 and NRC License SUA-1387. These ponds are located just to the north of the CPP, and are used for limited process effluent disposal and solids retention prior to transfer to the deep disposal injection wells. The capacity of each pond is 962 meters^3 (0.78 acre-feet) of water. Each pond is 30.5 meters x 30.5 meters and 2.4 meters deep (100 feet x 100 feet and 8 feet deep). During operations, 1 meter of freeboard is maintained in each pond to protect the berms from wave action damage due to wind.

Each pond is constructed with a compacted sandy clay base overlain by a 30 mil thick Hypalon liner. The bottom of each pond has a two way slope toward the center. A sand layer is placed over the bottom of the pond with the synthetic liner on top of the sand. For each pond, a perforated PVC pipe is installed in the sand layer parallel to the bottom slope. The perforated pipe is connected to a collection sump. The sumps are monitored for leaks of process solutions.

3.6.1.6 Equipment, Instrumentation and Control

Header House Instrumentation and Control

The production and injection headers within each new header house is instrumented to shut down a header house and associated patterns in the event of a piping failure. The injection and production headers in new header houses have pressure transducers that are monitored by a PLC (process logic controller). Each new header house has a combination pressure reducing and shutoff valve on the injection side. The valve controls the injection pressure at the header house to a predetermined pressure setting and shuts down the header house injection in the event of a problem in the header house. The PLC monitors the production and injection pressure and the presence of water in the header house basements. Depending on the programmed pressure set points, a pressure change (high or low) will be detected by the PLC and will shut the injection fluid control valve and turn the pumps off in the header house. A beacon installed on the outside of the header house comes on indicating to the operator that a problem in the house has occurred. The PLC also indicates to the control room computer that a header house has shut down for all newer houses in production.

The oxygen system in each header house has solenoid operated valves that close in the event of a loss of power or when a header house shuts down. This prevents the continued delivery of oxygen to the header house in the event of a loss of flow. The carbon dioxide injection system installed at some of the header houses or at the satellites have reagent addition and/or pH control. The carbon dioxide system utilizes solenoid valves that close in the event of a loss of power or when the header house shuts down. Instrumentation to monitor pH is installed in the header house or satellite as part of the carbon dioxide system. The pH is monitored by the PLC. Unlike the other satellites at Smith Ranch, the bicarbonate addition system at Satellite SR-2 is equipped with pH meters. This type of bicarbonate system will be installed at the Reynolds Ranch Satellite and at the remote satellites.

A conductivity probe, a level transducer, or a float has been installed in each new header house to detect fluids on the floor and/or basement of the house. There are two separate alarm stages associated with the floor leak detection system. The first will alarm when water is at a depth of about 7 centimeters (3 inches at which time the sump pump will automatically start pumping water from the sump. The second will alarm when water has reached a few feet in depth, indicating that the leak is larger than the sump pump can handle. If fluids are detected at the second alarm level, the PLC shuts down the injection flow and shut off the production wells in the header house. A beacon on the outside of the header house is activated in the event water is detected, and the PLC will alarm on the main control computer in the Control Room at the satellite facility that the header house has shut down. The only exception is Mine Unit F. There are no fiber optic capabilities at Mine Unit F to connect it to the satellite, so it acts as an independent or “stand-alone” mine unit. Starting in Mine Unit J at Smith Ranch, header houses were installed with earthen basements in an effort to contain spilled fluids. The next evolution of basements included leak resistant floors or basements, which were first employed in Mine Unit 15 at

Smith Ranch to prevent spilled fluids from soaking into the soil. Going forward all new wellfield header houses are equipped with cement basements. Each new header house floor or basement has a sump and a sump pump capable of pumping any spilled fluids from the floor back into a production pipeline. The flow from individual production and injection wells is measured using turbine meters which will be located in the header house. The individual well flows are measured and adjusted daily. A flow meter is used to measure the total production and injection flow rates from each header house. The flow meters' instantaneous flow rate is monitored by the PLC. Starting with Mine Unit 15A (i.e., newer header houses), the PLC sends an alarm to the satellite in the event of a flow problem. Except for Satellite 2, each production header house can be remotely shut down from the satellite.

All injection and production collection headers are monitored for pressure and flow. High and low pressure targets are set to detect abnormal operations. The totalized flow through the headers is compared to the total flow of all operating wells feeding the header to determine if there are flow balance problems.

Header houses that have leak detection equipment are tested at least once each month and documented. Each header house is also inspected at least once each day and documented. Starting in Mine Unit 15A, leak detection instrumentation has been installed on both production and injection wells. The production well leak detection instrumentation has been tied to the running control such that if there is a leak on an individual well, it will be shut down until the well is fixed.

To prevent flow through a shutdown header house, an automatic valve (Cla-Val™) is installed in the injection header just as it enters a header house. This valve automatically closes should the leak detection system shut down a header house. Previous failures of this type of valve has led to the current practice of backing up the Cla-Val with a motor operated valve that is actuated by a power failure and operated by an uninterruptible power supply (UPS).

Main Trunkline Instrumentation

The main trunk pipeline pressure is monitored and trended by the PLC at the satellite. During normal operation the trends are consistent. If an upset condition occurs, the pressure trends may become erratic. Alarms alert the operator if an unexplained upset occurs in the system so that an inspection can be made. Each valve manhole has a leak detection alarm that will give the operator a visual alarm if the manhole becomes filled with water. Each manhole is routinely inspected and documented.

3.6.2 Smith Ranch Satellite Facilities

3.6.2.1 General Facility Layout

As of September 2011, a total of five satellite IX facilities have been constructed at Smith Ranch, with four in operation. Satellites 1, 2 and 3 are located on the Highland portion of the Smith Ranch license area, and Satellites SR-1 and SR-2 are located on the Smith Ranch. Satellite 1 is not operational at this time as Mine Units A and B, that served Satellite 1, are no longer in production and have completed active groundwater restoration. Restoration of Mine Unit A has been approved by the WDEQ and NRC. Mine Unit B has been approved by the WDEQ. NRC approval is pending the submittal and approval of an ACL application which should be provided to NRC early in 2012. A sixth satellite facility will be built at the Reynolds Ranch expansion area to service the Reynolds Ranch mine unit wellfields. Construction of the Reynolds Ranch Remote Satellite is pending approval from the LQD. The NRC has approved Reynolds Ranch as an amended area to SUA-1548.

Satellites 2, 3, SR-1 and SR-2 are all operational providing production and/or restoration support to Smith Ranch. The satellite buildings typically house IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, RO units and bioremediation materials for groundwater restoration, a laboratory area, offices, and an employee break room. CO_2 and O_2 are stored in compressed form adjacent to each satellite building or in the mine unit areas.

Satellite 1 is located in the NW¼ Section 21, T36N, R72W. The building occupies approximately 743 m^2 (8,000 ft^2). The location of Satellite 1 is shown on **Figure 3.22, Satellite 1 Site Map**. As discussed above, Satellite 1 serves Mine Units A and B and is currently not in operation. No interior equipment layout is provided since this facility is not operational. During production operations, this facility had a capacity of approximately 6,804 liters/minute (1,800 gallons/minute).

Satellite 2 is located in the NE¼ Section 14, T36N, R73W. The building occupies approximately 1,208 m^2 (13,000 ft^2). Satellite 2 serves Mine Units C, D, D-Extension, F, E, H, and I. The Satellite 2 facility is designed to operate with a maximum flow of 12,096 liters/minute (3,200 gallons/minute) during production operations. As of September 2011, Mine Units C, D, D-Extension and E are undergoing groundwater restoration. Mine Units H and I are in production. The location of Satellite 2 is shown on **Figure 3.23, Satellite 2 and Selenium Plant Site Map**. Satellite 2 utilizes CO_2 and O_2 and has one operating RO unit used for groundwater restoration purposes. Additional RO capacity has recently been added to Satellite 2. The interior layout for this satellite is depicted on **Figure 3.24, Satellite 2 Floor Plan**.

Satellite 3 is located in the SE¼, Section 20, T36N, R73W. The building occupies approximately 1,208 $meters^2$ (13,000 $feet^2$). Satellite 3 and associated facilities serve Mine Units D-Extension, F, J and K. The piping is set up such that Mine Units D-Extension and F can be served by Satellite 3 as well as Satellite 2. Satellite 3 may also serve additional mine units that are currently being geologically evaluated for future expansion in the western portion of the original HUP license area (i.e., west of Satellite 3). The Satellite 3 facility is designed to operate with a maximum flow of 18,900 liters/minute (5,000 gallons/minute) for production operations. The location of Satellite 3 is shown on **Figure 3.25, Satellite 3 Site Plan**. The interior equipment layout is depicted on **Figure 3.26, Satellite 3 Floor Plan**.

Satellite SR-1 is located in the SE¼, Section 27, T36N, R74W. The building occupies approximately 1,812 m^2 (19,200 ft^2). Currently, this facility serves Mine Units 3, 4, 15 and 15A. Satellite SR-1 is designed to operate with a maximum flow of 17,010 liters/minute (4,500 gallons/minute) for production operations. The satellite also contains 1,890 liters/minute (500 gallons/minute) of RO capacity for groundwater restoration purposes. The location of Satellite SR-1 is shown on **Figure 3.27, Satellite SR-1 Site Plan**. The interior equipment layout is depicted in **Figure 3.28, Satellite SR-1 Floor Plan**.

The southwest Satellite, SR-2, is located in the NE¼, Section 17, T35N, R74W. The building occupies approximately 1,812 m^2 (19,200 ft^2). This satellite serves Mine Unit 9 and will serve planned mine units in the southwest area, including Mine Units 10, 11, and 12. Satellite SR-2 is designed to operate with a nominal flow of 18,900 liters/minute (5,000 gallons/minute) for production operations. The satellite also contains 1,890 liters/minute (500 gallons/minute) of RO capacity for groundwater restoration purposes. The location of Satellite SR-2 is shown on **Figure 3.29, Satellite SR-2 Site Plan**. The interior equipment layout is depicted in **Figure 3.30, Satellite SR-2 Floor Plan**.

As discussed in Section 3.2.1, The Reynolds Ranch Satellite will be located north of the CPP complex (see **Figure 1.3**) and will serve all mine units planned for the Reynolds Ranch satellite area. The satellite will be designed with a maximum through-flow of 22,680 liters/minute (6,000 gallons/minute) during production operations and will also contain 1,890 liters/minute (500 gallons/minute) of RO capacity for groundwater restoration purposes. The location of the Reynolds Satellite site is shown on **Figure 3.31, Reynolds Ranch Site Map**, and the interior layout is shown on **Figure 3.32, Reynolds Ranch Floor Plan**.

3.6.2.2 Ion Exchange/Lixiviant Makeup Circuit

The IX/lixiviant makeup circuit for the Smith Ranch satellites is described in Section 3.6.1.2, except that the uranium-bearing solution is pumped to the satellites

3.6.2.3 Waste Water Management

General

The primary process waste water streams for the Smith Ranch satellites will be similar to the Smith Ranch CPP except that the wellfield bleed will only average 1% of the production flow rates and because yellowcake is not produced, no excess water from the elution and precipitation circuits will be generated.

All of these waste streams will be combined and treated in the satellite as follows:

1. Filtration to remove suspended solids;
2. Disposal via a Class I UIC injection well(s) or land application.

As capacity is added to the CPP and/or satellites to meet production and restoration levels, disposal capacity will be added in the form of deep disposal injection wells or approved alternative disposal facilities.

In addition to the disposal wells, radium settling basins, purge storage reservoirs, and a selenium treatment facility have been installed to assist in the waste water disposal. **Figure 3.33, Mine Unit Piping Diagram** provides a schematic describing waste water treatment at the satellites.

Class I Injection Wells

Smith Ranch is permitted for ten Class I UIC injection wells to dispose of excess water generated by both mine unit and yellowcake processing operations. **Table 3-7** lists the well ID's, permits, authorized injection rates and analysis requirements for these disposal facilities. The locations of these wells are shown on **Figures 1.4** through **1.8**. Cameco will comply with permit conditions identified within the individual UIC permits.

Two wells, SR #1 and SR #2, are now approved to operate under Class I UIC Permit 99-347. Well SR #1 is located in the NE¼ of Section 35, T36N, R74W, approximately 0.8 kilometer (0.5 mile) west of the CPP. Well SR #2 is located in the NE¼ of Section 27, T36N, R74W, approximately 244 meters (800 feet north of Satellite SR-1. Both wells are permitted to inject into the Parkman, Teapot and Teckla formations.

During 2009, Class I UIC Permit 09-054 was approved by WQD authorizing the use of seven additional disposal wells; Morton 1-20, Vollman 33-27, and SRHUP #6 through SRHUP #10. The Morton 1-20 is located in NW¼ NW¼, Section 20, T36N, R72W; the Vollman 33-27 is located in NW¼ SE¼ Section 27, T36N, R73W (see Smith Ranch WDEQ Permit Plates OP-1-1 through OP-1-5). Both the existing Morton 1-20 well and the Vollman 33-27 are completed in a deep injection zone within intervals from 2,446 to 2,785 meters (8,024 to 9,138 feet below the surface and are permitted for injection into the Teckla, Teapot and Parkman formations.

Satellite 1 Radium Settling Basins

The radium settling basins were constructed in 1987 to settle residual radium-barium sulfate out of the Satellite 1 waste water after filtration and prior to land application. The area consisted of two 3,700 meters^3 (3 acre-feet lined ponds located east of Satellite 1. Water that passed through these basins then went to the Purge Storage Reservoir 1 (PSR-1) where it was stored prior to periodic land application. The

Radium Settling Basins were originally permitted by WQD under Permit 87-042R prior to being amended into the LQD Permit to Mine 603.

Cameco has initiated the decommissioning and reclamation of the radium settling basins. Most of the clay liner has been removed and disposed of as 11e.(2) byproduct material. A small amount of clay liner remains with low levels of uranium and Ra-226. Assessments are being made to complete final reclamation and decommissioning of the basins.

Purge Storage Reservoir 1

PSR-1 is located east of Satellite 1 and was used to store treated mine unit purge water and treated water from Mine Units A and B restoration activities. The reservoir contains 66,600 meters^3 (54 acre-feet) when at full capacity. Water stored in the reservoir was periodically land applied by sprinkler irrigation on a 23.5 hectare (58 acre) irrigation area when weather conditions permitted. PSR-1 was originally permitted by WQD under Permit No. 93-178, and later by Permit No. 95-156R. The PSR-1 and associated leakage pumpback system are permitted under the LQD Permit to Mine No. 603. PSR-1 is currently in an interim stabilization status and contains no water. There is an on-going investigation at the PSR-1 and associated land application area, including annual sampling of soils and vegetation, to assist in determining the best management of the facilities in the future as well as the reclamation and surety requirements.

The reservoir is underlain by a natural clay soil that contains an average permeability of approximately 1.8E-8 centimeters/second (7.1E-9 inches/second). Use of the reservoir began in January 1988 with the start of production from the Satellite 1 area. The reservoir performed as designed until August 1994 at which time a small amount of leakage was discovered seeping at the two ephemeral drainages located immediately east and south of the reservoir. A Corrective Action Plan (CAP), which addressed the conditions at the reservoir and corrective measures to be implemented, including the installation of two pump back sumps (North and South Pump Back Sumps), was submitted to the NRC and LQD in correspondence dated October 3, 1994. It was determined that the seepage resulted from erosion of the natural clay liner along the eastern most portion of the reservoir. The erosion was caused mostly by wave action. Erosion of the clay liner exposed an underlying sandstone which allowed seepage to move out of the reservoir, to the south and east, where the sandstone outcropped in the ephemeral draws.

On November 9, 1994, the treated excess water was diverted to Purge Storage Reservoir No. 2 (PSR-2)in order that the PSR-1 could be dried out and repairs to the liner accomplished. Due to the abnormally wet spring of 1995, construction activities, which included repair of the clay liner and the addition of a geotextile fabric along the eastern side of the reservoir to protect against erosion, were not completed until August 1995. The CAP also included the construction of a 244 meters (800 feet) long interceptor trench approximately 91 meters (300 feet) south of PSR-1 in August 1996. The trench captures subsurface seepage from the south side of PSR-1 and pumps it back into the reservoir. The pumping system is fully automatic and continuously operates. The interceptor trench has been very effective in preventing seepage from PSR-1 from surfacing and entering the drainage south of the system. After the Interceptor Trench went into service, it was no longer necessary to operate the South Pump Back Sump. Both the interceptor trench and North Pump Back Sump are on standby. PSR-1 is not currently in use. The system is monitored in accordance with requirements of the LQD. As part of the CAP, visual inspections, sampling of the seepage water, vegetation monitoring, and soil monitoring are conducted.

Figure 3.34, PSR-1 Interceptor Trench Details shows the details of the interceptor trench and associated pumpback sump. The trench is approximately 1.8 to 5.5 meters (6 to 12 feet) deep depending on the topography. The bottom of the trench intercepts the fractured sandstone unit which transmitted the seepage. Approximately 46 to 61 centimeters (18 to 24 inches) of 1.9 centimeters (0.75 inch) gravel was placed in the bottom of the trench and surrounded the 10.2 centimeters (4 inch) PVC drain pipe. A plastic liner was installed along the down gradient side of the trench to assist in capturing any seepage. The drain pipe drained seepage to the concrete sump which contains a submersible pump capable of pumping approximately 75.6 liters/minute (20 gallons/minute). When operational, the pump activates automatically by a float switch, and seepage is pumped back to PSR-1 through a buried 5.1 centimeter (2 inch) HDPE pipe. Although the reservoir has not held water for several years, minor seepage continues to enter the pump back system. Therefore, this part of the system remains operational.

Purge Storage Reservoir 1 Land Application

The PSR-1 Land Application Areas 1A and 1B are located east of Satellite No. 1 near PSR-1. The area consists of a center pivot irrigation system which covers 23.5 hectares (58 acres). There has been no land application for several years at this site.

The PSR-1 Land Application Area was originally permitted by the WDEQ WQD under Permit No. 92-077 and later by Permit No. 95-156R and was incorporated into WDEQ LQD Permit to Mine No. 603. Monitoring requirements for vegetation, soils, etc. are included in **Table 3-8, Purge Storage Reservoir No. 1 Land Application Monitoring Program**.

Purge Storage Reservoir 2 and Associated Land Application Area

The PSR-2 Land Application Area is used for the disposal of wellfield purge and groundwater restoration fluids from mine units served by Satellite Nos. 2 and 3. During months of land application, monthly samples are collected and analyzed for the parameters listed in **Table 3-9, Purge Storage Reservoir No. 2 Land Application Monitoring Program**. Samples are collected from the pump intake line and are collected using an automatic sampler. The samples are composited on a monthly basis and analyzed.

PSR-2 can contain approximately 40 hectare-meters (321 acre-feet) of water. The land application area comprises approximately 46 hectare (116 aces). The locations of Satellite No. 2, PSR-2, land application area and the 10.2 centimeter (4 inch) HDPE pipeline used to transport treated water from Satellite No. 3 to Satellite No. 2 and PSR-2 are shown on **Figure 1.3**. PSR-2 and associated land application facilities were originally permitted by WQD under Permit No. 93-410 prior to being amended into the LQD Permit to Mine No. 603. Similar to PSR-1, PSR-2 is underlain by several low permeability clay units.

Selenium Treatment Facility

A selenium treatment facility has been constructed and is operating at a location approximately 9 meters (30 feet southwest of Satellite No. 2. The facility is connected to Satellite No. 2 and Satellite No. 3 through buried pipelines and houses the selenium treatment circuit. After selenium treatment the water is returned to Satellite No. 2 for waste water disposal. See **Figure 3.23** for the selenium plant floor plan.

Satellite No. 2 and the selenium treatment facility both process waste water currently being discharged into PSR-2 for subsequent land application. The selenium treatment facility provides selenium removal to a target concentration not to exceed average selenium concentrations of 0.1 mg/L. The average selenium concentration of all samples taken from the PSR-2 compositor during the entire operating season (approximately March-October) must not exceed 0.1 mg/L selenium. The treatment facility includes a radium removal circuit that currently has replaced the radium removal that was done at Satellites No. 2 and No. 3.

Waste/remediation water is first treated for radium removal using a barium chloride solution that precipitates radium. The radium compound precipitate is allowed to gravity settle and is then concentrated by a filter press. The filtered solids are disposed at an NRC licensed 11e2 byproduct material disposal facility.

Following radium removal, the remediation stream is processed in selenium removal columns. The spent media of the columns is cleaned in sand washing equipment. The resulting precipitate is allowed to gravity settle and is then concentrated in a filter press. The filtered solids are disposed at an NRC licensed 11e2 byproduct material disposal facility.

The washed sand media is recharged with iron to reestablish the 5:1 volume ratio and put back into the selenium removal columns for further processing.

3.6.2.4 Equipment, Instrumentation and Control

The satellite buildings will house IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, disposal well equipment, RO units (SR-1 and SR-2) and chemical reductant/bioremediation materials for groundwater restoration, a laboratory area, offices, and employee break rooms. Satellite No. 2 utilizes CO_2 and O_2 and has one operating RO unit used for groundwater restoration purposes. The interior layout for this Satellite is depicted on **Figure 3.23**. Satellite No. 3 utilizes CO_2 and O_2, and does not have a RO unit. The interior equipment layout is depicted on **Figure 3.26**. Satellite SR-1 utilizes CO_2 and O_2 and has one operating RO unit used for groundwater restoration. The interior equipment layout for this satellite is depicted on **Figure 3.28.** Finally, Satellite SR-2 utilizes sodium bicarbonate, CO_2, and O_2 and has one operating RO unit used for groundwater restoration. The interior layout for this Satellite is provided on **Figure 3.30**. As shown on the figures, each satellite IX system consists of varying numbers of fixed bed IX vessels. The layout and size of each building is different. CO_2 and O_2 are stored in compressed form adjacent to the satellite buildings or in the mine unit areas.

Header house and main trunkline instrumentation and control for the Smith Ranch satellites are similar to that described in Section 3.6.1.4.

3.6.3 North Butte Remote Satellite

3.6.3.1 General Facility Layout

The surface facilities at the North Butte Remote Satellite will include the wellheads, header houses, buried pipelines, overhead and buried power lines, facilities access roads, deep disposal wells, surge ponds and the satellite IX building. The satellite building is located in the NE¼ Section 24, T44N, R75W. The building will occupy approximately 2,378 meters (25,600 ft^2) and will be designed to operate with a maximum flow of 22,680 liters/minute (6,000 gallons/minute) during operations. Mineral processing and water treatment facilities will be located at the satellite facility shown on **Figure 1.10**. The water treatment facilities will include the surge ponds, also shown **on Figure 1.10** Map. The detailed design and design report for the surge ponds are provided in **Appendix D, North Butte Surge Pond Design**.

Pipeline and power lines will follow access roads. **Figure 1.10** depicts the proposed locations of main and secondary access roads. Additional detail and wellfield access roads for Mine Unit No.1 are shown on **Figure 3.35, Primary and Secondary Access Road Construction**. As shown on **Figure 3.35** power lines and pipelines will run along opposite sides of the access road right-of-way. Power lines will be constructed to meet current codes for wildlife protection. Pipelines within the mine unit wellfields and from the header houses to the main collection and distribution lines will nominally be 20 centimeters (8 inch) in diameter or smaller. The main collection and distribution pipelines will nominally be up to 61 centimeters (24 inch) in diameter. The main pipeline corridor will house up to eight lines to facilitate water handling, treatment, recycling, and groundwater restoration. The location of the satellite facility is shown on **Figure 1.10**.

3.6.3.2 Ion Exchange/Lixiviant Makeup Circuit

The IX/lixiviant makeup circuit for the North Butte Remote Satellite is described in Section 3.6.1.2, except that the uranium bearing solution is piped to the North Butte Remote Satellite.

3.6.3.3 Waste Water Management

The four primary process waste water streams for North Butte are the same as that for the Smith Ranch satellites.

All of these waste streams will be combined and treated in the satellite as follows:

1. Filtration to remove suspended solids;
2. Disposal via a Class I UIC injection well(s).

In addition to the disposal wells, two surge ponds will be installed to assist in the waste water disposal. **Figure 3.36, North Butte Waste Water Treatment Schematic** provides a schematic describing waste water treatment at the North Butte Remote Satellite.

Class I Injection Wells

Cameco has an existing Class I UIC permit for two deep disposal wells. Currently, (January 2012) Cameco is drilling one test well at the North Butte Remote Satellite in preparation for installing the two disposal wells future operations. The North Butte Remote Satellite will ultimately have four Class I UIC wells. The installation of these wells will be staged to be installed as needed for operation and restoration requirements. The proposed location of these wells is shown on **Figure 1.10**. Each disposal well will be equipped with a high-level shutoff switch on the injection tubing to prevent operation of the injection pump at pressures greater than the limiting surface injection pressure. Additionally, each well will be equipped with a low pressure shut-down switch on the surface injection line that will deactivate the injection pump in the event of a surface leak. Finally, each installation will include a high/low pressure shut-down switch with a pressure sensor on the tubing/casing annulus. This switch will stop the injection pump in the event of either a tubing leak or a casing, packer or wellhead leak. This instrumentation and control system will provide the best protection against process waste water spills to the environment by limiting the amount of fluid released and providing immediate indicators of potential well integrity issues.

Back-up for the automatic emergency shut-down systems will include local displays and instrumentation metering in the satellite control room and at the wellhead building. Additionally, inspections of the disposal well systems will be performed once per shift. **Figure 1.10** shows the disposal well equipment layout within the satellite. In addition to the disposal wells, two surge ponds will be installed to assist in the waste water disposal. **Figure 3.36** provides a flow chart for the waste water disposal system and **Figure 3.37, North Butte Disposal Well Building Layout** describes the disposal well building layout.

Surge Ponds

The North Butte Remote Satellite design includes the construction of a surge pond to contain waste water from the satellite facility. The overall pond dimensions will be approximately 85 meters by 104 meters (280 feet by 340 feet) and will be divided into two cells. The cell bottoms will have approximate dimensions of 15 meters by 37 meters (50 feet by 120 feet) and the pond side slopes will be constructed at 3:1. The majority of the pond will be below grade and the second cell will provide redundancy. The pond location is shown on **Figure 1.10**. Pond design details, the geotechnical investigation and final design report are provided in **Appendix D**. Additional information, including operations and maintenance recommendations and closure requirements are included in the same attachment. The ponds will have a double synthetic liner with a leak detection system between the two liners. The upper liner will consist of a 60 mil HDPE liner and the lower liner will consist of 40-mil HDPE. Underlying the lowest synthetic liner will be 1 meter (3 feet) of compacted clay. The leak detection system will consist of a perforated 5 centimeter (2 inch) diameter collection pipe system with a sump (well) as presented on the design drawings (**Appendix D**). The sumps will be monitored every two weeks for the presence of fluid as long as the ponds are in use.

The design of the ponds has met the guidance provided in NRC Regulatory Guide 3.11, "Design, Construction and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" and the standards provided in 10 CFR Part 40, Appendix A, Criterion 5(A). It should be noted that the standards and requirements referenced above apply to tailings impoundments and some of the requirements are not applicable to the design of surge ponds.

Evaluation criteria for selection of the liner system included:

1. The liner material's physical and chemical inertness to the materials to be stored in the ponds;
2. The top liner's physical and chemical inertness to ultra violet exposure; and
3. Method of placement, seaming requirements and puncture resistance.

Surge Pond Probable Maximum Flood Hydrologic Analysis

According to the NRC Regulatory Guide 3.11, "If impoundments are designed to contain only direct precipitation that falls into the reservoir area, a single occurrence of the 6 hour probable maximum precipitation (PMP) may be used to determine storage capacity and freeboard requirements. If the tailings retention system has some external drainage area, and hydraulic structures (such as diversion channels) are needed to safely divert the probable maximum flood (PMF), the peak PMF inflows and runoff used to design such structures should be determined in accordance with the suggested flood design criteria in NUREG-1623, 'Design of Erosion Protection for Long-Term Stabilization'".

The surge pond will be constructed on top of a ridge as shown in **Figure 1.10**. Cameco has allowed for 1.5 meters (5 feet) of freeboard in accordance with the design report and design considerations presented in **Appendix D**. In order to determine whether the surge pond is located at an elevation that is high enough to be protected from the PMF, a model was created routing the PMP through each of the two adjacent drainages. The Hydrometeorological Report No. 55A, entitled "Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian" was released by the National Oceanic and Atmospheric Administration, the Army Corp of Engineers and the US Bureau of Reclamation in 1998. The 6-hour PMP was identified for the North Butte license area as 48.3 centimeters (19 inches).

HydroCAD is a design tool used by hydrologists and civil engineers to model storm water runoff. The model generates hydrographs for individual basin areas and hydrographs are routed downstream through channels and/or reservoirs. Multiple sub-areas can also be modeled within a given watershed model. The HydroCAD model was used to calculate flood flows throughout the North

Butte permit area and was also used to evaluate the hydrology and hydraulics in the vicinity of surge ponds.

The HydroCAD methodology incorporates the Soil Conservation Service curve number calculations into the flood flow predictions. The runoff curve number is an empirical parameter used in hydrologic calculations for predicting direct or infiltration-excess runoff. The runoff curve number is based on hydrologic soil group, land use, surface treatment and hydrologic condition. Two different curve numbers were applied to the North Butte site. A curve number of 76 was used for the upper portions of several of the basins, in particular those that abut the North Butte. These sub-basin areas show areas of visible outcropping or shallow soils on aerial imagery and will accordingly exhibit lower infiltration rates. An average curve number of 70 was used in the lower, downstream sub-basin areas where outcropping was not visible and/or well drained soils are indicated. It should be noted that the calculated discharges do not account for potential flood volume storage within the several stock ponds in the basin. For conservatism, the presence of the stock ponds is not incorporated in the analysis even though, under average conditions, a large amount of abstraction of the run-off would occur as a result.

The drainage to the west of the surge pond (**Figure 1.10**) is the smaller of the two adjacent drainages and has a contributing area of 16 hectares (39 acres). The drainage to the east is significantly larger with a contributing area of 113 hectares (278 acres). **Table 3-10, PMP Hydrologic Analysis** shows the results of the HydroCAD modeling including the calculated flood stage in each of the drainages. **Table 3-10** also lists the approximate topographic relief between each drainage invert and the existing land surface grade at the location of the surge pond. Based on the difference between the existing land surface relief and the calculated PMF flood stage, it is clear that the natural topography will pass the flow associated with a PMP. No diversions will be required. Relief in the East Drainage was estimated from five foot contours created from an aerial flight of the permit area on June 2010. Relief in the area and in particular the West Drainage was estimated from 1-foot contours created from a survey completed by Ladd Engineering Company (November, 2010).

3.6.3.4 Remote Satellite Plant Equipment, Instrumentation and Controls

The North Butte Remote Satellite building will house IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, disposal well equipment, RO units and bioremediation materials for groundwater restoration, a laboratory area, offices, and an employee break room. The IX system consists of ten fixed bed IX vessels. The IX vessels will be operated as four sets of two vessels in series with two vessels available for restoration. WDEQ Figure OP-13 shows the equipment layout for the proposed satellite building. CO_2 and O_2 will be stored in compressed form adjacent to the building or in the mine unit areas. Header house and main trunkline instrumentation and control for the North Butte Remote Satellite are similar to that described in Section 3.6.1.4.

3.6.4 Gas Hills Remote Satellite

3.6.4.1 General Facility Layout

The surface facilities at the Gas Hills Remote Satellite will include the wellheads, header houses, buried pipelines, pump stations, overhead and buried power lines, facilities access roads and the satellite IX buildings, which includes the Carol Shop, designated as the Carol Shop Satellite Building. Mineral processing and water treatment facilities will be located at the Carol Shop Satellite Building (SW1/4, Section 33, T33N, R89W) and Gas Hills Alternative Satellite Building shown on **Figures 1.11** and **1.12**. During production operations, this facility will have a capacity of approximately 51,030 liters/minute (13,500 gallons/minute) for both the Carol Shop (34,020 liters/minute or 9,000 gallons/minute) and

Alternative Satellite (17,010 liters/minute or 4,500 gallons/minute). The final product at the Gas Hills will be loaded IX resin or yellowcake slurry, which will be transported to the Highland CPF. The yellowcake slurry will only be produced at the Carol Shop. The water treatment facilities will include the evaporation ponds, also shown on **Figures 1.11** and **1.12**. The design and details for the evaporation ponds are provided in **Appendix E, Gas Hills Evaporation Pond Design.** Cameco is also evaluating the efficiency of deep disposal injection for the waste water.

Due to the varying elevations of the wellfields and the remote satellite facilities, several injection composite (IC) pump stations, called IC Boosters, will be required. Preliminary engineering work indicates that IC Booster No. 1 will be designed for a peak operating flow of 34,020 liters/minute (9,000 gallons/minute) and provide a pressure increase of 0.76 MPa (110 psig). IC Booster No. 2 will be designed for a peak operating flow of 26,460 liters/minute (7,000 gallons/minute) and provide a pressure increase of 0.41 MPa (60 psig). IC Booster No. 3 will be designed for a peak operating flow of 26,460 liters/minute (7,000 gallons/minute) and provide a pressure increase of 0.41 MPa (60 psig). Preliminary schematics of these booster stations are included as **Figure 3.38, Pump Station No. 1 – Typical Layout** and **Figure 3.39, Pump Station No. 2 and No. 3 – Typical Layout**. The final design of the booster stations, and their actual locations, will be determined during the detailed engineering for each mine unit. Approximate locations of these booster stations are shown on **Figures 1.11** and **1.12**.

Pipeline and power lines will follow access roads whenever possible. Gas Hills WDEQ Permit Plates OP-1E and OP-1W depicts the proposed locations of main and secondary access roads. Additional detail and wellfield access roads for Mine Unit No.1 are shown on **Figures 3.16** and **3.17**. Pipelines within the mine unit wellfields and from the header house to the main collection and distribution lines will typically be 20 centimeter (8 inch) in diameter or smaller. The main collection and distribution pipelines will typically be up to 61 centimeter (24 inch) in diameter. The main pipeline corridor will house up to eight lines to facilitate water handling, treatment, recycling, and groundwater restoration.

3.6.4.2 Uranium Recovery Process

Ion Exchange/Lixiviant Makeup Circuit

The IX/lixiviant makeup circuit for the Gas Hills Remote Satellite is described in Section 3.6.1.2, except that the uranium-bearing solution is piped to the Carol Shop or Alternative Gas Hills Remote Satellites.

Resin Loading/Elution Circuit

The resin loading/elution circuit will be the same as described above for the Smith Ranch satellites and the North Butte Remote Satellite.

Precipitation Circuit

The rich eluate containing the uranium will be routed to tankage for temporary storage ahead of the batch or continuous precipitation circuit. To initiate the precipitation cycle, hydrochloric or sulfuric acid will be added to the uranium bearing solution to convert the uranyl carbonate present in the solution to uranyl chloride or uranyl sulfate, both soluble species for precipitation. Hydrogen peroxide and sodium hydroxide will then be added to the acidified eluate to effect precipitation of the uranium as uranyl peroxide or sodium diuranate. The addition of hydrogen peroxide lowers the pH of the solution, and to optimize crystal growth and settling, sodium hydroxide is added as a pH adjustment. The uranium precipitate will then be allowed to settle. The uranium depleted supernate solution is removed and stored for re-use in future elutions as lean eluate or disposed via evaporation ponds or deep well injection. Sodium chloride and sodium carbonate will be added to the lean eluate as needed for reconstitution.

Precipitate Dewatering, Filtration and Transport

The resulting slurry from the elution/precipitation circuit will be transferred to a storage vessel allowing the uranium to continue to precipitate and consolidate by gravity. The precipitated and thickened yellowcake slurry will be sent to a filter press for washing to remove soluble contaminates and then de-watering prior to packaging. The dewatered yellowcake slurry product will be placed into DOT approved containers and transported to the Highland CPF in exclusive-use, DOT authorized transport vehicles.

3.6.4.3 Waste Water Management

There will be four primary process waste water streams for Gas Hills that are similar to other Smith Ranch SUA-1548 Project satellites. All of these waste streams will be combined and treated in the Carol Shop satellite as follows:

1. Filtration to remove suspended solids;
2. Volume reduction using reverse osmosis, ultra-filtration, nano-filtration, elecrodialysis reversal, thermal concentration, and/or a combination of the above methods to reduce the volume as needed;
3. Solar evaporation of the reject concentrated fluid in evaporation ponds, which may include limited evaporation sprayers or forced evaporation and crystallization (FE) of the solids in solution; and
4. Reinjection of reject concentrated fluid via a deep disposal well (pending permit approval).

Evaporation Ponds

As previously described, the Carol Shop Satellite Building will provide the final water treatment facilities for the Project. The two evaporation ponds, shown on **Figure 1.11** will be constructed for the disposal of bleed and process fluids during the first phase of development. The design and technical specifications, geotechnical engineering study, operations and maintenance plan and closure plan for Ponds 1 and 2 are provided in **Appendix E. Figure 1.11** shows the locations of four additional evaporation ponds, but the evaporation pond design has not been completed for Ponds 3, 4, 5 and 6. Cameco intends to use deep disposal well technology as the primary means of wastewater disposal. Cameco will be drilling two test holes (2012)to evaluate the efficacy of deep disposal wells at the Gas Hills Remote Satellite. If these wells are successful, Cameco may not construct Ponds 3, 4, 5 and 6. If construction is proposed, detailed designs of these facilities will be presented to the NRC in advance of construction.

The water treatment plan allows for sufficient capacity to store all of the waste fluids described above. The ponds have been designed with additional freeboard capacity, above the designed operating levels, such that each pond has sufficient capacity to hold the combined anticipated operating volume of both ponds. This is necessary to allow evacuation of one pond into another in the event that a pond requires servicing. The pond capacity will allow for inventory increases from the waste streams and for precipitation, and decreases due to solar evaporation. Pond design will isolate ponds from surface water input.

Ponds 1 and 2 will have an active surface area of approximately 2 hectares (5 acres). The combined storage capacity of the evaporation ponds is approximately 3 hectare-meters (22 acre-feet), with a normal operating freeboard of 1.5 meters (5 feet).

Design of Evaporation Ponds

The basic design criteria for the evaporation ponds will comply with the standards provided in 40 CFR 264.221 and will, as a minimum, include the following:

1. Excavated materials from the pond will be utilized to construct berms which will isolate the ponds from the surrounding surface drainage and increase the pond capacity to provide for freeboard and storage of additional direct precipitation.
2. The ponds will have a primary synthetic liner consisting of a AGRU HDPE Drain Liner™, or equivalent, with a typical thickness of 60 mils. This type of geomembrane is produced with a series of studs on one side. The studs have a typical asperity height of 3.69 millimeters (145 mils). The studs provide a gap between the primary and secondary geomembrane resulting in in a geosynthetic drainage layer.
3. Underlying the primary HDPE Drain Liner™, will be a secondary liner of 30 mil Polyvinyl Chloride (PVC), or an equivalent material. Together, the primary and secondary liners provide a synthetic porous media for the leak detection system. Under a confining load of 718 kPa (15,000 psf), manufacturer testing indicates a transmissivity of this layer ranges from 2E-3 to 1E-2 m^2/sec. The expected load for the liner is 24 kPa(500 psf), and the transmissivity of the system should far exceed 3E-4 m^2/sec or greater specified under 40 CFR 264.221(c) (2)(ii). A piping network consisting of perforated drain pipes will be constructed between the primary and secondary liners. The perforated piping will connect to a solid conveyance line and ultimately to a leak detection well where fluid can be collected and sampled. Each pond will have two perforated drain pipes and two leak detection wells.
4. The leak detection piping will be installed at a nominal 0.5% grade and will gravity flow to the leak detection well. The bottom of each pond will be sloped at a minimum of 1% grade to the leak detection piping.
5. To minimize the migration of pond fluids into the subsurface should the secondary liner leak, the underlying surface of the pond will be constructed with at least three feet of compacted soil material having an hydraulic conductivity of no more than 1E-7 cm/sec (4E-8 in/sec).
6. The leak detection system will be constructed of materials that are chemically resistant to the pond fluids, and of sufficient strength and thickness to prevent collapse under the pressure exerted by the overlying fluids.

Design Capacity

The two evaporation ponds are designed with sufficient capacity such that one pond can contain the combined maximum operating capacity of both ponds and allow for a minimum emergency freeboard of 0.5 meters (1.6 feet). The Gas Hills Remote Satellite water balance (see **Table 3-11, Gas Hills Water Balance)** details the production schedule and pond water accumulation estimates. Forced Evaporation (FE) equipment equivalent to 245,000 meters^3 (199 acre-feet) per year of disposal capacity will be added at the beginning of operational Year 5. Beginning in operational Year 7, an additional equivalent of 245,000 meters^3 (199 acre-feet) of disposal capacity will be added by the installation of additional FE equipment. As additional disposal capacity is required, Cameco will prepare and submit final pond designs and/or information pertaining to the deep disposal wells well in advance of the demand for this evaporation capacity.

Forced evaporation and crystallization (FE) is a process that has been used for many years at power plants across the country to treat and recycle saturated waste waters utilizing a distillation and crystallization process. The evaporator system heats the waste water feed to the boiling point. The steam is then allowed to cool resulting in a condensate of distilled water. The waste brine generated by the evaporator is transferred to the crystallizer where it is heated to drive off residual moisture and reducing it to a dry solid which can be removed and stored for disposal as solid waste.

Evaporation Ponds 1 and 2 have been designed to operate during normal operations with a storage capacity of 13,500 meters^3 (11 acre-feet) per pond or a combined capacity of 27, 000 meters^3 (22 acre-feet). The approximate total capacity of each pond is 32,070 meters^3 (26 acre-feet) and the combined approximate capacity is 64,140 meters^3 (52 acre-feet). Allowing for a 0.6 meter (2 feet) maximum freeboard, the available storage capacity for each pond is approximately 49,340 meters^3 (20 acre-feet) with a combined capacity of 49,340 meters^3 (40 acre-feet). This additional capacity will provide freeboard based on wind and wave action and storage in the event of a high intensity precipitation event. It will also provide for the evacuation of the contents of one pond into the other in the event that a pond is taken out of service for repairs and/or removal of solids.

The maximum cumulative project storage requirements are projected to be when Mine Unit No. 2 begins active restoration. The additional ponds or deep disposal wells will be constructed earlier than needed to provide surge capacity for planned maintenance of water treatment equipment and other unforeseen operational problems. The proposed operation of the ponds would provide redundancy in the case of a liner leak. Pond 1 or 2, operating at the normal operational level, would have sufficient storage capacity for the contents of both ponds. The ponds are designed for the worst case scenario of a leak at the lowest point of the liner in one pond, requiring total evacuation of one pond into the other. The normal operational capacity for one pond is approximately 13,500 meters^3 (11 acre-feet). In the event of a leak, one pond will hold approximately 27,140 meters^3 (22 acre-feet) required to hold the contents of both ponds with sufficient freeboard capacity (under normal wind conditions).

Freeboard capacity is based on estimated wave height and direct precipitation as follows (English units were maintained for consistency with cited reference):

1. Wave Height: A site specific comparison of wind data to the regional NOAA reporting stations. Based on this comparison, the long term wind data for Casper, Wyoming, Natrona County Airport is the most representative source of long term wind data. The data shows that peak average monthly wind speeds occur during the months of December and January averaging approximately 21 miles/hour. If the ponds were full, the maximum fetch (the diagonal measurement of the ponds), is approximately 113 meters (370 feet) or 0.1 kilometers (0.07 mile). Based on these conditions, the significant wave height calculates (after Linsley and Franzin, 1992) as:

   Wave Height = (0.034) wind velocity (21.2 miles/hour)$^{1.06}$

   Fetch (0.07 mile)$^{0.47}$ = 0.08 meters (0.25 feet).

If the same calculation were made for wind at 97 kilometers/hour (60 miles/hour), or three times the average, the resultant wave height would be 0.23 meters (0.75 feet).

2. Direct Precipitation: The 6-hour probable maximum precipitation event (PMP) is estimated at 30 centimeters (12 inches) of rainfall. The maximum pond surface area is approximately 0.8 hectare (2 acres). Thus, a PMP event would add approximately 2,500 meters^3 (2 acre-feet) of water to the pond. The addition of 2,500 meters^3 (2 acre-feet) of water from a PMP storm would result in an increase in water level of approximately 0.3 meters (1 feet).

In summary, the combination of design freeboard, direct precipitation and wave action, would require a minimum freeboard of approximately 0.5 meters (1.6 feet) for average wind speeds and approximately 0.6 meters (2 feet) with winds at 97 kilometers/hour (60 miles/hour). The combination of events necessary for the ponds to reach the emergency freeboard would include: both ponds operating at maximum capacity; the occurrence of a PMP rainfall event; and simultaneous winds in excess of 97 kilometers/hour (60 miles/hour). Since this combination of events is very unlikely, and there is a small effective fetch length for the build-up of wind, the design capacity provides an adequate margin of safety with respect to storage capacity and wave action.

To divert surface runoff away from the evaporation ponds, which could create the potential for overtopping and erosion of the ponds, several drainage diversion ditches, one drainage control berm, and a modification to the Carol Shop Road have been incorporated into the design. The design addresses the diversion of surface water runoff away from the evaporation ponds as discussed later in this TR.

Dam Stability Analysis

The State of Wyoming Safety of Dam Regulations apply to dams with either impoundment structures in excess of 7.6 meters (25 feet) in height or capacities in excess of 62,000 $meters^3$ (50 acre-feet). The proposed ponds will have above grade embankment heights less than 7.6 meters (25 feet and individual operating capacities less than 62,000 $meters^3$ (50 acre-feet), and will therefore be exempt from the Safety of Dams Regulations.

A stability analysis for Ponds 1 and 2, in accordance with Regulatory Guide 3.11, Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills, is provided in **Appendix E**. According to the analysis, the pond slopes, both interior and exterior, will be stable in the post-construction condition and the steady-state seepage condition.

Construction Methods

During construction, site inspection quality control testing will be completed under the direction of a professional engineer registered in the State of Wyoming and experienced in similar construction requirements and/or methods. Construction and testing methods will adhere to the most recent version of ASTM procedures and/or manufacturer's recommendations. Technical specifications for the construction of the ponds are provided in **Appendix E**. Synthetic liner specifications, including installation details, seaming details, anchoring procedures, and QA/QC Procedures, will be submitted to LQD for review prior to pond construction. The basic construction sequence will be in accordance with WQD Rules & Regulations Chapter 11, Part C.

The design of all of the ponds incorporates a local balance of earthwork cut and fills for each pair of ponds. Available topsoil will be salvaged and stockpiled locally. . Approximately 6,650 $meters^3$ (8,700 $yards^3$) of excess material will be generated during the construction of the two ponds. During reclamation, the berm material will be used as backfill to restore the ponds to approximately their original contours and stockpiled topsoil will be replaced.

Prior to the evaporation pond design, 13 exploratory borings were drilled in the proposed location of the ponds. The depth of the borings ranged from approximately 5 to 11 meters (15 to 37 feet) below grade. Shallow groundwater was not encountered in any boring. Samples were collected to determine in-place density, size gradation, Atterberg limits, soils classification, presence or absence of shallow groundwater, and moisture density relationships. The geotechnical engineering study is provided in **Appendix E**.

Inspection and Maintenance

The evaporation ponds will be visually inspected on a daily basis to insure that the system is operating normally. Visual inspections will also include a general inspection of the condition of all ancillary features including the exposed liner above the water surface, the berm, fences and any diversion and/or storm runoff control measures. In addition, the leak detection manhole will be visually inspected daily and the sump pump tested at least once every two weeks. These inspections will be documented and maintained on site. If at any time flow from the leak detection sump pump is observed, a water sample will be collected and analyzed for chloride, bicarbonate and conductivity. Should the analysis indicate that a pond is leaking, a verification sample will be collected within 24 hours of receipt of the first analysis results. If the analytical results of the verification sample verify that the pond is leaking, the NRC and LQD will be notified by telephone within 24 hours of verification. Within 5 days of the verbal notification, a written report will be submitted to NRC and LQD. The report will include analytical data and describe mitigative actions and the results of those actions. Once every seven days during the leak and for two weeks following completion of repairs, water samples will be collected from the leak detection sump and analyzed for chloride and conductivity. Additionally, once per month while the pond is leaking, water samples will be collected from the leak detection sump and analyzed for the suite of parameters contained in LQD Guideline 8, Appendix 1.

Once a leak has been verified and reported, the contents of the leaking pond will be transferred into another pond or ponds, and an investigation will be conducted to determine the source of the leak. This investigation will include inspection of the manhole and individual drain line clean out systems. When the source of the leak has been identified, appropriate actions will be taken to repair any damage to the system.

Once the pond liner has been repaired and tested, the agencies will be notified verbally or in writing (via a letter or e-mail) that the pond has been repaired and is being put back into service. A final report describing all remedial and repair activities will be provided to the agencies within 60 days after repairs have been completed.

Diversion Hydrology

The design addresses the diversion of surface water runoff away from the evaporation ponds. NRC Regulatory Guide 3.11recommends that "there shall be no release of process solids or fluids from the evaporation ponds. To address this guidance, the NRC recommended that the designed diversion structures accommodate the PMP event. The PMP is considered the most severe rainfall event probable and is defined by the World Meteorological Organization as "theoretically the greatest depth of precipitation for a given duration that is physically possible over a given storm size area at a particular geographic location."

Since the life of the evaporation pond structures will be less than 30 years, the PMP design is extremely conservative. Cameco has committed to an active monitoring and routine inspection program for all hydrologic and storm water control structures. If damage were to occur to any hydrologic structure, Cameco would repair that structure as part of their ongoing maintenance program.

The design objective is to ensure that there is minimal erosion to the diversion channel or the evaporation pond berms. Channel flow velocities during the passage of the probable maximum flood (PMF) will range from 1.3 to 2.7 meters/second (4.3 to 8.9 feet/second). No riprap protection is proposed or required. Although the PMF velocities could exceed the typical non-erosive velocities of 1.5 m/sec (5 feet/second) or less, the highest channel velocities will occur within the "cut" portion of the diversion channel. The adjacent diversion channel berm will provide PMF freeboard. The evaporation pond process fluids will be isolated from the concentrated flow of the storm by the (1) "cut" diversion channel; (2) diversion channel "compacted" berm; and (3) "compacted" evaporation pond berm. The higher velocity channel flows will not impact the evaporation pond berm. A final design consideration recognizes that the duration of the PMF will be relatively short, and repair of these diversion structures will be performed as soon as practicable following the passage of the PMF or any erosion-causing event.

Seven PMF drainages have been shown on the **Figure 3.40, PMF Diversions and Evaporation Ponds**. Six of these drainages will require actual construction of a channel diversion or ditch. The general location of these proposed structures is shown on **Figure 3.40**. Design details as well as hydrologic and hydraulic computations are also shown on **Figure 3.40**. The complete drainage basin boundaries for all seven basins can be found on **Figure 3.40**. The magnitude of the 1 hour PMP was determined using methods described in Hydrometeorological Report No. 55A (HMR-55A) (Hansen, et al., 1988) and is estimated to be 23 centimeters (8.9 inches).

PMP runoff hydrology for small basins (those less than 40 hectares or 100 acres) was determined using the Rational Method:

Where:

Q	= PMF peak discharge in cubic feet per second
C	= 1.0
i	= PMP intensity in inches per hour
A	= Drainage basin area in acres

The runoff coefficient, C, was assumed to be 1.0, suggesting that there will be no infiltration of rainfall. Smith Ranch WDEQ Permit Addendum OP-1 presents the rainfall intensity curve applicable to the Rational Method calculations for Basins B-1, B-2, B-4, B-5, B-6, and B-7.

Site Location: Gas Hills, Wyoming
Average Site Elevation = 6,800 ft AMSL
Max 12-hr Dew Point = 24 degrees Celsius (75.2 degrees Fahrenheit)

Drainage Basin Size:

Basin 1 =	7.9 hectares (19.5 acres)	$Q_{(pmf)}$ =	15 meters^{3}second (520 feet^3/second)
Basin 2 =	37.0 hectares (91.5 acres)	$Q_{(pmf)}$ =	60 meters^{3}second (2,125 feet^3/second)
Basin 3 =	613.1 hectares (1,515 acres)	$Q_{(pmf)}$ =	361meters^{3}second (12,750 feet^3/second)
Basin 4 =	7.5 hectares (18.5 acres)	$Q_{(pmf)}$ =	17 meters^{3}second (590 feet^3/second)
Basin 6 =	8.5 hectares (21.1 acres)	$Q_{(pmf)}$ =	18 meters^{3}second (645 feet^3/second)
Basin 7 =	16.7 hectares (41.2 acres)	$Q_{(pmf)}$ =	33 meters^{3}second (1,155 feet^3/second)

PMP runoff hydrology for Basin 3 (613.1 hectares) was determined using the USACE Runoff Hydrology computer package (HEC1). To estimate the peak flow associated with the PMP event, a storm distribution was required for the HEC-1 analysis. The Soil Conservation Service (SCS) Type II rainfall distribution was utilized for the 6-hour PMP rainfall. A Curve Number of 87.6 was used to describe the runoff characteristics of this well-vegetated native basin. **Appendix F, Gas Hills Drainage Basin Hydrology (HEC-1 Input/Output)** presents the HEC-1 input and output file and the hydrologic computations for Basin B-3.

Basin 1 generates and delivers water to drainage diversion DD-1. Although this basin exhibits no well-defined drainage, water from this slope could impact the berms around Evaporation Ponds 1 and 2. DD-1 is designed to capture and pass the PMF around the constructed evaporation ponds.

Basin 2 generates and delivers water to drainage diversion DD-2, which ultimately delivers runoff to West Canyon Creek (WCC). This is a relatively large (37 hectares or 180 acres) drainage area and is characterized by a well-defined ephemeral drainage. The PMF design incorporates construction of a large trapezoidal channel and an adjacent berm to ensure that the PMF does not negatively impact Evaporation Ponds 1 and 2.

There are several existing gullies that will intersect the new DD-1 and DD-2. In some cases, these existing gullies may intersect at sharp angles. Cameco will transition all existing gullies into the diversion channel to reduce erosion during the more frequently occurring runoff events. In a similar manner, Cameco will transition all diversion channels into their receiving waters to ensure a smooth hydraulic entrance condition with minimal adverse impact to the receiving waters.

Basin 3 generates and delivers water to WCC, which is a native intermittent stream in the general area of the project. Cameco does not propose to divert or reroute WCC. Where the Carol Shop Road crosses WCC, Cameco has replaced existing culverts with new culverts, which are designed to convey the 25-year, 6-hour storm event. To ensure that (1) WCC meets the above-described PMF design criteria and (2) the Carol Shop Road will not act as a dam and divert WCC flow into the adjacent Evaporation Pond 1 and 2 Basins (Basin B-2), Cameco proposes to lower the Carol Shop Road in accordance with the plan presented on **Figure 3.40**. The constructed weir-geometry will ensure that the entire PMF will remain within the WCC basin and not adversely impact Evaporation Ponds 1 and 2.

In the event that Evaporation Ponds 3, 4, 5 and 6 are constructed, Cameco has conducted a second analysis to ensure that the waters of WCC will not adversely impact Evaporation Ponds 3, 4, 5 and 6. In accordance with Cameco design, the reconstructed Carol Shop Road will initially act as a dam; later will act as an outflow weir; and finally will probably fail during the course of the PMF. The worst case condition for WCC is during the period when the road is acting as a weir and the water surface elevation for the PMF is at its highest. Based on Cameco calculations ($Q = CLH^{3/2}$), the water surface elevation for the PMF at the Carol Shop Road is 2,062 meters (6,765 feet) above mean sea level (AMSL). The toe of the embankment of the closest evaporation pond (northwest corner of Evaporation Pond 3) is 2,068 meters (6,785 feet) AMSL. The toe of the evaporation pond slope is 6.1 meters (20.1 feet) above the PMF water surface elevation. Since the evaporation ponds are adequately isolated from WCC, no diversion of WCC and no armor protection of the evaporation ponds is required.

Basins 4, 5, and 6 are small basins adjacent to Evaporation Ponds 3, 4, 5 and 6. Although these basins do not exhibit well-defined drainages, water from their adjacent basin slopes could impact the berms around Evaporation Ponds 3 through 6. DD-4, DD-5 and DD-6 are designed to capture and pass the PMF around the constructed evaporation ponds.

There are several existing gullies that will intersect these diversion ditches. Cameco will transition all existing gullies into each diversion channel to ensure that there will be minimal erosion during the more frequently occurring runoff events. In a similar manner, Cameco will transition all diversion channels into their receiving waters to ensure a smooth hydraulic entrance condition with minimal adverse impact to the receiving waters.

Basin 7 originates from reclaimed ground to the south of the evaporation ponds. Diversion 7 (DD-7) collects the PMF from this basin and delivers it to an incised gully to the east of Evaporation Pond 6. The construction of DD-7 fully protects the embankment of the evaporation ponds from the PMF.

The pipelines leading from the wastewater treatment facility to the evaporation ponds will be buried a minimum of 5 feet bgs to protect from freezing. To protect the pipeline crossing West Canyon Creek from channel scour damage, the crossing portion of the creek will be protected with appropriately sized riprap or the pipe will be run through an appropriately sized carrier pipe which will be encased in concrete. Riprap will be sized to accommodate flows associated with the PMF without damage.

Estimated Quantity of Evaporation Pond Water and Content of Evaporation Solids

Using the estimated Gas Hills lixiviant concentration in Section 3.5.3.1, the Water Balance and Evaporation Pond fluid Inventory (**Table 3-11**) as input data, the amount of TDS in the water was estimated using the reverse osmosis manufacturer's (Hydraunautics, Inc.) design program. The estimate assumes that all of the TDS contained in the treatment reject fluid would become a solid needing to be disposed of offsite. The solids formed by the water treatment process will consist of salts of sodium and calcium dominated by carbonate and sulfate. Radium is expected to be the predominant radionuclide. The TDS concentration of the water treatment concentrate is anticipated to range from a high of 25,000 mg/L to a low of 3,500 mg/L, with an average concentration of 9,500 mg/L.

The high TDS water resulting from waste water treatment will be sent exclusively to the ponds only during Years 1 through 4. At Year 5 and again at Year 6, forced evaporation/crystallization (FE) equipment will be installed which will essentially treat the waste stream to distilled water quality. At that time the use of the ponds will shift from complete evaporation to surge capacity to provide for in-plant consumption and restoration water makeup as well as excess water disposal capacity for unanticipated operational upsets and equipment problems. The excess volume of treated water that will not be needed for in-plant consumption will be used for restoration water makeup, mine unit hydrologic control, or will be stored in the ponds. The FE process will remove all of the TDS from the waste water stream at the treatment facility where it will be stored and periodically transported to and disposed as an 11e2 byproduct material at an NRC licensed disposal facility. The solid residue in the ponds resulting from liquid evaporation over the life of the Project will be equivalent to approximately 1.0% of the total working pond volume and will not affect the total pond capacity over the life of the Gas Hills Remote Satellite operations. The water balance (see Section 3.9.3) for the Gas Hills Remote Satellite accounts for the anticipated volume of sludge to be generated over the project life.

Class I Injection Wells

Cameco is investigating the feasibility of a mine wastewater disposal Class I injection well or multiple wells at the Gas Hills site as a disposal supplement to the planned evaporation ponds. If technically feasible, Cameco plans to add wastewater disposal via injection well(s) because (a) injection wells are less costly to operate and reclaim, and (b) there are fewer environmental concerns as compared to evaporation ponds. Use of injection wells disposes of concentrated process reject fluids underground, thereby eliminating the surface contamination concerns associated with evaporation ponds and greatly reducing the volume of 11e2 material that will require over–road hauling to distant permitted disposal facilities.

Cameco has already completed a preliminary geologic siting study that identified three candidate test injection well locations (see **Figures 1.11** and **1.12**). Based on a preliminary review of the currently available site groundwater quality and geologic data, WQD staff agreed that further site well testing and a UIC permit application for this site seem feasible. Two of the sites will be drilled in late 2011 or early 2012.

The feasibility of the injection well option is dependent upon favorable injectivity tests, groundwater quality of the receiving formation meeting the requirements for a Class I injection well, and approval of a WDEQ WQD UIC Class I injection permit. If down-hole testing of the initial test well(s) indicates that the well is suitable for injection, Cameco will proceed with preparation of a UIC permit application. Upon approval of the UIC permit, Cameco will provide a copy of the UIC permit and application to the regulatory agencies. Cameco will obtain the permits from BLM and WSEO necessary to operate the proposed injection wells for wastewater disposal.

3.6.4.4 Remote Satellite Plant Equipment, Instrumentation and Controls

Carol Shop Remote Satellite Building

The Carol Shop Remote Satellite building will house IX columns, water treatment equipment, resin transfer facilities, yellowcake slurry facilities, pumps for injection of lixiviant, disposal well equipment, RO units and bioremediation materials for groundwater restoration, a laboratory area, offices, and an employee break room. The IX system consists of 12 fixed bed IX vessels. The IX vessels will be operated as six sets of two vessels in series with two vessels available for restoration. Gas Hills WDEQ Permit Figure OP3-2 shows the equipment layout for the Carol Shop satellite building. Gas Hills WDEQ Permit Table OP-3-1 Typical Tank Designations provides the Carol Shop satellite tank designations and sizes. CO_2 and O_2 will be stored in compressed form adjacent to the building or in the mine unit areas.

The Carol Shop building is approximately 5,094 m^2 (56,985 ft^2), but only a portion of the building will be utilized for the ISR operations. Cameco is completing the final engineering design for the Carol Shop and **Figure 3.2, Carol Shop Floor Plan** does not show the locations of the ancillary features (e.g., offices, employee breakroom, and so on) in the Carol Shop building. The Carol Shop Remote Satellite will be designed to operate with a maximum flow of 35,910 liters/minute (9,500 gallons/minute) during operations, and will include a central water treatment facility that can be expanded, as needed, to a capacity of approximately 4,536 to 5,670 liters/minute (1,200 to 1,500 gallons/minute) for treating production and restoration waste water prior to its disposal. The alternative remote satellite building may not be built and the Carol Shop design includes the capacity to operate with a maximum flow of 51,030 liters/minute (13,500 gallons/minute).

Alternative Remote Satellite Building

An Alternative Remote Satellite facility will be installed as a IX, resin loading and unloading facility, and future restoration RO at one of the two locations shown on Plate OP-1W. Bleed and restoration reject fluids from the associated wellfields will be transferred through pipelines to the central water treatment facility at the Carol Shop for treatment and disposal. The satellite will have an installed flow capacity of approximately 17,010 liters/minute (4,500 gallons/minute) of produced fluids. The layout for the Alternative Remote Satellite building is shown on **Figure 3.3**.

Header house and main trunkline instrumentation and control for the Gas Hills Remote Satellite will be similar to that described in Section 3.6.1.4.

Monitoring at booster pump stations will be very similar to header house monitoring. Each station will have leak proof floors and/or basements equipped with sumps and sump pumps. Each booster pump will have the capability of being remotely monitored running/not running, flow, pressure, temperature, voltage, and phase balance. Additionally, each pump will have the capability of being started and stopped remotely as well as remote flow adjustment.

3.6.5 Ruth Remote Satellite

3.6.5.1 General Facility Layout

The Ruth Remote Satellite is located about 10 kilometers (6 miles) east of Linch, in T42N, R77W (Johnson County) and consists of portions of Sections 1, 3, 14, 23, 24 and 26. The Ruth site has approximately 572 hectares (1,414 acres). As previously mentioned, all existing facilities at the Ruth Project are non-operational and on stand-by status. Currently, three buildings, two evaporation ponds and three monitoring wells are all that remain on the property. Cameco has plans to extract uranium at Ruth within the next ten years, but an operations plan that details the mine field layout, elution circuit and other details has yet to be developed. In general, the Ruth Remote Satellite will operate similar to the North Butte Remote Satellite, but the process flow rate will be lower at 3,780 liters/minute (1,000 gallons/minute).

3.7 Access Roads

3.7.1 Primary Access Roads

3.7.1.1 Smith Ranch

Smith Ranch is located in the southern Powder River Basin in Converse County. The main office complex and CPP is approximately 27 air kilometers (17 air miles) or 35 road kilometers (22 road miles) northeast of the town of Glenrock and approximately 37 air kilometers (23 air miles) or approximately 40 road kilometers (25 road miles) northwest of Douglas. Access to the site from the intersection of State Highway 93 and State Highway 95 is by Converse County Road 31, also known as the Ross Road. The Reynolds Ranch satellite is accessed via Ross Road. **Figure 1.3** shows the general project location and access to the mining area.

3.7.1.2 North Butte Remote Satellite

The North Butte Remote Satellite can be accessed from State Highway 50 near Savageton. From Highway 50, travel is west and south on Van Buggenum Road, then Christensen Road (approximately 10 kilometers or 6 miles) to an existing oil field road owned by T-Chair Ranch. There will be two main access routes to the site that will utilize the T-Chair Road. To access the site from the northeast side of the permit boundary, travel along the T-Chair Road for approximately 2.1 kilometers (1.3 miles). At that point turn north onto a graveled CBM road and travel approximately 1.2 kilometers (0.75 miles) and turn west onto the Project Access Road. This road begins at a point located in the NE1/4, NE1/4 of Section 19, T44N, R76W. This access road will be a combination of existing and new roadway that will cover a distance of approximately 3 kilometers (2 miles) to the proposed satellite IX facility. This access road is an existing road built by Cleveland-Cliffs during the initial development of the North Butte orebody. Cameco plans to upgrade this road, which is all within the permit boundary.

The proposed access roads are shown on **Figure 1.10**. Tetra Tech, Inc. has recently completed road designs to upgrade the access roads at the North Butte Remote Satellite. The design documents and easement descriptions are provided in **Appendix G, North Butte Road Design**. Cameco will rehabilitate the existing roads by upgrading the level of service (top width, surfacing and grading). A 6.1 meter (20 feet) top width will be provided with approximately 7.6 to 15.2 centimeter (3 to 6 inches) of crushed gravel or scoria placed on the road surface. The design has included hydraulic investigations to verify the capacity and condition of existing culverts in the road and to provide miscellaneous drainage. The upgrading and new construction of the access roads will comply with the landowner's desires, as provided in letters to Cameco and LQD. New sections of road will be constructed by blading the top 7.6 to 15.2 centimeters (3 to 6 inches) of soil to each side of the road and constructing a drain ditch on each side with the topsoil windrowed to the outside of each drain. The windrowed topsoil from the construction of the road and the drain will be placed in the bottom of the drain and seeded. The typical road construction standard is presented on **Figure 3.35**. Where BMPs or alternate sediment control measures (ASCM) are required to ensure that no topsoil is lost, Cameco will commit to their implementation (see Section 3.8).

3.7.1.3 Gas Hills Remote Satellite

Primary access to the Gas Hills Remote Satellite can be either from Casper or Riverton. From Casper, access is via 80 kilometers (50 miles) of paved highway on US 20/26 to Waltman, thence 40 kilometers (25 miles) southwest on unpaved, graded Natrona County Road 321 (also called the Gas Hills Road) to the Fremont County line. From the county line, the gravel road turns private and is locally called Dry Creek Road. Approximately 5 kilometers (3 miles) west of the county line, an unimproved dirt road, locally called the AML Road, turns south for approximately 6 kilometers (4 miles) and ends at the Carol Shop Road, a haul road used by previous conventional mine operators in the area. The Carol Shop Road leads to the Carol Shop complex and provides access to the majority of the site.

From Riverton, access is via 64 kilometers (40 miles) of paved highway on Wyoming State Highway 136 which ends at the Dry Creek Road. Approximately 6 kilometers (4 miles) east of the Highway 136 intersection is the AML Road which leads to the Carol Shop Road and the Project site.

A right-of-way (ROW) for the portion of the Dry Creek Road in the vicinity of the Project is held by Umetco Minerals. A portion of the road also crosses land owned by Philp Sheep Co. The road has been utilized for public access to the area for many years. Use agreements for the Dry Creek Road have been obtained from Umetco Minerals and Philp Sheep Co.

The AML Road (see **Figure 1.11**) was constructed by the WDEQ/AML program in 1989 to provide access to reclamation projects within and adjacent to the Project site. The road crosses land owned by Philp Sheep Co. and the US Government (i.e., BLM). A use agreement has been obtained from Philp Sheep Co. for that portion of the road that crosses their property. Prior to Project construction, Cameco will obtain a ROW from BLM for the portion of the AML Road administered by them, in accordance with 43 CFR 2800. Cameco will accept the maintenance and reclamation responsibility for that portion of the AML Road Cameco wishes to use as primary access to the site.

The AML Road and the portion of the Dry Creek Road that will be used for primary access will be upgraded with culverts and gravel surface prior to facilities construction, including proposed road realignments to allow for pond construction. Road upgrades will be in accordance with Fremont County and BLM standards (BLM Manual 9113-Roads and the BLM Gold Book). The upgraded roads will be approximately 7 meters (24 feet) in width and will be graded, drained, surfaced and capable of carrying highway loads. Professional engineering design and construction oversight will be utilized as necessary. Plans and designs for the upgrades will be submitted to LQD, BLM and Fremont County for review prior to commencement of road construction. As defined below, the BLM designation for these two access roads and the Carol Shop Road is "Local".

BLM classifies roads into two broad categories (The Gold Book, 2007). Non-constructed roads are "primitive" two-track roads or overland route corridors that have no graded or drained surfaces and are typically limited to four wheel drive or high clearance vehicles. They can consist of existing or new roads with minor or moderate grading; two-track roads created by direct vehicle use with little or no grading; overland routes within a defined travel corridor leaving no defined roadway beyond crushed vegetation; or any combination of the above. They should not be flat-bladed, and drainage must be maintained to avoid erosion or the creation of a muddy, braided road. They are not intended for use as all-weather access roads. Any damage to the surface, such as mud-holes, ruts or washouts must be repaired as soon as possible by grading and/or placement of road base or gravel fill material. Monitor well ring access roads and access roads from mine unit header houses to individual wells fit into this road category.

Constructed roads consist of three basic road types based on several criteria, including expected traffic volume, seasonal or year-round use, soil types, rainfall, topography and construction.

Resource roads are low-volume, single lane roads. They normally have a 3 to 4 meters (12 to 14 feet) travelway, "intervisible turnouts", as appropriate, where approaching drivers have a clear view of the section of road between the two turnouts and can pull off to the side to let the approaching driver pass. They are generally used for dry weather, but may be surfaced, drained, and maintained for all-weather use. These roads connect facilities to collector, local, or other higher-class roads. They serve low average daily traffic (ADT) and are located on the basis of the specific resource activity need rather than travel efficiency. Secondary access roads (from primary access roads to header houses) fit into this road category.

Local roads may be single-lane or double-lane with travelways 3 to 7 meters (12 to 24 feet) in width and intervisible turnouts. They are normally graded, drained, and surfaced and are capable of carrying highway loads. These roads provide access to large areas and are for various uses. They collect traffic from resource roads or facilities and are connected to collector roads or public highways. The location and standards for these roads are based on both long-term needs and travel efficiency. Primary access roads (eg., Dry Creek Road, AML Road, and Carol Shop Road) fit into this road category.

Collector roads are usually double-lane, graded, drained and surfaced, with a 6 to 7 meters (20 to 24 feet) travelway. They serve large land areas and are the major access route into development areas with high average daily traffic rates. They usually connect with public highways or other arterials to form an integrated network of primary travel routes. Natrona County Road 321 fits into this road category.

Inberg-Miller Engineers (IME) has recently completed road designs to upgrade Dry Creek Road, AML Road and the Carol Shop Road. The design documents and easement descriptions are provided in **Appendix H, Gas Hills Road Design**. Two road design reports were prepared by IME – AML Road 7 kilometer (5 mile) alignment and Dry Creek Road 12 kilometer (8 mile) alignment. The AML Road design alignment is from Dry Creek Road to the Carol Shop satellite building and includes the Carol Shop Road previously described in this section. Cameco has entered into discussions with Natrona County about the possibility of upgrading the road from Waltman to the Fremont County line. If this road is upgraded, then IX resin and/or yellowcake slurry can be transported to the Smith Ranch CPP or Highland CPF via a more direct route than through Riverton.

3.7.1.4 Ruth Remote Satellite

The Ruth Remote Satellite can be accessed from State Highway 387 between Edgerton and Pine Tree, Wyoming. From the intersection of Highway 192 and 387, travel east 6.8 kilometers (4.2 miles) to a gravel road which bears north 7 kilometers (4 miles) to the site. The gravel road roughly follows the Dry Fork of the Powder River drainage.

3.7.2 Secondary Access Roads

A series of roads will be constructed along and within the mine units to provide access for drill rigs, pump pulling units, maintenance vehicles, etc. These roads will connect with Primary Access Roads and will be designed and constructed in such a manner so as to minimize the amount of land disturbance. Road designs have not yet been developed for this remote satellite location.

3.8 Construction Considerations

3.8.1 General Consideration

The Smith Ranch is operational whereas the Reynolds Ranch Satellite, North Butte, Gas Hills, and Ruth Remote Satellites have not yet been developed. The topsoil management and erosion control methods employed at each facility are similar, but facility-specific requirements exist and are detailed where appropriate in the following sections. Mine delineation will be ongoing at each facility and the most current BMP will be employed.

3.8.2 Topsoil Management

LQD Rules and Regulations Chapter 11, Section 4(a)(iii) stipulates that procedures required in Chapter 3, Section 2(c)(i) through (iii) be used to ensure the protection of topsoil and subsoil from excessive compaction, degradation, and wind and water erosion where stockpiling of topsoil and subsoil is necessary. These regulations require that Cameco perform ISR activities in a manner that minimizes topsoil damage and controls the amount of sediment lost to wind and water erosion. Should any surface drainage require diversion around an operating area, such diversions will be constructed in an erosionally stable manner in accordance with certain design standards. Similarly culverts, which pass below disturbed areas, including roads, will be protected. Additionally, LQD Noncoal Rules and Regulations, Guideline No. 4 Attachment III provides guidance for the management of topsoil and subsoil resources at ISR operations. The LQD Guideline No. 4 stresses that the ISR operator limit areas of disturbance during mine unit delineation, construction and operation by minimizing temporary access roads, and segregating topsoil and subsoil materials during mud pit, pipeline, mine unit pattern construction, and other excavations. Although topsoil and subsoil are generally not stripped and stockpiled for the entire mine unit area, soil salvage in specific mine unit pattern areas, where traffic is concentrated, may be necessary in site-specific situations.

3.8.3 Erosion Control Methods

The main hydrologic control features will consist of culverts to be installed during the development of access roads (see Section 3.5). Installation of these culverts will allow road crossings of drainage ways without erosion or sedimentation problems related to vehicle traffic on water courses. Culverts will maintain existing site drainage conditions. Culvert design includes providing adequate capacity for both water and sediment yield. Culvert design criteria are based on LQD Guideline No. 8, which factors the design life of the facility or structure with hydrologic return period or flood frequency probability. Culvert slope will be adequate (greater than 2%) to convey sediment through the culvert. Inlet and outlet protection will occur as required.

On a local scale, surface drainage will be directed away from or under facilities, roads and topsoil stockpiles utilizing shallow ditches, culverts and/or berms. As delineation drilling and mine unit development proceeds, should it become necessary to disturb lands adjacent to surface waters and/or wetland areas, these areas will be protected by the installation of appropriate silt fencing or other appropriate sediment control measures as outlined in the Smith Ranch Storm Water Pollution Prevention Plan (SWPPP). Smith Ranch has an Industrial General Permit (IGP). A SWPPP will be developed and permits will be obtained for the remote satellites prior to beginning any construction activities.

3.8.4 Surface Water Diversions

Surface water diversions are constructed as necessary to divert water around buildings, ponds, and other structures as required to protect facilities and minimize erosion and sedimentation. Any diversion structure will be constructed in accordance with accepted BMPs and standard engineering practices.

3.8.5 Construction Quality Assurance Plan

Cameco will develop a construction quality assurance plan that addresses all aspects of constructing surface facilities. The plan will include the following:

1. A description of the responsibilities and authorities of key personnel, including the level of experience and training;
2. A description of the required level of experience, training, and duties of the contractor, the contractor's employees, and the quality assurance inspectors;
3. A description of the testing protocols for every major phase of construction, including the frequency of inspections, field testing, and sampling for laboratory testing;
4. The sampling and field testing procedures and the equipment to be used;
5. The calibration of field testing equipment;
6. The laboratory procedures to be used; and
7. Documentation to be maintained.

3.9 Project Schedule and Water Balance

Project schedules and water balances have been developed for each of the SUA-1548 Project facilities. The following general assumptions were made for all SUA-1548 license areas, and specific assumptions for the individual facility are provided in the further discussions.

1. The groundwater sweep is calculated on the volume of water withdrawn from the formation.
2. The 8 pore volumes of the RO treatment were calculated on the volume of permeate injected not the volume of water withdrawn from the formation.
3. The recovery on the RO units is 80%.
4. The pore volumes are based on 2010/2011 approved surety estimates.
5. Future production is accounted for in the water balance.
6. The operational time is 360 days per year or 98.6%.

The production water balances detailed on **Table 3-11**, **Table 3-12, Smith Ranch Water Balance, Table 3-13, Reynolds Ranch Water Balance, Table 3-14, Highland Water Balance,** and **Table 3-15, North Butte Water Balance,** for each of the SUA-1548 license areas show the sequencing of the development and restoration of the individual mine units. Anticipated production flows, disposal requirements and capacity are also detailed in the aforementioned tables. The actual production schedule for each facility is dependent upon several factors, including mine unit flows, production rates and economics.

Groundwater restoration will occur concurrently with mining throughout the life of the Project. The groundwater restoration portion of the schedule is designed to achieve the fastest restoration possible, given the ability of the aquifer to yield water. After groundwater restoration and stability have been achieved in a mine unit and regulatory concurrence has been granted, approximately one to two years are typically needed to decommission and reclaim the mine unit surface and ancillary buildings and equipment.

3.9.1 Smith Ranch and Satellites

The estimated project and restoration schedules for Smith Ranch, Highland and Reynolds Ranch, presented in **Tables 3-12, 3-13,** and **3-14** are based on an average annual production rate of 907 metric tons (1,000 tons) of uranium. The assumptions for the Smith Ranch water balance include the following:

1. The Reynolds Ranch production is processed at the Smith Ranch CPP.
2. The production bleed is 1%.
3. A mine unit control bleed of 76 liters/minute (20 gallons/minute) was included in the water balance for use anywhere onsite. The control bleed is a provision for excursion control.
4. The groundwater sweep is used for RO make-up water in the water balance. A provision was included for up to a 5% bleed to be used during the RO phase for hydraulic control.
5. The disposal capacity is maintained for the life of the project.
6. The deep disposal well disposal volumes are the most recent volumes to date from the mine.
7. The water balance assumes that the 1,890 liters/minute (500 gallons/minute) [feed] RO unit will be installed at Smith Ranch in 2028.
8. A 945 liters/minute 250 gallons/minute [feed] RO unit will be added at Smith Ranch satellite SR2 in 2029 and an additional 1,890 liters/minute (500 gallons/minute) [feed] will be installed at SR2 in 2032 for the restoration of Mine Units 9 and 10.
9. Mine Units 9 and 10 need to be restored together because they are in the same sand unit.

Cameco also plans to process IX resin at the Highland CPF beginning in 2013. **Table 3-14** provides an estimate of the annual processing rates, number of elutions, disposal capacities and water consumption for the Highland CPF.

3.9.2 North Butte Remote Satellite

The estimated project operations and reclamation schedule, presented in **Table 3-15** is based on an initial annual production rate of 227 metric tons (250 tons) of uranium per year, with that rate being increased to the maximum sustainable production rate, currently estimated to be approximately 680 metric tons (750 tons) of uranium per year. The assumptions for the North Butte water balance include the following:

1. The production bleed is 1%.
2. Two deep disposal wells will be installed at the beginning of the project and a third deep disposal well will be installed at the start of restoration. A fourth well will be installed as needed. The disposal capacity of each well was estimated at 189 liters/minute (50 gallons/minute).
3. The water balance assumes a 2,268 liters/minute (600 gallons/minute) [feed] RO unit.

3.9.3 Gas Hills Remote Satellite

The estimated project and restoration schedules for Gas Hills, presented in **Table 3-11** are based on an average annual production rate of 907 metric tons (1,000 tons) of uranium. The assumptions for the Gas Hills water balance include the following:

1. The production bleed is 1%.
2. Initially, two evaporation ponds will be installed and additional ponds will be constructed as needed. Up to six evaporation ponds will be constructed and the total capacity of the ponds is 180,000 meters^3 (146 acre-feet).
3. Cameco is evaluating utilizing deep disposal wells at Gas Hills, but the water balance only assumes utilizing evaporation ponds.
4. The evaporation rate is 23,000 meters^3 (19 acre-feet) per year for the first four ponds and 42,000 meters^3 (34 acre-feet) per year for all of the ponds.
5. The cumulative sludge in the evaporation ponds was conservatively calculated to the TDS of the water evaporated from the ponds.

Mine unit development scheduling will also reduce the potential for flare near abandoned mine workings or other areas of high TDS groundwater. The portion of the production pattern area located nearest the mine workings will be developed last. This may result in a shorter production life for the patterns nearest the mine workings before restoration of the wellfield begins. Although the short production life may reduce ultimate recovery from the ore zone, it will result in a lower potential for excursions from the production areas or incursions of high TDS groundwater from the mine workings.

The location of any previously affected groundwater zones (by historic mining activities) or naturally degraded groundwater outside the mine unit monitor well will affect the restoration activities. Groundwater restoration activities will be designed to avoid drawing such water towards or into the wellfield pattern area.

3.9.4 Ruth Remote Satellite

A project schedule and water balance has not been developed for the Ruth Remote Satellite. When it is completed it will be submitted to NRC for review and approval.

3.10 Potential Impacts of Operations on Surrounding Waters

3.10.1 Spills

3.10.1.1 Summary of Spills and Releases

This section provides a summary of releases under License SUA-1548 since the previous license submittal of November 15, 1999, and an evaluation of the potential environmental impacts of the releases. All liquid spills which entered a water of the state, any liquid spill in excess of 1,600 liters (420 gallons), or any spill that threatened to enter "Waters of the State", comprised of lixiviant, pregnant liquid, acid, solvent, process waste water or any similar stream, are reported to the WDEQ LQD and the NRC. "Waters of the State" include playas and wetlands, as well as streams, rivers, and lakes, dry draws, and so on. The releases reported to the NRC since the previous license submittal are summarized in **Table 3-16, Summary of Spills and Releases**.

A total of 94 reportable releases have occurred at Smith Ranch since the previous license renewal, totaling approximately 3.3M liters (865,800 gallons). The volume released represents approximately 0.001% of the total volume of fluid circulated since the previous license submittal. Approximately 50% of spills involved injection fluids, which have low uranium concentrations, averaging approximately 2 mg/L. Approximately 40% of the spills involved production fluids, with uranium concentrations ranging from <1 to 149.7 mg/L and averaging approximately 20 mg/L. Spills and releases of deep disposal fluids, restoration fluids, and treated process water make up a small percentage (approximately 10%) of the total number of spills. Approximately 82% of spills resulted from mechanical and equipment failures, such as failed fittings, joints, flanges, and unions of pipelines, with 18% of spills resulting from human error.

Based on release investigations and associated sampling, none of the releases occurring during the past ten years has resulted in any surface water contamination. In addition, routinely conducted groundwater monitoring well sampling of overlying aquifers indicates that none of the releases have resulted in groundwater contamination.

While all releases are thoroughly investigated, additional action was instigated to assess future actions that could be taken to eliminate releases by creating a Spill Committee. This committee was formed in 2004 to investigate all releases, determine the cause, recommend corrective actions, and evaluate procedures, training and equipment being used. Cameco Resources Spill Committee currently meets periodically or after a release to discuss corrective actions, status of previously assigned actions, and preventative measures to minimize the potential for a fluid release from the Smith Ranch operations.

Corrective actions resulting from Spill Committee reviews have included:

- Installation of a leak detection system at the wellheads that has evolved to electronic surveillance tied into the associated satellite's computer monitor with alarms.
- Daily inspection of all wellfields and header houses.
- Unions will not be reused when repairs or maintenance is conducted on a wellhead or header house.
- All points containing fittings along buried pipelines are accessible by a bellhole, an oversized culvert large enough for a work crew to access all connections, and are fitted with early warning detection systems.
- When one component of a wellhead or header house is found to be faulty, all like components are replaced to reduce the chance for releases.
- All wetted fixtures at a wellhead are replaced every five years; this coincides with the ongoing required five year MIT of all injection wells.
- Wellheads in the vicinity of monitor wells will be visually inspected by Water Samplers performing their routine sampling duties. There were 17,000 wellheads visually inspected in 2009, with 96 potential problems noted and corrective actions taken.
- Pop-off valves failed to reset and were replaced with newer versions.
- Installed an asbestos-free (green) gasket in all new Production/Injection lines.
- When moving into restoration phases, replace gaskets with either red-rubber or asbestos-free gaskets.
- All hose connections on wells were replaced with a more robust version, which went through two stages until the best connection was found.
- Gaskets have been changed from paper gaskets to neoprene.
- Stainless steel fittings replaced all brass fittings to minimize corrosion.

Upon detecting a release, site personnel have responded immediately by taking actions to stop and contain the release. Actions taken include, isolating the pipeline or shutting down the well, header house, wellfield, or plant, as necessary. Additionally, released fluids have been recovered, when possible, with a vacuum truck and disposed of via deep well injection at the satellites or CPP, if the fluids had not already soaked into the soil. Gamma surveys were conducted in affected area and soil samples collected as determined by the Radiation Safety Officer on a case-by-case basis. Gamma surveys of release-impacted soil areas during the past ten years resulted in no immediate requirement for corrective action. Cameco's de-commissioning file contains a report for all releases both reportable and non-reportable, map, sample results and radiological survey data, as applicable. All release sites will be re-evaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards are met.

3.10.1.2 Evaluation of Potential Impacts from Spills

According to the "Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities" (NUREG-1910), impacts to soils from spills could range from small to large in the short-term, depending on the volume of soil affected by the spill. However, NUREG-1910 states that because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary and overall long-term impact to soils would be expected to be small. Spills listed in **Table 3-16,** document that no adverse impacts are expected due to the small quantity of fluid involved, the small extent of the spill, and the low precipitation rate and ephemeral nature of surface water at the site. Potential impacts to surface water are also monitored by the surface water monitoring program described in Section 5.10. The results of this monitoring program show that measured concentrations of natural uranium and Ra-226 in stock ponds (some stock ponds are filled by windmills and wells) along drainages near active mine units are all below the ECLs from 10 CFR 20, Appendix B. Additionally, shallow windmills and wells sampled in the past 10 years show no impact from releases, with concentrations of uranium (nat) and Ra-226 below the ECLs, with one exception. Well GW-5 is located in an area with shallow natural uranium mineralization, resulting in naturally high uranium concentrations that exceed the ECL. Uranium and radium concentrations are naturally elevated in the vicinity of the site and may vary spatially depending on proximity to naturally occurring uranium mineralization and level of oxidation.

The surface water monitoring locations have shown a slight decreasing trend in uranium (nat) and Ra-226 concentrations since the last license renewal in November 1999. The largest spill occurred in June 2007 and involved a spill of 750,300 liters (198,500 gallons) of injection fluids resulting from human error. That spill had no immediate or long-term environmental impacts as indicated from post-release radiological survey results, soil and vegetation sampling results, and wells specifically drilled to confirm that there were no impacts to the shallow aquifer.

3.10.1.3 Spill History Summary

Spills and/or releases at Smith Ranch have been related to operational activities typically associated with piping/fittings. Other potential activities that could result in spills and/or releases include transportation, evaporation pond storage, or land application of treated waste water. BMP and an active Spill Committee review of spills having occurred at Smith Ranch have resulted in leak detection upgrades to existing systems as identified early in this section. These in conjunction with Project (SUA-1548) operational procedures including detection and response to leaks and spills (e.g., soil cleanup), monitoring of treated waste water, surveys of potentially impacted soils help limit the magnitude of overall impacts to soils.

Cameco has contingency plans and spill response equipment necessary to respond to spills and/or releases of process fluids from valve, pipe, or tank failures; evaporation pond liner tears and transportation accidents.

A review of these plans and procedures with regard to operations during the last ten years indicates that that Cameco addresses contingencies for all of the types of spills that have occurred, including any reasonably expected system failures. All of the appropriate plant and corporate personnel who must be notified in the event of specific types of failures is current. Also, spill and/or release procedures for complying with notification requirements in the NRC license, regulations and other permits are current, including agencies and points of contact to make the required notifications.

Mitigation measures taken during spill and/or releases at the Smith Ranch Project (SUA-1548) have included securing the affected area with perimeter fencing and/or hurricane fencing and soil removal.

Smith Ranch spill and/or release impacts from surface facilities and equipment on shallow aquifers are a major concern as these aquifers are important sources of agricultural and drinking water in surrounding areas.

3.10.2 Excursion, Incident investigation or Root Cause Analysis, and Resultant Cleanup History or Status

3.10.2.1 Wellfield Excursions

This section provides a summary and review of wellfield excursions reported for the Smith Ranch SUA-1548 license areas during the period since the previous license renewal (submitted November 15, 1999). It also provides an investigation into the causes of the excursions, corrective actions as necessary, the status of each, and conclusions as to the overall impact of the excursions. Potential impacts to groundwater resources can occur from various facility activities and operations, for example excursions of leaching solutions from wellfields during production and/or restoration. The Environmental Monitoring Program at the Smith Ranch SUA-1548 license areas (presented in Section 5.10) is conducted to verify that groundwater excursions are detected in a timely fashion to prevent degradation of groundwater quality outside of the mine unit wellfields. The mine units at Smith Ranch are shown on **Figures 1.4** through **1.8.**

A migration of production fluids into the overlying or underlying aquifers and/or detected at the monitor well ring is termed an excursion. Excursions are indicated from monitoring well data when two or more excursion parameters (i.e., alkalinity, chloride, and specific conductivity) exceed the UCLs as determined from the approved baseline water quality data. When an excursion is first indicated by monitoring results, a confirming sample is collected within 24 hours of receiving the original analytical data to confirm the excursion. If the excursion is confirmed by the second sample, NRC and WDEQ are notified in accordance with the license, and subsequent sampling of the well is conducted at least every seven days for the UCL parameters and uranium. If the second sample does not confirm the excursion, a third sample is collected within 24 hours of the second sample results to confirm or deny the excursion, if the excursion is confirmed the appropriate regulatory agencies are contacted and sampling is conducted at least every seven days. Weekly monitor well sampling is continued until the excursion parameter exceedance(s) are no longer detected in the sample analytical results. Excursion events do not necessarily result in environmental impacts, but can be indicators of the unintended movement of production fluids.

Section 5.10.3 provides a summary of the groundwater monitoring program. Excursions, if any, for each mine unit is discussed in the following paragraphs. The completion zone for the excursion monitor well is denoted by the prefix (see Section 3.5.1.2) of the well designation. For example, well BM-42 is a monitoring ring well in mine unit B and was completed in the ore zone. Monitor wells installed in the older mine units at Smith Ranch are denoted with a U (upper) and D (deep) in the well designation.

Mine Unit 1

There were no excursions in MU 1 and analytical results of the monitoring well sampling were below the UCL concentrations throughout the license renewal period, which is defined as the period from the submittal of previous license renewal (November 15, 1999) through the first quarter 2011 (March 31, 2011).

Mine Unit 2

Analytical results for monitoring well MD-208 located in the underlying aquifer on September 1, 2006 indicated that an excursion had potentially occurred as two of the excursion parameters exceeded the UCLs. Confirmatory sampling of the well was conducted on September 5, 2006 and showed that no excursion had occurred. A review of monitor well analytical results during the license renewal period confirms that no excursions have occurred at this mine unit.

Mine Unit 3

Analytical results for monitoring well MD-306 located in the underlying aquifer on September 30, 2008 indicated that an excursion had potentially occurred as two of the excursion parameters exceeded the UCLs. The original sample was re-analyzed the same day. Results of the analysis indicated the concentrations above the UCLs were due to laboratory error, not an excursion. No other sample results have indicated an excursion or potential excursion at MU 3 during the license renewal period.

Mine Unit 4 and 4A

An excursion occurred in MU 4 and was detected at well M-428. The well went on potential excursion status during production on September 3, 2004, followed by confirmatory sampling conducted on September 8, 2004. During the subsequent sampling event on September 14, 2004, only one excursion parameter exceeded the UCL concentrations and the well was therefore removed from excursion status. Following that sampling event, concentrations of excursion parameters have been below the UCLs. No other excursions have occurred at MU 4 or MU 4A during the license renewal period.

Mine Unit 9

Analytical results have indicated that sampling parameters were below the approved UCLs and there were no excursions in MU 9 during the license renewal period.

Mine Unit 15 and 15A

Analytical results have indicated that sampling parameters were below the approved UCLs and there were no excursions in MU 15 and 15A during the license renewal period.

Mine Unit A

Groundwater monitoring at MU A was not conducted during the license renewal period because restoration is complete. Restoration was conducted from July 1991 to October 1998 and was approved by WDEQ on November 23, 2003 and by NRC on June 19, 2005. Monitoring wells were plugged from March 2005 through May 2005.

Mine Unit B

During the license renewal period, one excursion occurred at MU B. Well BM-42 went on excursion on November 5, 2002, with confirmatory sampling conducted on November 6, 2002. Since that time, the well has been monitored approximately every 7 days for excursion parameters and uranium, and concentrations of excursion parameters continue to be above the UCLs. The location of well BM-42 is shown on **Figure 1.4**. On March 31, 2008, the LQD notified Cameco that Mine Unit B had been restored and well BM-42 was plugged and abandoned on January 14, 2011. The excursion at well BM-42 occurred during restoration of the wellfield, which began in July 1991.

Although the LQD approved the restoration of MU B based on class of use, well BM-42 still had concentrations above the UCLs. The original BM-42 well had failed MIT was replaced with a new well in 2011. The new well was taken off excursion status after subsequent water quality sampling.

Mine Unit C

At MU C, one potential excursion and three confirmed excursions occurred during the license renewal period. At well CM-14, monitoring results indicated a potential excursion on September 4, 2008. Verification samples were inadvertently not taken at that time, but the next routine sampling performed in November 2008 indicated that the concentrations of excursion parameters were below UCLs. WDEQ was notified of the missed verification sample event. Confirmed excursions have occurred at four wells at the wellfield: CM-15, CM-32, CM-33 and CM-38. While on excursion status, these wells were monitored approximately every 7 days for excursion parameters and uranium. The locations of these wells are shown on **Figure 1.5**. The confirmed excursions are discussed below:

- Well CM-32 went on excursion on July 3, 2007, with follow up confirmatory sampling conducted on July 6, 2007. Samples collected from CM-32 from July 2007 through October 20, 2009 have had two or more parameters exceed the UCL concentrations.
- Well CM-33 went on excursion on February 22, 2008, with follow up confirmatory sampling conducted on February 25, 2008. Concentrations of two UCL parameters exceeded the UCLs from February 2, 2008 through May 20, 2008. From June 3, 2008 through October 6, 2009, the well had no excursions.
- Well CM-15 went on excursion on November 18, 2008, with follow up confirmatory sampling conducted on November 19, 2008. From November 19, 2008 through September 22, 2009, two UCL parameters exceeded the UCLs. Well CM-38 went on excursion on June 14, 2010, with follow up confirmation sampling conducted on July 20, 2010. A second confirmation sample was collected on July 27, 2010 and UCL levels were exceeded. Subsequent sampling has shown that the well has had no additional excursions.

At the time of these excursions, MU "C" was in restoration. Wells CM-32 and CM-33 are located within 274 meters (900 feet of past underground mine workings. During 1991, it was determined that production fluids from the 50-Sand production zone within MU "C" had entered the abandoned underground workings. Following the excursion at CM-32 in 2007, Cameco turned on seven wells associated with nearby header house C-22 to form a cone of hydraulic depression, thereby bringing the solutions back into the wellfield and controlling the excursion. Following the excursion at CM-33 in 2008, Cameco re-balanced the wellfield in an attempt to mitigate the excursion. Cameco Resources is in the process of analyzing historical data and evaluating methods to fine tune the balancing in MU "C".

Mine Unit D

During the license renewal period, excursions had initially been indicated by concentrations above the UCLs at monitoring wells DM-1, DM-16 and DM-24, but confirmatory sampling showed that the wells were not on excursion. However, excursions have been confirmed at three wells within the wellfield: DM-3, DM-9, and DM-10. The locations of these wells are shown on **Figure 1.5**. These excursions are summarized below:

- Well DM-9 went on excursion on November 5, 2001, with confirmatory sampling on November 6, 2001. From November 2001 through February 2004, excursions occurred at this well, with few exceptions. However, an excursion has not occurred at this well since February 24, 2004.
- Well DM-3 went on excursion on January 21, 2002, with confirmatory sampling on January 22, 2002. Excursions occurred from January 2002 through May 2009, with few exceptions. On September 8, 2009, another potential excursion was reported for well DM-3; however, confirmatory sampling showed no excursion. This well was on excursion status throughout 2010, but was removed from excursion status in the summer of 2011.
- Well DM-10 went on excursion on March 20, 2002, with confirmatory sampling on March 21, 2002. From March 2002 through April 2005, two or more parameters have exceeded the UCL concentrations, with periodic exceptions when only one parameter exceeded the UCL concentrations. From May 2, 2005 through August 4, 2008, no excursions occurred at this well. Concentrations of two UCL parameters exceeded the UCLs on June 3 and 6, 2011 and the well is currently being monitored.

Excursions at DM-3 are attributed to abandoned underground workings in the area. As discussed in the section above for MU C, production fluids have entered the underground workings, which extend to the 40-Sand production zone at MU D. Excursions can indicate an over-injection of lixiviant; however, at the time of some of the excursions at DM-3, there was a lack of injection in the MU, which further suggests that underground mine workings are the cause.

Excursions at wells DM-9 and DM-10 are also related to the abandoned underground mine workings and like the excursion at DM-3, they also occurred when there was a lack of injection in the MU. As shown on **Figure 1.5**, these wells are located south of the abandoned mine workings and northeast of MU- D-extension, which started production in May 2001. The excursions are thought to have occurred from water-level drawdown in the D-Extension wellfield and resulting changes in the potentiometric surface of the 40-Sand, allowing fluids to migrate from the abandoned mine workings (or nearby wellfield pattern area) towards wells DM-9 and DM-10. Corrective actions were taken following these excursions to alter the groundwater flow paths in the area of concern.

Mine Unit E

Samples at well ET-1 in the first quarter of 2006 showed concentrations of excursion parameters exceeding the UCLs. However, well ET-1 is a "trend" well, used only to indicate water quality trends in the wellfield and not for compliance monitoring. No excursions have occurred at MU E.

Mine Unit F

Results from the July 7, 2009 sampling event for well FM-8 indicated an excursion; however, as stated on the notification letter to WDEQ on July 27, 2009, results from July 7, 2009 were likely inaccurate because evacuation of one casing volume was not sufficient for this well to ensure sampling of formation fluids. Additionally, issues with the well were being investigated and resolved during that time. Therefore, confirmatory sampling was not conducted. The investigation ultimately showed that the well had failed at the 46 meter (150-foot) level due to joint failure and the well was abandoned on August 14, 2009. A replacement monitoring well was installed and completed on August 4, 2009, and subsequent results have not indicated any further excursions. No other excursions or potential excursions have occurred at MU F.

Mine Unit H

One confirmed excursion has occurred at MU H during the license renewal period. Initial sample data from January 12, 2010 at well HM-20 indicated an excursion, with confirmatory sampling conducted on January 13, 2010. The location of well HM-20 is shown on **Figure 1.4**. Following the excursion, the operation of injection and production pumping rates were optimized to balance flows in the wellfield to yield an increased bleed rate of approximately 76 liters/minute (20 gallons/minute). The results of subsequent sampling of the well have shown that the well is off excursion.

Mine Unit I

During the license renewal period, one potential excursion occurred at MU I and three confirmed excursions occurred. Well IM-11 appeared to be on excursion status on May 1, 2007. However, the elevated concentrations were likely caused by over-pumping the monitoring well prior to sample collection (11 casing volumes were purged prior to sampling). Due to this suspected cause, confirmatory sampling was delayed until May 11^{th} of the same month to allow well recovery. Confirmatory sampling showed that the concentrations were below the UCLs. Since May 11, 2007, sampling results have been below UCLs.

Excursions have been confirmed at three wells within MU I: IM-10, IM-14, and IM-8. The locations of these wells are shown on **Figure 1.4**. These excursions are summarized below:

- Well IM-10 went on excursion on February 11, 2009, with confirmatory sampling conducted on February 13, 2009. Results from sampling on March 3, 2009 showed the excursion was resolved. Since that time, no additional excursions have occurred at well IM-10.
- Well IM-14 went on excursion status following sampling on March 27, 2009, with confirmatory sampling on March 30, 2009. The excursion was resolved in April 2009 based on sampling results that were below the UCLs.
- Well IM-8 went on excursion on April 14, 2009, with confirmatory sampling conducted on April 15, 2009. The well has been on and off excursion status several times between the April 14, 2009 excursion and September 1, 2009, when the excursion was resolved.

In response to the excursions at monitoring wells IM-10, IM-14, and IM-8, Cameco shut off the injection wells in the vicinity of the excursions and reduced the pumping rates in other nearby wells. Additionally, Cameco is developing a groundwater flow model of the mine unit to help determine optimal pumping and injection rates to prevent excursions in the future.

Mine Unit J

At MU J, monitoring results at wells JMO-009, JMO-013, and JMO-015 are affected by their very low yield. During each sampling event, these wells are pumped dry, which oxygenates the water and ultimately the sampled formation, causing fluctuations in alkalinity. At JMO-013, the pumping off had occasionally resulted in concentrations of two excursion parameters (alkalinity and conductivity) exceeding the UCLs and at JMO-009, pumping off resulted in one occasion in which two excursion parameters exceeding the UCLs. A proposal to revise UCLs for JMO-009, JMO-013 and JMO-015 wells, because of low water yield, was submitted to LQD on November 15, 2007. Following LQD review and approval (May 13, 2010), these wells were placed on a normal twice monthly sampling schedule with new UCLs. Water levels continue to be monitored with pressure transducers due to the potential for communication between this aquifer and the production zone. Well JMO-014 is monitored on a weekly basis for water level only, as it does not contain enough water to sample.

Other than UCL exceedances described above for low-yielding wells JMO-009 and JMO-013, no other sample results have indicated an excursion or potential excursion at this MU.

Mine Unit K

Analytical results have indicated that sampling parameters were below the approved UCLs and there were no excursions in MU K during this license renewal period.

3.3.1.1 Summary and Impacts of Excursions

Since the previous license renewal submittal in November 1999, approximately 1,000 wells have been monitored for excursion parameters, most of which have been sampled twice a month with 10 days between sampling events. Of those wells, excursions have been confirmed at only twelve wells, located at only five of the 16n MUs: MU B, MU C, MU D, MU H, and MU I. These excursions are horizontal excursions that have occurred within the production zone aquifer at monitoring wells installed in a "ring" around the production zone. Since the previous license renewal submittal, no excursions have occurred in the overlying and underlying aquifers. Of the twelve confirmed excursions, eight excursions lasted more than 60 days. These excursions occurred at the following monitoring wells: BM-42 (MU B), CM-32 (MU C), CM-33 (MU C), CM-15 (MU C), DM-9 (MU D), DM-3 (MU D), DM-10 (MUD), and IM-8 (MU I).

Following detection of an excursion, actions are immediately taken to mitigate potential migration of production fluids. These actions include immediately shutting off the injection wells in the vicinity of the excursion, thereby drawing in production fluids and creating a negative hydraulic gradient. The negative hydraulic gradient, or cone of depression, prevents further migration of production fluids.

Excursions at a Restored Wellfield

Concentrations of excursion parameters at well BM-42 within MU B are below the UCLs. The restoration is complete at the MU and the water quality at the excursion well was returned to its previous WDEQ Class of Use. Restoration at MU B is awaiting approval from the NRC. According to the NRC "*Staff Assessment of Groundwater Impacts from Previously Licensed In-Situ Uranium Recovery Facilities*" (Miller, 2009), of the 11 approved wellfield restorations for the three ISR facilities evaluated, all restorations had levels of one or more parameters above the baseline (pre-operational) levels. Despite not returning concentrations of all parameters to baseline conditions, the NRC states that groundwater impacts from the NRC-approved restoration sites do not pose a threat to human health or the environment.

Excursions Related to Underground Mine Workings

Abandoned TVA underground mine workings are known to exist in the area near MU "C" and MU "D", as shown on **Figure 1.5**. The underground mine workings extend into the 40-Sand production zone of MU "D" and the 50-Sand production zone of MU C. During 1991, it was determined that production fluids from MU C entered the abandoned underground workings. The production fluids in the underground mine workings have affected the groundwater quality and led to long-term excursions at wells CM-32 and CM-33 within MU C and well DM-3 and DM-10 within MU D.

In November 1992, the WDEQ approved a permit revision to include the mine workings in the MU C production zone. Additional wells were installed to monitor the potential movement of production fluids within and surrounding the mine workings. This group of 11 monitoring wells will be sampled during the restoration and stability periods to assess the progress of groundwater restoration in the underground workings. Since restoration began in 1997 at MUC, most of the additional monitoring wells show a decreasing trend for conductivity, chloride, and bicarbonate. Additionally, monitoring well CM-33 is no longer on excursion status. Following complete restoration of MU C and MU D, no impacts are expected from production fluid in the underground mine workings.

Excursions Controlled by Corrective Actions

During operations, a negative hydraulic gradient is expected to be maintained so that groundwater flow is toward the production zone from the edges of the wellfield. If a negative gradient is not maintained, horizontal excursions can occur and lead to the spread of production fluids in the production zone aquifer, beyond the mineralized zone (NUREG-1910, Chapter 4). This imbalance of pumping and injection is likely the cause of excursions at wells DM-9 and DM-10 at MU D and well IM-8 at MU I. These excursions were controlled through corrective measures. Corrective measures have consisted of optimizing the injection and production pumping rates to balance flows in the wellfields. The corrective measures have resulted in the wells being taken off excursion status and therefore these excursions are expected to have no environmental impact.

Well CM-15 at MU C went on excursion status during the restoration period. The exact cause of this excursion is not known. Even though well CM-15 is farther from the underground mine workings than wells CM-32 and CM-33, where excursions have also been reported, the excursion at CM-15 may also be attributed to the underground workings. Another possibility is that a natural hydrologic sink may exist in the area of well CM-15. Regardless of the cause, the excursion was corrected by turning off nearby injection wells and over-pumping the closest production wells, thereby drawing solutions back towards the center of the wellfield, away from the monitoring wells. Corrective actions were effective at reducing the conductivity readings and chloride concentrations and the well has been taken off excursion status.

Conclusion

Cameco has operated its Smith Ranch Project (SUA-1548) in a manner to limit the number of excursions to a very small number relative to the number of mine units operated and the number of wells monitored. As discussed in the NRC's *"Staff Assessment of Groundwater Impacts from Previously Licensed In-Situ Uranium Recovery Facilities"* (Miller, 2009), the number of excursions reported and the duration of the excursions at the Smith Ranch constitute a small percentage of the total number of samples analyzed. For example, at the Smith Ranch site, approximately 1,000 wells have been sampled and analyzed twice a month for excursion parameters since the previous license renewal in 1999, compared to confirmed excursions of 12 wells (1% of the wells). Approximately 240,000 monitor well samples have been analyzed for excursion parameters, of which 12 wells have been confirmed to be on excursion status. Only five of the 16 mine units that are operational or in restoration have had excursions during the license renewal period. Additionally, the above mentioned NRC staff assessment report on groundwater impacts states that for most excursion events, the licensees were able to control and reverse the excursions through pumping and extraction at nearby wells. The excursions have not resulted in environmental impacts. This has been true at the Smith Ranch in that Cameco has been able to successfully mitigate the impact of the limited number of excursions through corrective actions such as rebalancing of nearby wells.

3.10.3 Pond Leaks

This section provides a summary of storage pond leak events occurring at the Smith Ranch-Highland operation since the previous license submittal and associated design and/or operational changes to reduce the frequency of leak events. All storage pond leak events are reported to the LQD and the NRC.

3.10.3.1 East and West Storage Ponds

A total of 14 leak events have occurred at the East and West Storage Ponds since the previous license submittal (see **Table 3-17, Summary of East and West Storage Pond Leaks**). Upon detecting a leak, site personnel have responded immediately by taking actions to stop and contain the leak. Typical actions include lowering of pond water (freeboard) levels to prevent additional inflow to the secondary containment/leak detection system, recovery of pond leakage from the secondary containment system, isolation of the area of the leak and repair of the liner breach. Once all repairs have been made, water levels are raised to test the integrity of the primary liner prior to resuming operation of the storage pond.

Based on the leak event investigations and associated corrective actions, leak events since the previous license submittal have been limited to minor breaches (e.g., small holes and/or tears) to the primary liner of the pond containment system. As part of the corrective action process associated with these events, several design and/or operational changes have occurred to reduce the frequency of pond leakage. These changes include:

- Installation of pumps in each pond to supplement the need for transfer hoses and prevent leaks caused by the camlock end of transfer hoses (1999);
- Use of higher grade patch kits during liner repair, consisting of HH-66 vinyl cement and vinyl laminated fabric or equivalent materials (starting 2000);
- New liner installations on the West Pond (2004) and East Pond (2008); and
- Fencing upgrades (2009) to restrict wildlife (deer) access.

Since replacement of the primary liner in 2004, the West Pond has performed well with no leaks occurring since that time. The East Pond, which had the primary liner replaced in 2008, has continued to experience leaks in consecutive years since 2008. While these leaks from the East Pond have been limited to minor breaches (holes and/or tears) in the primary liner, Cameco continues to evaluate the performance of the liner system and potential design and/or operational changes to reduce the frequency of leak events in the future.

3.10.3.2 Purge Storage Reservoir 2

This section describes information pertaining to Cameco's investigation activities to evaluate seepage from PSR-2 and potential impacts to the surrounding groundwater. In response to NRC Unresolved Item 040-08964/0801-03 identified by NRC inspectors during the March 2008 inspection, Cameco committed to installing four monitor wells to determine whether or not PSR-2 was leaking into the groundwater. The following discussions summarize the 2009 investigation activities and Cameco's plans to further investigate any potential impacts to the surrounding aquifer.

Background

PSR-2 is located north of Wellfield C, approximately 0.8 kilometers (0.5 miles) north-northeast of Satellite 2 of Cameco's Highland Operation. It was originally constructed in 1979 for use by TVA as a wastewater settling pond prior to discharge in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. In 1994, PRI took over operations of the area and PSR-2 was refurbished and permitted as a storage pond for a wastewater land-application facility. While the PSR-2 facility was designed to prevent adverse impacts to shallow groundwater, it was not designed to be completely impermeable and was not subject to the design criteria of Regulatory Guide 3.11 in 1994. This was acknowledged by the NRC in their technical evaluation report on the PSR-2 facility (NRC, 1994).

PSR-2 temporarily stores waste water from Satellite No. 2 and Satellite No. 3 after the water has been treated for uranium, radium and selenium removal and before the water is disposed via land application at Irrigator No. 2. Waste streams feeding PSR-2 consist of wellfield purge and groundwater restoration waters (wellfield bleed, groundwater sweep, and reverse osmosis concentrate). According to information submitted by PRI for the 1994 Permit, the wastewater met the WDEQ Class of Use limitations for Class III groundwater, except for selenium (WDEQ Water Quality Rules and Regulations, Chapter 8, Section 4(d), Cameco Resources 2009. The WDEQ Class III (livestock) limit for selenium is 0.05 mg/L, which is also the limit for Class I (domestic) waters.

The selenium concentration has been monitored since 1995 at Irrigator #2, which draws its water from PSR-2. Concentrations of selenium began decreasing in approximately 2000 and were less than 0.5 mg/L since that time except for a period during 2006 and 2007. As of September 23, 2009, a selenium treatment facility has been in operation at a location southwest of Satellite No. 2. Since that time selenium concentrations have decreased (Cameco Resources, 2010) with the addition of treated water with selenium concentrations less than 0.05 mg/L as shown in measurements conducted from Irrigator #2 in 2010.

Groundwater Monitoring

The 1994 Permit (Permit No. 93-410, *Satellite #2 Wastewater Holding Pond and Land Application Facility)* required the construction of two shallow monitoring wells, known as the East and South shallow wells. The East and South wells were completed to depths of approximately 3 and 4.5 meters (10 and 15 feet) bgs, respectively. Baseline monitoring of these wells was not required; however, the wells have been routinely monitored since their installation.

Due to concerns of water potentially leaking from PSR-2, Cameco Resources installed four new shallow monitoring wells in July 2009. Two of the new wells were installed next to the existing East and South wells (MW-4S and MW-3S, respectively). The other two wells were installed north (MW-2S) and west (MW-1S) of the reservoir.

Groundwater did not accumulate in boreholes during drilling at each of the four well locations. According to Cameco Resources (2009), each boring was dry when drilled and was then terminated at a depth of approximately 15 meters (50 feet) in a gray shale. Wells were completed with a 6 meter (20-foot) screen section, from 9 to 15 meters (29 to 49 feet) bgs. After installation of wells MW-1S through MW-4S was completed, water accumulated in these wells. The wells were developed using pumps on September 10, 2009. All of the wells pumped dry after removal of one borehole volume of water at an approximate pumping rate of 8 to 11 liters/minute (2 to 3 gallons/minute) (Cameco Resources, 2009). It was not clear from the available lithologic data whether the screened intervals from these four wells intersect a continuous permeable sand zone.

Based on water level data collected after installation of these four new wells, the groundwater flow direction in this shallow zone was assumed to be to the south-southeast (Cameco Resources, 2009). However, this direction is heavily influenced by the presence of PSR-2 and may not be indicative of regional groundwater flow directions around PSR-2. The groundwater encountered in the shallow monitoring wells is considered to be perched and laterally discontinuous. The uppermost, continuous water-bearing zone is postulated to be at a depth of at least approximately 15 to 18 meters (50 to 60 feet) below grade based upon a review of historic hydrogeologic data from wells and borings completed in the area of PSR-2.

Groundwater samples were collected from the four new monitoring wells (MW-1S through MW-4S) just after their initial development in September 2009. Groundwater samples were collected on a quarterly basis from all 6 wells (the four new wells and the South and East wells) from March through March 2011. Results of selenium analyses on these samples are presented in **Table 3-18, Groundwater Sampling Results for Monitor Wells near PSR-2**. As shown in **Table 3-18**, concentrations are highest in samples from the South well and well MW-1S, located west of PSR-2. Concentrations are also greater than the WDEQ Class III limit of 0.05 mg/L at wells MW-3S, located south of PSR-2, and at well MW-4S, located east of PSR-2. The analytical results suggest that selenium concentrations in groundwater are elevated in the shallow sediments surrounding the reservoir, except in areas located upgradient (north) of the reservoir.

Installation of Additional Groundwater Monitor Wells

To further evaluate any impacts from seepage from PSR-2, Cameco is committed to conduct additional investigations. Aquifer testing will be conducted at existing monitor wells near PSR-2. Groundwater velocities and the potential impacts from PSR-2 will be estimated using the hydraulic conductivity, hydraulic gradient and an estimated porosity. The estimated velocity and potential extent of impact will be utilized to select locations for additional monitor wells. The groundwater investigation plan was discussed with the NRC during the August 29 through September 1 inspection, and in a letter to Cameco the NRC found the plan acceptable (NRC, 2011). Once the investigation is completed, Cameco will determine if the groundwater in the lower sandstone has been impacted by seepage at PSR-2.

3.11 References

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4.0 Effluent Control Systems

Section Summary: Section 4.0 describes effluent control systems for existing operations associated with the Smith Ranch SUA-1548 license areas and those that will be installed at the Reynolds Ranch Satellite and at the North Butte, Gas Hills and Ruth Remote Satellites. Effluent control systems that are discussed relating to existing satellites and yellowcake processing facilities will also be implemented at future satellite and processing facilities.

4.1 Gaseous and Airborne Particulates

The processes associated with ISR operations generate airborne effluents, liquid wastes and solid wastes (NRC, 2009). Historically, emissions from ISR operations are significantly lower than conventional mining and milling operations. The primary source of emissions is from the Smith Ranch CPP, the existing satellite IX facilities and additional future remote satellite IX facilities and their associated equipment and the refurbished Highland CPF.

Because the Smith Ranch Satellites, Reynolds Satellite, North Butte Remote Satellite, and Ruth Remote Satellite are strictly IX facilities and will have no precipitation of uranium, the only significant radioactive airborne effluent is Rn-222 (radon). Yellowcake slurry may also be produced at the Gas Hills Remote Satellite, but because it will be a wet product, again the only significant radioactive airborne effluent will be radon. At the Smith Ranch CPP, the primary effluent will be radon released during resin transfer operations. Uranium particulate emissions are related only to the yellowcake packaging area when product is being drummed. Because the dryers themselves are low emission vacuum dryers and contain no vent stacks, no uranium particulates are released to the atmosphere from the drying process (see Section 4.1.2).

4.1.1 Site Location and Layout

SUA-1548 utilizes IX satellites with IX resin loaded with uranium being transported to the CPP or CPF for elution, precipitation and drying. There are currently five satellite IX facilities at Smith Ranch, with one additional satellite IX facility to be constructed at the Reynolds Ranch satellite area. Remote satellites will be constructed at North Butte and Ruth, with two remote satellites planned for Gas Hills. At the satellites, periodic deliveries of bulk materials such as cement and sodium bicarbonate and other bulk reagents occur during the life of the operation. The bulk material handling systems have or will have proper bag houses to reduce emissions, and the deliveries are of an intermittent nature. Therefore, air particulates have historically not been a major concern and are not expected to be a concern at future facilities. Routine plant wash downs and good housekeeping techniques prevent the possibility of any dried salts from spills of uranium solutions from becoming a potential airborne hazard.

As mentioned above, the primary radioactive airborne effluent at the satellites is radon. Radon is found in the uranium rich lixiviant that comes from the mine unit wellfields into the IX facility. The uranium is separated from the groundwater by passing it through fixed bed IX units operated in a pressurized downflow mode. Vessel vents from the individual IX vessels are directed to a sump that is exhausted to the atmosphere outside the building.

A separate ventilation system is installed for all indoor non-sealed process tanks and vessels where radon or process gases would be expected. The system consists of an air duct or piping system connected to the top of each of the process tanks. Redundant exhaust fans direct collected gases to discharge piping that exhaust to the outside atmosphere. The design of the exhaust fans is such that the system is capable of limiting employee exposures even with the failure of any single fan. Discharge vents are located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Section 3.3 of NRC Regulatory Guide 8.31 (NRC, 2002a). Airflow through any openings in the vessels is from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Venting any released radon to the atmosphere outside the plant minimizes employee exposure.

Small amounts of radon may be released inside the satellite buildings via solution spills, filter changes, IX resin transfer, RO system operation during groundwater restoration, and equipment maintenance activities. Separate ventilation systems are used as needed for the functional areas within the plant to remove radon from the buildings. Radon is monitored at all facilities to measure potential exposure to employees. This monitoring program and results are provided in Section 5.0. The more than 20 years of radon sampling data show that there have been no negative impacts to employees, the public or the environment from radon. Since the Reynolds Ranch Satellite, North Butte, Gas Hills, and Ruth Remote Satellites will have the same equipment and ventilation systems, it is anticipated that there will be no impacts from radon at these facilities as well.

Since the satellite IX and yellowcake slurry processes are entirely wet processes and uranium is not dried at the facilities, there are no uranium particulate effluents. Spills inside the satellites are immediately washed down, thereby eliminating the potential for any buildup of radioactive particulates inside the building.

Small amounts of radon may also be released at the header houses via spills or during well sampling. Data collected indicate that these releases are minimal and occur on an infrequent basis. Each header house is equipped with an exhaust fan to remove any radon that is released in the buildings. Header houses associated with active mine unit wellfield pattern areas (production or restoration) are routinely monitored for radon. A total of four header houses are sampled each month rotating through a schedule ensuring that all header houses are sampled in a timely fashion. A review of radon monitoring records for header houses between 2000 and 2010 indicates that the average radon concentrations within the header houses did not exceed 10% of the derived air concentration (DAC) during the period. The same header house design will be used at all future satellites. Therefore it is anticipated that radon daughter levels from the header houses at the Reynolds Ranch Satellite, North Butte Remote Satellite, Gas Hills Remote Satellites and Ruth Remote Satellite will not create an exposure problem see **Table 4-1, Trend Analyses of Concentrations of Radon-222 Progeny in the Air**.

Other non-radiological particulate emissions are vehicle exhaust, fugitive dust from limited vehicular traffic and minor sodium bicarbonate releases during the filling of the outside storage vessel. Impacts from fugitive dust and vehicle emissions are described in Section 7.2 of this TR and Section 4.6 of the ER. Impacts from potential emissions from process chemicals (e.g., hydrochloric acid) that will be used at the plant are described in Section 7.2. There are no significant combustion related emissions from the process facility as commercial electrical power is available at the site. A backup diesel electrical generation system is installed at the CPP, CPF and each satellite facility, but the unit is located and vented to the atmosphere so as not to allow any exhaust to enter the building.

4.1.2 Smith Ranch Central Processing Plant

All yellowcake processing activities (elution, precipitation, drying, and packaging) are currently conducted at the Smith Ranch CPP. As described above, the dryers at the CPP are low emission vacuum dryers that do not have stacks venting to the atmosphere and therefore do not require emission stack testing. Operation of these vacuum dryers is as follows. The dryer is loaded with yellowcake slurry. Oil which has been heated to approximately 215°C (420°F) is pumped through an isolating jacket surrounding the drying chamber. The oil is heated by a gas fired heater in a closed loop system. The interior chamber containing the yellowcake is indirectly heated by the circulating hot oil. The yellowcake slurry will reach between 100°C to 420°C (210°F to 300°F) for approximately 12 hours. When the yellowcake slurry reaches the boiling point of water under vacuum, the water is flashed off as a vapor at approximately 79°C (175°F). This vapor is passed to a filter bag house which is directly connected to and located on top of the dryer shell. The baghouse removes particulates down to 5 micron. The solids from the filter baghouse are returned to the dryer for packaging. The filtered water vapor continues through a closed loop system to the condenser where the water vapor is condensed. The condensed water drains to a seal tank and is transferred for further processing and/or disposal. Liquid ring vacuum pumps are used to create the vacuum on the entire system, including the seal tank, condenser, filter baghouse and the dryers prior to and during the entire drying cycle. The discharge from the vacuum pump is directed to the dryer area enclosure. Air particulate sampling in this area is conducted monthly pursuant to NRC regulations and guidance. The average uranium concentration for 2011 was 6.21E-13 µCi/mL or approximately 0.1% of the DAC.

Similar to the satellite facilities, the primary source of radiological emissions from the CPP is radon, with a minor amount of particulate emissions from the dryer packaging system. Radon and particulates are routinely monitored at several locations within the CPP (see Section 5.0). Sampling results have not indicated an exposure problem for either radon or uranium particulates during the last renewal period. Other non-radiological minor emission sources include fugitive dust from bulk dry reagent deliveries, vehicular traffic and vehicle exhaust emissions. Radon is vented from the CPP in the same manner as described above for the satellites. Impacts from fugitive dust and vehicle emissions are described in Section 7.2 of this TR and Section 4.6 of the ER. Impacts from potential process chemical emissions (e.g., hydrochloric acid) used at the CPP are described in Section 7.2.

4.1.3 Highland Uranium Project Central Processing Facility

When the Highland CPF was operational, Cameco monitored the yellowcake dryer (calciner) and packaging scrubber exhaust stacks to determine the emissions rate of particulates, uranium, radium, and thorium to the atmosphere. Additionally, routine radon sampling was conducted throughout the facility. The CPF has been in a non-operating standby status since 2003 but is scheduled to be refurbished as an IX and yellowcake processing facility similar to what is currently being done at the Smith Ranch CPP, including low temperature, vacuum dryer systems. Therefore, uranium particulate emissions should not be an issue.

Cameco has proposed to complete the demolition and refurbishment of the Highland CPF in phases starting in early 2012. Phase 1 consists of infrastructure installation and upgrades including modernization of the building services, installation of a contractor support facility and new electrical substation. Phases 2 and 3 consist of interior building demolition activities and demolition of the existing dryer. Effluents during these phases are expected to be minimal. The two air stations (AS-4 and AS-5) will be recommissioned and utilized during Phases 2 and 3. This information was provided to the NRC in a letter dated September 15, 2011.

4.2 Liquids and Solids

4.2.1 Liquids

Liquid effluents from an ISR operation are generated during all phases of the uranium recovery process, including construction, operations, aquifer restoration, and decommissioning. As a result, there are several sources of liquid wastes. The potential waste water sources that exist at the Smith Ranch Project (SUA-1548) include the following.

4.2.1.1 Liquid Process Wastes

The operation of the IX process generates production bleed, the primary source of liquid waste, as discussed in Section 3.9. This bleed is treated for the removal of radium and selenium and is routed to surge ponds or storage tanks and eventually to the deep disposal well(s) or land application facility for disposal. The bleed may also be processed through reverse osmosis and sent again through the IX process before final disposal. Liquid process waste (bleed) from the Gas Hills Remote Satellite will be routed to evaporation ponds or possibly deep disposal wells. Other liquid process waste streams from the satellite plants, the CPP and the CPF include plant wash down water and spills collected in the sumps of the plant buildings. However, these other liquid process waste streams make up a very small portion of the total waste stream volume.

During mine unit wellfield development and operation, well stimulation (swabbing) and aquifer test waters are generated. Water collected from well swabbing is containerized and transported to the surge or storage ponds for eventual discharge to the deep disposal wells. Water collected during aquifer tests is containerized and can be used on-site as drilling water or for dust suppression. Depending on the quality of the aquifer test water, a temporary Wyoming Pollution Discharge Elimination System (WYPDES) discharge permit may be obtained for land application of the test water.

Aquifer Restoration

Following production, restoration of the affected aquifer commences which results in the production of additional wastewater. The current groundwater restoration plan described in Section 6.0 consists of three primary activities:

- Groundwater sweep;
- Treated water reinjection (typically RO treatment with permeate injection, as described in Section 6.0);
- Addition of a chemical reductant; and
- Potentially bioremediation.

Aquifer restoration using bioremediation should be considered as experimental at this time, although Cameco is actively researching the efficacy of bioremediation as a restoration treatment method. Only the groundwater sweep and groundwater treatment and reinjection activities generate waste water. During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of native aquifer water to sweep the affected wellfield area. The extracted water is sent directly to the wastewater treatment and disposal systems during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected wellfield area. An RO unit is used to reduce the total dissolved solids of the groundwater. The RO unit produces relatively clean water stream (RO permeate) and a high TDS waste water stream (RO reject). The permeate is injected back into the formation and the reject is sent to the RO/IX for further TDS reduction prior to disposal. The purpose of recycling the reject stream is to reduce the final volume of water needing to be discharged to the waste disposal systems. Chemical reducing (pH) agents such as sodium sulfide or biological reducing agents (R&D) are also employed during the groundwater treatment phase.

Water Collected from Well Field Releases

Water from wellfield releases consists of injection or recovery fluid recovered from areas where a liquid release has occurred from a well or pipeline. The water is collected and transported to the waste water disposal system for treatment and disposal using the deep well injection system or land application.

Water Collected at Header Houses

Water from header houses consists of injection or recovery fluids recovered from the sump or basement in the header house(s) where a liquid release has occurred. Each new header house basement floor has a sump and a sump pump capable of pumping any spilled fluids from the floor back into a production pipeline. Many of the older Smith Ranch header houses do not have concrete basements. A discussion of the conversion to header houses with basements is provided in Section 4.2.4.

Water Collected at Satellite Facilities

Water collected within a satellite consists of injection or recovery fluids recovered from the sump in the satellite building where a liquid release has occurred from a piping failure, tank or IX column leakage, or collection of plant wash down water. These fluids are pumped to a holding tank within the building and then pumped either to the deep disposal well(s) or, after treatment, to the land application system.

Water Collected at Deep Injection Wells

The well house at the deep injection well(s) contain a sump and sensor that allow detection of a release. Collected water from the well house is pumped back into the waste disposal system.

Water Collected at the Central Processing Plant/Central Processing Facility

Water collected at the CPP/CPF consists of IX fluids or yellowcake process fluids recovered from the sump in the CPP/CPF where a liquid release has occurred from a piping failure, tank or IX column leakage, or collection of plant wash down water. These fluids are pumped to a holding tank within the building and then pumped to the deep disposal well(s).

Water Collected from Bulk Reagent Storage Locations

Reagents and fuels stored outside and near the facilities are placed within bermed areas to provide secondary containment and meet the requirements of the Spill Prevention Control and Countermeasures (SPCC) regulations. The storage tank bermed area collects any spills, which are then removed for appropriate disposal. Accumulated storm water in the bermed area is allowed to evaporate as the bermed areas are engineered in accordance to the SPCC requirements.

Domestic Liquid Wastes

Domestic liquid wastes from the restrooms and lunchrooms are disposed in an approved septic system that meets the requirements of the State of Wyoming. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal. Liquid waste from the facility laboratories are disposed at the deep disposal wells. The septic system designs for all SUA-1548 facilities do and will meet all requirements of the State of Wyoming.

Storm Water Runoff

A final source of water is storm water runoff. Storm water management is controlled under WYPDES permits issued by the WDEQ-WQD. Facility drainage is designed to route storm water away or around the buildings, ancillary buildings and parking areas, chemical and fuel storage areas. The design of the facilities and procedural and engineering controls contained in a SWPPP utilizing BMP has been implemented at all facilities such that runoff is not considered to be a potential impact to the environment.

4.2.2 Liquid Waste Disposal

This section describes the liquid waste disposal methods for Smith Ranch (SUA-1548) facilities. As capacity is added to the CPP and/or satellites to meet production and restoration levels, disposal capacity is added in the form of deep disposal injection wells or approved alternative disposal methodologies. Additionally, Cameco plans to install a buried waste water transfer pipeline system which, when fully implemented, will allow disposal fluid to be transferred from all facilities (except the Reynolds Ranch satellite) to any waste disposal system. The Reynolds Ranch satellite facility will have its own dedicated deep disposal well. Storage tanks at each deep disposal well site will provide surge capacity within the system. To ensure the integrity of transfer lines, the flows leaving each facility will be compared to the flows arriving at each deep disposal well site. DEQ SR Plate OP-4 shows the proposed layout of the transfer piping system.

4.2.2.1 Smith Ranch Central Processing Plant Liquid Waste Disposal

Composition of waste streams to permitted deep disposal wells are liquid effluents from the project that include the production bleed streams, excess fluids from the elution and precipitation circuits, yellowcake rinse water, water softener regeneration, plant and satellite wash down water, CPP and satellite laboratory waste water, groundwater restoration bleed, and RO waste water.

The production bleed stream is approximately 0.5 to 1.5% (1% average) of the production flow. The bleed is taken after the IX units have removed the uranium. The bleed stream and wash down water from the Smith Ranch satellite IX facilities is transferred by pipeline to the CPP. The bleed is then commingled with other liquid effluents is either discharged to a deep disposal well, or alternatively to a RO unit. The resulting RO brine may be commingled with other plant water for disposal in the waste disposal system. The RO permeate may be used as process water for chemical makeup or returned to the production or restoration circuits. The RO brine may also be reprocessed through the RO/IX units. Excess liquids from the CPP elution and precipitation circuit and water softener regeneration are routed to lined storage ponds prior to deep well injection, or alternatively, routed directly to deep well disposal.

Deep Disposal Wells

Smith Ranch is currently (January 2012) permitted for ten Class I UIC injection wells to dispose of excess water generated by both operational and restoration processes. As of September 2011, eight of the ten wells have been installed and are operable. The two remaining wells to be constructed include SRHUP #7 and SRHUP #8. **Table 3-7** lists the well ID's, permits, authorized injection rates and analysis requirements for these disposal facilities. The wastes are injected into permeable portions of three Cretaceous-aged formations: the Parkman, Teapot, and Teckla sandstones, at depths below surface ranging from approximately 2,650 to 2,925 meters (8,700 to 9,600 feet). The waste water from the CPP is routed to deep disposal well SR1. The locations of these wells are shown on DEQ SR Plate OP-1. Cameco will comply with permit conditions identified within the individual UIC permits.

Waste Water Storage Ponds

Two small, lined storage ponds are in operation at the CPP. These ponds (East and West Storage Ponds) were initially constructed in 1981 and authorized under the Q-Sand Pilot Project and WDEQ Permit to Mine 633 and NRC License SUA-1387. These ponds are located just north of the CPP, and are used for limited process effluent storage prior to transfer to the deep disposal injection wells. The capacity of each pond is 0.10 hectare meter (0.78 acre feet) of water. Each pond is approximately 30 meters x 30 meters and 2 meters deep (100 feet x 100 feet and 8 feet deep). During operations, 0.9 meter (3 feet) of freeboard is maintained in each pond to protect the berms from wave action damage due to wind.

Each pond is constructed with a compacted sandy clay base overlain by a 30 millimeters thick Hypalon liner. The bottom of each pond has a two way slope toward the center. A sand layer is placed over the bottom of the pond with the synthetic liner on top of the sand. Each lined pond is constructed with a leak detection system consisting of a network of perforated pipes in a sand layer beneath the liner with the pipes draining to a collection sump. Should a leak in the liner occur, the water will flow through the sand, enter a perforated pipe and flow to the sump. Standard operating procedures (SOP) detail the monitoring program for the leak detection system. The monitoring program for the lined ponds includes either a fluid level sensor in each pond sump with an alarm displayed at the CPP or a daily inspection of each sump by an operator. The storage ponds are inspected daily for visual indications of leaks or embankment deterioration by an individual instructed in proper inspection procedures. The pond inspections are recorded and initialed by the inspector.

If 15.2 centimeter (6 inches) or more of fluid is detected in any leak detection system sump, it will be sampled and analyzed for chloride and conductivity. If analyses indicate a pond leak, and the analyses are confirmed, the LQD and NRC are notified by telephone within 24 hours after receiving the confirming analyses, and the water level in the pond with the indicated leak will be lowered by transferring the contents to another cell. A written report will be submitted to LQD and NRC within 30 days after the notification of the suspected leak and every 30 days thereafter until the leak is repaired. The reports will include the available analytical data, the corrective actions taken, and results of the actions. As long as water continues to flow to the sump, samples will be collected every 7 days and analyzed for chloride and conductivity. Additionally, once per month, a sample will be analyzed for bicarbonate, uranium, and sulfate as well as chloride and conductivity.

A total of 14 leak events have occurred at the East and West Storage Ponds since the previous license submittal. Based on the leak event investigations and associated corrective actions, leak events since the previous license submittal have been limited to minor breaches (e.g., small holes and/or tears) to the primary liner of the pond containment system. A discussion of the leak history and corrective actions is provided in Section 3.10.3.

4.2.2.2 Highland Central Processing Facility

When in operation, excess liquids from the CPF are disposed at the Morton 1-20 deep disposal well located approximately one mile north of the CPF. No liquid disposal from the Highland CPF currently exists as it has been on a standby status since 2003. However, as discussed in Section 4.1.3, the Highland CPF will be refurbished as an IX and yellowcake processing facility similar to what is currently being done at Smith Ranch CPP, including low temperature, vacuum dryer systems. Once the facility is operational, liquid waste will again be disposed of at the Morton 1-20 deep disposal well. Prior to utilizing this well, Cameco will evaluate the condition of the well and perform a MIT.

4.2.2.3 Smith Ranch Satellite Facilities

When not used for RO makeup, combined water from the production bleed stream, wash down water, and groundwater restoration excess water generated at Satellites 2 and 3 is currently treated for removal of uranium, and is then transferred to the Selenium Treatment Plant for removal of selenium and radium. The treated fluid is then pumped back to PSR-2 prior to disposal via land application at the associated pivot irrigator. As an alternative option, this waste water may also be disposed using deep disposal wells Volman 33-27 or SRHUP #9. PSR-1 and the associated pivot irrigator are currently (January 2012) not operational.

Waste water from Satellites SR-1 and SR-2 is disposed of by deep well injection. The waste water from the SR-1 are routed to deep disposal wells SR-2 and SRHUP #10 and deep disposal well SRHUP #6 services SR-2. **Table 3-7** provides additional information about these wells.

Satellite No. 1 Radium Settling Basins

The radium settling basins were constructed in 1987 to settle residual radium-barium sulfate out of the Satellite 1 waste water after filtration and prior to land application. The area consisted of two 0.4 hectare-meter (3 acre-feet) lined ponds located east of Satellite 1. Water that passed through these basins was then transported by buried pipeline to PSR-1 where it was stored prior to periodic land application.

Cameco has initiated decommissioning and reclamation of the radium settling basins. Most of the clay liner has been removed and disposed of as 11e.(2) byproduct material. A small amount of clay liner remains containing low levels of uranium and Ra-226. Assessments are being made to complete final reclamation and decommissioning of the basins.

Purge Storage Reservoir No. 1 and Associated Land Application Facility

PSR-1 is located east of Satellite 1 and was used to store treated mine unit operational purge water and treated water from Mine Units A and B restoration activities. The reservoir contains approximately 7 hectare-meter (54 acre-feet) when at full capacity. Water stored in the reservoir was periodically land applied by sprinkler irrigation on a 23 hectare (58 acre) irrigation area when weather conditions permitted. PSR No. 1 is currently not operating and contains no water. There is an on-going investigation at the PSR-1 and associated land application area, including annual sampling of soils and vegetation, to assist in determining the best management of the facilities in the future as well as the reclamation and surety requirements. PSR-1 and its associated land application facility will both either be decommissioned and reclaimed after the NRC has concurred with the Mine Unit B restoration and ACL application pending submittal by Cameco, or used again to provide additional waste water disposal capacity.

The PSR-1 Land Application Areas 1A and 1B are located east of Satellite 1 near PSR-1. The area consists of a center pivot irrigation system which covers 23 hectares (58 acres). There has been no land application at this site since restoration ceased at Mine Unit B in 2003. Monitoring requirements for vegetation, soils, and so on are included in **Table 3-3.**

Purge Storage Reservoir No. 2 and Associated Land Application Area

PSR-2 can contain approximately 39 hectare-meters (321 acre-feet) of water. The land application area comprises approximately 46 hectares (116 acres). The locations of Satellite 2, PSR-2, land application area and the 4-inch HDPE pipeline used to transport treated water from Satellite 3 to Satellite 2 and PSR-2 are shown on DEQ SR Plate OP-1.

Concerns about leakage of water from PSR-2 prompted a subsurface investigation to determine if groundwater had been impacted. A summary of the investigation and the results is provided in Section 3.10.3.2.

The PSR-2 Land Application Area is used for the disposal of purge and groundwater restoration fluids from mine units served by Satellites 2 and 3 after treatment at Satellite 2 for the removal of radium and selenium. During periods of land application, weekly samples are collected and analyzed for the parameters listed in **Table 3-4**.

Selenium Treatment Facility

A selenium treatment facility has been constructed and is operating at a location approximately 9 meters (30 feet) southwest of Satellite 2. The facility is connected to Satellite 2 and Satellite 3 through buried pipelines and houses the selenium treatment circuit. After selenium treatment, the water is returned to PSR-2 for wastewater disposal.

Satellite 2 and the Selenium Treatment Facility both process waste water currently being discharged into PSR-2 for subsequent land application. The selenium treatment facility provides selenium removal to a target concentration not to exceed average selenium levels of 0.1 mg/L. The average selenium concentration of all samples taken from the PSR-2 compositor irrigator sample port during the entire operating season (approximately March-October) must not exceed 0.1 mg/L selenium. Compliance sampling for selenium occurs at the irrigator suction line feeding the pivot.

The treatment facility includes a radium removal circuit that has replaced the radium removal currently being done at Satellites 2 and 3. Following radium removal, the remediation stream is processed in selenium removal columns. The spent media of the columns is cleaned in sand washing equipment. The wastes are disposed at a NRC licensed 11.(e)2 byproduct material disposal facility as described above.

4.2.2.4 North Butte Remote Satellite Facility

Class I UIC Wells

Cameco has an existing Class I UIC permit for two deep disposal wells at the North Butte Remote Satellite. This satellite facility will ultimately have four Class I UIC wells. The installation of these wells will be staged as needed for operation and restoration requirements. DEQ North Butte Permit Figure OP-16 shows the disposal well equipment layout within the satellite. In addition to the disposal wells, two surge ponds will be installed to provide for temporary storage of waste water prior to disposal into the deep disposal wells. Specific details pertaining to the operation of the deep disposal wells are provided in Section 3.6.6.3. Prior to operation of the disposal wells, Cameco will evaluate the components of the deep well disposal in reference to 10 CFR 20.2002 under a SERP and will consider the following:

1. The waste to be disposed of, including the physical and chemical properties important to risk evaluation, and the manner and condition of the deep well disposal;
2. An analysis and evaluation of the pertinent information on the nature of the affected environment;
3. The nature and location of potentially affected licensed and unlicensed facilities; and
4. Analysis and procedures to ensure that doses are maintained ALARA and within dose limits.

Surge Ponds

The North Butte Remote satellite includes the construction of a surge pond to temporarily contain waste water from the satellite facility. The overall pond dimensions will be approximately 85.3 meter by 103.6 meter (280 feet by 340 feet) and will be divided into two cells. The cell bottoms will have approximate dimensions of 15 meter by 36 meter (50 feet by 120 feet) and the pond side slopes will be constructed at 3:1 side slopes. The majority of the pond will be below grade and the second cell will provide redundancy. The pond location is shown on DEQ North Butte Permit Plate OP-1. Pond design details, the geotechnical investigation and final design report are provided in DEQ North Butte Permit Operations Plan Attachment OP-7 and are discussed in Section 3.6.6.3.

4.2.2.5 Gas Hills Remote Satellite

Evaporation Ponds

The Carol Shop Satellite Building will provide the final water treatment facilities for the Gas Hills Remote Satellite. The evaporation ponds, shown on DEQ Gas Hills Permit Plate OP-1E, are designed to be the primary waste water disposal mechanism at the Gas Hills Remote Satellite. The evaporation ponds will be constructed in phases to match the development and restoration needs of the satellite operation. Designs for Ponds 1 and 2 are provided on DEQ Gas Hills Permit Plate OP-2. Designs for Ponds 3, 4, 5, and 6 are provided on DEQ Gas Hills Permit Plate OP-2A. Evaporation pond design details are provided on DEQ Gas Hills Permit Plate OP-2B. Evaporation ponds will be constructed in pairs, i.e., Ponds 1 and 2, followed by Ponds 3 and 4, followed by Ponds 5 and 6. Design details for the evaporation ponds are provided in Section 3.6.7.6.

Class I UIC Wells

Cameco is investigating the feasibility of a Class I injection well(s) at the Gas Hills Remote Satellite as a disposal supplement to the planned evaporation ponds. If technically feasible, Cameco plans to add wastewater disposal via injection well(s) because (a) injection wells are less costly to operate and reclaim, and (b) there are fewer environmental concerns as compared to evaporation ponds. Use of injection wells disposes of concentrated process reject fluids underground, thereby eliminating the surface contamination concerns associated with evaporation ponds and greatly reducing the volume of 11e(2) solid material that will require over-the-road transport to distant licensed disposal facilities. Disposal of waste water using deep disposal wells will be assessed using 10 CFR 20.2002 as detailed in Section 4.2.2.4.

4.2.2.6 Ruth Remote Satellite Facility

All existing facilities at the Ruth Project are non-operational and on stand-by status. Currently, three buildings, two evaporation ponds and three monitoring wells remain on the property. Cameco has plans to extract uranium at Ruth within the next ten years, but an operations plan that details the mine unit layout, IX facility design and other details have yet to be developed. Cameco anticipates that deep disposal well(s) will be utilized at the Ruth Remote Satellite for waste water disposal.

4.2.3 Solid Wastes

Solid wastes generated at the Smith Ranch (SUA-1548) are expected to include 11.(e)2 materials (eg., spent resin, resin fines, miscellaneous pipe, pumps and fittings) and non 11.(e)2 wastes (eg., domestic trash and construction debris, empty reagent containers (totes and bags), etc.) which are separated into the following categories.

Uncontaminated Solid Wastes

Waste which is not contaminated with radioactive material or which can be decontaminated to unrestricted release criteria may include valves, instrumentation, process equipment, etc. Prior to release for unrestricted use, surveys for residual surface contamination are made and the results documented. To be released for unrestricted use, decontaminated materials must have activity levels lower than those specified in NRC guidance titled *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials"*, September 1984. Methods for decontamination and release of contaminated equipment are discussed in further detail in Section 5.8.6.4.

Cameco tracks the solid waste disposal at the Smith Ranch facility and estimates that the facility transports off-site approximately 32,659 kilograms of uncontaminated solid waste per year. Cameco anticipates that the North Butte and Gas Hills Remote Satellites will each produce approximately 329-

382 meters^3 (300-500 yards^3) of uncontaminated solid waste per year. The addition of the Reynolds Ranch satellite will increase the solid waste production for the Smith Ranch facility by an estimated 153 meters (200 yards^3) per year. Uncontaminated solid waste will be collected on the respective site and disposed of in the nearest sanitary landfill.

Domestic solid wastes from the restrooms and lunchrooms are disposed in an approved septic system that meets the requirements of the State of Wyoming. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal.

Byproduct Solid Wastes

Solid and liquid wastes that have become contaminated with uranium and uranium daughter products as a result of recovering uranium are called 11.e(2) byproduct material. These types of wastes may include: tanks, vessels, IX resin, filter media, process piping and equipment. It could also include fluids such as the production and restoration waste water streams as well as the solids remaining in the surge or evaporation ponds at the end of the Project.

All contaminated items that cannot be decontaminated to meet unrestricted use criteria release criteria are properly packaged, transported, and disposed at a disposal site licensed to accept 11e.(2) byproduct material. It is estimated that between 38 and 329 meters^3 (50 and 300 yards^3) of solid 11.e(2) byproduct material will be generated each year at the Smith Ranch (SUA-1548) Project sites. Annually, approximately 150,000 kilograms (330,000 pounds) of barium sludge will be shipped off-site for disposal. Those materials that cannot be decontaminated for unrestricted release will be stored in appropriately labeled and covered containers and will periodically be transported to an NRC licensed disposal facility. Cameco currently has a contract disposal agreement with Denison Mines (USA) Corp. for disposal at the White Mesa Mill in Blanding, Utah.

Hazardous Wastes

The potential exists for any industrial facility to generate hazardous waste as defined by the RCRA. In the State of Wyoming, hazardous waste is governed by WDEQ Hazardous Waste Rules and Regulations. Based on preliminary waste determinations conducted by Cameco in consideration of the processes and materials that are used at the project, Cameco will likely continue to be classified as a Conditionally Exempt Small Quantity Generator, defined as a generator that generates less than 100 kilograms of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. No pesticides or anti-freeze are stored on-site. Cameco expects that only used waste oil and universal hazardous wastes such as spent batteries, florescent light bulbs, etc. will be generated at the Smith Ranch (SUA-1548) Project. The used oil is burned for heating purposes and excess oil is recycled. In 2010, approximately 3,780 liters (1,000 gallons) of used oil was recycled. Cameco is committed to recycling universal wastes whenever possible.

4.2.4 Potential Release Events Involving Liquid Wastes

Spills from Well Houses, Pipelines and Header Houses

Wellfield header houses are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within them. The only instance in which these wellfield features could contribute to pollution would be in the event of a release of injection or recovery fluids due to a pipe or well failure. The possibility of such an occurrence is considered to be minimal as the piping will be leak checked first. In addition, the flows through the piping will be at a relatively low pressure and can quickly be stopped, thus any release would not migrate far. Piping from the wellfields to the header houses is typically buried, minimizing the possibility of an accident. Large piping leaks would quickly become apparent to the plant operators due to a decrease in flow and pressure, thus any release could be mitigated rapidly. All piping is leak checked prior to operation.

A conductivity probe or a level transducer is installed in each new header house to detect fluids on the floor and/or basement of the house. There are two separate alarm stages associated with the floor leak detection system. The first alarms when water is at a depth of a few inches at which time the sump pump will automatically start pumping water from the sump. The second alarms when water has reached a few feet in depth, indicating that the leak is larger than the sump pump can handle. If fluids are detected at the second alarm level, the PLC shuts down the injection flow and shuts off the production wells in the header house. A beacon on the outside of the header house activates in the event moisture is detected, and the PLC alarms on the main computer in the Control Room at the satellite facility that the header house has shut down. All newer header houses (as of March 2008), beginning with Mine Unit 15, Header House 17, have concrete basements to prevent spilled fluids from soaking into the soil. All additional header houses 15-18 through 15-23 also have concrete basements and all of MU-9 and MU-K-6 through K-9 currently have this style of basement as will all new constructed header houses. Each newer header house basement has a sump and a sump pump capable of pumping any spilled fluids from the floor back into a production pipeline. The flow from individual production and injection wells is measured using turbine meters which are located in the header house. The individual well flows are measured and adjusted daily. A flow meter is used to measure the total production and injection flow rates from each header house. At all new header houses, the flow meters' instantaneous flow rate is monitored by the PLC. The PLC sends an alarm to the satellite in the event of a flow problem. High and low flow limits are set for each well, and the well automatically shuts down if the limits have been exceeded. The automatic shutdown of a well triggers an alarm at the satellite. A high flow alarm for an injection well may indicate a break in a line between the injection wellhead and the header house. A low flow alarm for a production well may indicate a leak between the pump and the header house. The run status of all production pumps is monitored continuously enabling the pumps to be stopped and started remotely. Additionally, each new header house can be remotely shut down from the satellite.

As discussed above and in Section 3.6.5.1, the above discussions pertain to header houses constructed from March 2008 forward. Basement free header houses were constructed at Mine Units D, F, E, H, I, J, and headerhouses K1-K5. Furthermore, many of the older header houses do not have PLC based controls. Older wellfields prior to Mine Unit K and 9 do not have basements nor are there plans to install basements.

In general, trunk line piping from the plant to the header houses and within the wellfield is constructed of HDPE with butt welded joints or the equivalent. All pipelines are pressure tested before being buried and placed into operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the piping. In addition, underground pipelines are protected from a major cause of potential failure, which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes will be at the central plant, at the wellheads, and in the header houses in the wellfields. Main trunkline flows and manifold pressures are monitored for process control.

The older header houses are fitted with pneumatic valves and a straight line pipe configuration. These valves called Cla-Vals in the older header houses have responded accordingly during power outages. It is only in the newer header houses where the pipeline configuration has included the use of a 90 degree "T" in the line that failure of the pneumatic valve has been noted; most recently at the May 3, 2011 Mine Unit 15A spill in the wellfield serviced by header house HH15-20. This failure was due to a pressure variance caused by the lack of power, essentially creating a hammer effect and causing the Cla-Vals to fail.

As a result, those new header houses equipped with a 90 degree "T" in the pipeline and Cla-vals will be identified and replaced with a mechanical valve. The mechanical valve would shut off the flows at the header house on any indication of a spill or power outage. Also, when there is a power outage, the phase indicator will alarm in the satellites.

In a letter to NRC dated July 30, 2007 (related to an H-wellfield release) it was indicated that bell holes were retro-fitted with leak indicators. All new installations, in areas where fiber optics are being used, will be installed with "wet sump" detectors that alarm to the nearest satellite plant. Additionally, all header houses, starting in Mine Unit K, header house 6, utilize wellhead leak detection devices. For all future wellfields, the well heads will be fitted with leak detection systems. Older wellfields have not been retro-fitted as it would potentially create a greater chance for a fluid release than leaving them in their current status.

Engineering and administrative controls are in place at the satellite facilities to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

Satellite Facilities

The satellite and remote satellite facilities are a major component of the ISR operations at the Smith Ranch (SUA-1548) Project. Therefore, the satellite plant areas have the greatest potential for spills or accidents resulting in the release of fluids containing radioactive materials. Spills could result from a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure. New satellite facilities will be constructed for the Reynolds Ranch, North Butte, Gas Hills and Ruth expansion areas, and the engineering design for these facilities will incorporate proven designs from the Smith Ranch satellites along with new features.

The design of the satellite plant building is such that any release of liquid waste would be contained within the structure. A concrete curb is built around the entire process building. This pad is designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut down, limiting any release. Liquid inside the building, both from a spill or from wash down water, will be drained through a sump and sent to the liquid waste system.

Similar to the header houses, a conductivity probe or a level transducer is installed in the satellite plant building to detect fluids on the floor and/or sump of the building. There are two separate alarm stages (high and high/high) associated with the floor leak detection system. The first alarms when water is at a depth of a few inches at which time the sump pump automatically starts pumping water from the sump. The second alarms when water has reached a few feet in depth, indicating that the leak is larger than the sump pump can handle. If fluids are detected at the second alarm level, the PLC shuts down the injection flow and shuts off the production wells. Each satellite building has leak resistant floors, berms and water stops to prevent spilled fluids from soaking into the soil or leaving the building.

Deep Disposal Wells

The design of the deep disposal well houses and wellheads are such that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Released fluids inside the building are contained and managed as discussed in Section 4.2.2.1.

Surge Ponds

For the North Butte Remote satellite facility, the two-celled double-lined surge pond will be constructed with a leak detection system consisting of a network of perforated pipes between the primary and secondary liners with the pipes draining to a collection sump. Should a leak in the liner occur, the water will enter a perforated pipe and flow to a sump. SOPs will detail the monitoring program for the leak detection system. The monitoring program for the lined ponds will include either a fluid level sensor in each pond sump with an alarm displayed at the satellite or a daily inspection of each sump by an operator. The storage ponds will be inspected daily for visual indications of leaks or embankment deterioration by an individual instructed in proper inspection procedures. The pond inspections will be recorded and initialed by the inspector.

If 15.2 centimeters (6 inches) or more of fluid is detected in any leak detection system sump, it will be sampled and analyzed for chloride and conductivity. If analyses indicate a pond leak, and the analyses are confirmed, the LQD and NRC will be notified by telephone within 24 hours after receiving the confirming analyses, and the water level in the pond with the indicated leak will be lowered by transferring the contents to another cell. A written report will be submitted to LQD and NRC within 30 days after the notification of the suspected leak and every 30 days thereafter until the leak is repaired. The reports will include the available analytical data, the corrective actions taken, and results of the actions. If water continues to flow to the sump, samples will be collected every seven days and analyzed for chloride and conductivity. Additionally, once per month a sample will be collected and analyzed for bicarbonate, uranium, and sulfate. A freeboard of at least 1.5 meters (5 feet) will be maintained in each pond to prevent loss of waste water by wave action and to allow for holding the contents of another pond on a temporary basis in the event of a leak

Evaporation Ponds

The evaporation ponds at the Gas Hills Remote Satellite will be visually inspected on a daily basis to insure that the system is operating normally. Visual inspections will also include a general inspection of the condition of all ancillary features including the exposed liner above the water surface, the berm, fences and any diversion and/or storm runoff control measures. In addition, the leak detection manhole will be visually inspected daily and the sump pump tested at least once every two weeks. These inspections will be documented and maintained on site. If at any time flow from the leak detection sump pump is observed, a water sample will be collected and analyzed for chloride, bicarbonate and conductivity. Should the analysis indicate that a pond is leaking a verification sample will be collected within 24 hours of receipt of the first analysis results. If the analytical results of the verification sample verify that the pond is leaking, the NRC and LQD will be notified by telephone within 24 hours of verification. Within 30 days of the verbal notification, a written report will be submitted to NRC and LQD. The report will include analytical data and describe mitigative actions and the results of those actions. Once every seven days during the leak and for two weeks following completion of repairs, water samples will be collected from the leak detection sump and analyzed for chloride and conductivity. Additionally, once per month while the pond is leaking, water samples will be collected from the leak detection sump and analyzed for the suite of parameters contained in LQD Guideline 8, Appendix 1.

Once a leak has been verified and reported, the contents of the leaking pond will be transferred into another pond or ponds, and an investigation will be conducted to determine the source of the leak. This investigation will include inspection of the manhole and individual drain line clean out systems. Once the source of the leak has been identified, appropriate actions will be taken to repair any damage to the system.

Once the pond has been repaired and tested, the agencies will be notified verbally or in writing (via a letter or e-mail) that the pond has been repaired and is being put back into service. A final report describing all remedial and repair activities will be provided to the agencies within 60 days after repairs have been completed.

4.3 Contaminated Equipment

Surface contamination surveys will be conducted of potentially contaminated equipment and materials before they are released to unrestricted areas. The applicable surface contamination limits are provided by NRC, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials, September 1984. A comprehensive radiation survey will be made in conformance with these guidelines, which establishes that contamination is within the limits specified in the referenced guidelines and is as low as is reasonably achievable before release of the equipment or material for unrestricted use.

If contamination above these limits is detected, the equipment or material will be decontaminated until the limits are satisfied, or the item will not be released to unrestricted use. Radioactivity on surfaces will not be covered by paint, plating, or other covering unless contamination levels, as determined by a survey and documented, are below the aforementioned limits before application of the covering. A reasonable effort will be made to minimize the contamination before use of any covering. The radioactivity of the interior surfaces of pipes, drain lines, or duct work will be determined by making measurements at all traps and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or duct work.

4.4 References

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U.S. Nuclear Regulatory Commission (NRC). 1984. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source, and Special Nuclear Material", September.

5.0 Operations

Section Summary: Section 5.0 provides for administrative operations at Cameco such as corporate structure, management programs, personnel requirements, training, security, etc. and applies to all SUA-1548 sites. Many of the titled sections have been reviewed and approved in past submittals to the NRC; however, sections containing updates and revisions since the last renewal are summarized below.

Section 5.1 presents Cameco's organizational structure. Many of the position descriptions have been modified for clarification of roles, responsibilities and reporting structure to ensure compliance with the NRC regulations and provide safe working conditions. Of note, the Director, Radiation Safety and Licensing, Section 5.1.1.4 is a position SERP'd in during the renewal period. Likewise, the Corporate Radiation Safety Officer, Section 5.1.1.6 is a new position presented in this renewal.

Section 5.2 addresses the management control program which has remained relatively unchanged since the last renewal as has most of Section 5.3, which describes the internal inspections, audits and reports performed at Smith Ranch SUA-1548 with the exception of Section 5.3.2 Annual ALARA (as low as reasonably achievable) Audits. This section has been updated to include a summary of the ALARA reports, by year, with regard to the major actions resulting in reduced radiological exposures.

Sections 5.4 through 5.9 contain revisions and updated and/or new information for this renewal. Section 5.4 includes new detailed qualification requirements for personnel administering the radiation safety program. Section 5.5 describes training programs which have been revised to include training requirements for visitors and contractors to the sites. Section 5.6 presents the DOT Hazardous Materials Training Program never before reviewed. Section 5.7 deals with security which has been updated since the last renewal to include new security measures. Section 5.8 addresses radiation safety controls and monitoring all of which have been reviewed in past renewals. However, many of the subsections present summaries of data collected between 2000 and 2010 as well as the historical data. Additionally, a new section discussing prenatal and fetal exposure is presented in Section 5.8.3.4. Section 5.9 contains new and updated information and data regarding environmental monitoring, plus new information related to the remote satellite facilities. Additionally, data provided in semi-annual reports submitted to the NRC have been tabulated by subsection topic and trended for discussion.

5.1 Corporate Organization and Administrative Procedures

Required NRC licenses, amendments and financial surety arrangements/mechanisms are issued in the name of PRI, a wholly owned subsidiary that does business as Cameco.

Cameco is committed to conducting operations at all of its operations in compliance with applicable parts of 10 CFR Chapter 1 as well as all conditions provided by NRC in SUA-1548, and will maintain a performance-based approach to the management of the environment, health and safety program, including radiation safety. The Safety Health Environment and Quality Management System (SHEQMS) encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes company-wide involvement, from the individual worker to senior Cameco management.

5.1.1 Corporate Organization and Responsibilities for Safety

Figure 5.1, Cameco Organizational Chart provides a partial organization chart for Cameco with respect to the operation of the Smith Ranch SUA-1548 license areas, including North Butte, Gas Hills and Ruth Remote Satellites, and represents the management levels that play a key role in the SHEQMS and may serve a functional part of the SERP described in Section 5.2.3. This organization allows environmental, health, industrial safety, and radiation safety matters to be considered at any management level.

5.1.1.1 Board of Directors

The Board of Directors has the ultimate responsibility and authority for radiation safety and environmental compliance for all activities at the Smith Ranch SUA-1548 license areas. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of Cameco.

5.1.1.2 President

The President is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises the General Managers and Director, Radiation Safety and Licensing. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs. He/she is responsible for ensuring that operations staff are complying with all applicable regulations and permit/license conditions through direct supervision of the General Managers and Director, Radiation Safety and Licensing.

5.1.1.3 General Manager

The General Managers are responsible for managing day-to-day operations at all Smith Ranch SUA-1548 license areas and report directly to the President. The General Managers are responsible for ensuring that site personnel at Smith Ranch and at the North Butte, Gas Hills, and Ruth Remote Satellites comply with Industrial Safety, Radiation Safety, Environmental Protection Programs, and all relevant state and federal regulations.

The General Managers have the responsibility and authority to suspend, postpone or modify, immediately, if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The General Managers cannot unilaterally override a decision for suspension, postponement or modification if that decision is made by the Manager, Safety Health Environment and Quality (SHEQ), or the Radiation Safety Officer (RSO).

5.1.1.4 Director, Radiation Safety and Licensing

The Director of Radiation Safety and Licensing reports directly to the President, is responsible for submitting quality permit and license applications to appropriate regulatory agencies and will manage the approval process. The position will also act as a resource to site SHEQ managers and ensure that permit conditions, agency responses, revisions, and, other Cameco SHEQ requirements are met. The Director, Radiation Safety and Licensing has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment or potentially become a violation of state or federal regulation. The Director, Radiation Safety and Licensing supervises the Corporate Radiation Safety Officer (CRSO).

5.1.1.5 Manager, Safety Health Environment and Quality

Reporting directly to the General Manager, the Manager, SHEQ oversees all Industrial Safety, Health, Environmental and Quality Programs as stated in the SHEQ Management System at the site(s). This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager, SHEQ has the responsibility and authority to suspend, postpone, or modify any activity that is determined to be a threat to employees, public health, the environment or potentially a violation of state or federal regulations.

5.1.1.6 Corporate Radiation Safety Officer

The CRSO is primarily responsible for ensuring a consistent application of Cameco's Radiation Safety Program, Regulatory Guides, Regulations, interpretation of sampling/surveying results, assisting with license amendments and internal reviews, as needed.

The CRSO reports directly to the Director, Radiation Safety and Licensing while overseeing and supporting the site RSO. The CRSO has the responsibility and authority, through appropriate line management, to suspend, postpone, or modify any work activity that is unsafe or potentially a violation of NRC regulations or license conditions, including the ALARA program.

5.1.1.7 Radiation Safety Officer

Reporting directly to the General Manager, the RSO is responsible for the daily supervision of the radiation safety programs at company operations. The RSO has a secondary reporting requirement to the CRSO. Responsibilities include the development and implementation of all radiation safety programs and ensuring that all records are correctly maintained. The RSO will work with the Manager, SHEQ to ensure compliance with the NRC regulations and license conditions applicable to public and worker health.

The RSO conducts and/or oversees training programs for the supervisors and employees with regard to the proper application of radiation protection procedures. The RSO or a designee inspects facilities to verify compliance with all applicable radiological health and safety requirements. The RSO has the responsibility and the authority, through appropriate line management, to suspend, postpone, or modify any work activity that is unsafe or potentially a violation of NRC regulations or license conditions, including the ALARA program. The position of RSO may be fulfilled on an interim basis by the CRSO or the Director of Radiation Safety and Licensing. Depending on the level of activity at the site, the RSO may also fulfill the responsibilities of the Health Physics Technician (HPT).

5.1.1.8 Health Physics Technician

The HPT conducts radiological surveys, collects air, water, soil and vegetation samples, performs analyses and collects data for the radiation safety program, performs calculations of employee radiation exposures, keeps records, and conducts various other activities associated with implementation of the environmental and radiation protection programs. The HPT reports directly to the RSO.

5.1.2 ALARA Policy

The purpose of the ALARA Policy is to keep exposures to all radiation as low as possible and to as few personnel as possible, taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

In order for an ALARA Policy to correctly function, all individuals, including management, supervisors, health physics staff, and workers, must take part and each share in the responsibility to keep all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each.

5.1.2.1 Management Responsibilities

Consistent with Section 1.1 of NRC Regulatory Guide 8.31, the licensee management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These shall include:

- The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;

- An Annual Audit Program which reviews radiation monitoring results, and procedural and operational methods;
- A continuing evaluation of the Health Physics Program including adequate staffing and support; and
- Proper training and discussions which address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.2.2 Radiation Safety Officer Responsibility

The RSO is responsible for ensuring technical adequacy, proper radiation protection, and the overall surveillance and maintenance of the ALARA program including the following:

- Development and administration of the ALARA program;
- Possess sufficient authority to enforce regulations and administrative policies that affect any aspect of the Health Physics Program;
- Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the Health Physics Program;
- Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
- Assist with conducting Annual ALARA Audits with Management to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
- Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
- Conduct or designate daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.1.2.3 Supervisor Responsibility

Supervisors are the front line personnel responsible for implementing the ALARA program. Each shall be trained and instructed in general radiation safety practices and procedures. Their responsibilities include:

- Adequate training to implement the general philosophy behind the ALARA program;
- Provide direction and guidance to subordinates to enable adherence to the ALARA program;
- Enforcement of rules and policies as directed by regulatory agencies and company management; and
- Seek additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.1.2.4 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

- Adherence to all rules, notices, and operating procedures as established by management and the RSO;
- Making valid suggestions which might improve the ALARA program;
- Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an unacceptable increased radiological hazard;
- Proper use and fit testing of any respirator; and
- Proper use and returning of any bioassay sample kit at its required time.

5.2 Management Control Program

5.2.1 Safety, Health, Environment and Quality Management System

Cameco's SHEQMS formalizes the approach and ensures consistency across its operations. The management system is a key element assuring that management demonstrates "due diligence" in addressing SHEQ issues and describes how the operations of the facility will comply with the requirements of the Cameco SHEQ Policy and Regulatory requirements.

The SHEQMS:

- Assures that sound management practices and processes are in place to ensure that strong SHEQ performance is sustainable.
- Clearly sets out and formalizes the expectations of SHEQ management.
- Provides a systematic approach to the identification of SHEQ issues and ensures that a system of risk identification and management is in place.
- Provides a framework for personal, site and corporate SHEQ responsibility and leadership.
- Provides a systematic approach for the attainment of Cameco's SHEQ objectives.
- Ensures continued improvement of SHEQ programs and performance.

The SHEQMS has the following characteristics:

- The system is compatible with the ISO 14001 Environment Management System.
- The system is straightforward in design and is intended as an effective management tool for all types of activities and operations, and is capable of implementation at all levels of the organization.
- The system is supported by standards that clearly spell out Cameco's expectations, while leaving the means by which these are attained as a responsibility of line management.
- The system is readily auditable.
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their SHEQ objectives while satisfying Cameco's governance requirements.

The SHEQMS uses a series of standards that aligns with specific management processes and sets out the minimum expectations for SHEQ performance. The standards management processes consist of assessment, planning, implementation (including training, corrective actions, safe work programs, and emergency response), checking (including auditing, incident investigation, compliance management, and reporting), and management review. Cameco has developed procedures consistent with these standards and regulatory requirements to implement these management controls. The procedures are contained in the following eight volumes:

Volume 1 — Management System Manual
Volume 2 — Management Procedures
Volume 3 — Operating Procedures
Volume 4 — Health Physics Manual
Volume 5 — Health and Safety Manual
Volume 6 — Environmental Manual
Volume 7 — Training and Awareness Manual
Volume 8 — Emergency Procedure Manual

5.2.2 Performance-Based License Condition

Pursuant to 10 CFR 40.44, SUA-1548 is a Performance-Based License (see License Condition 9.4 of SUA-1548), and under that license condition, Cameco may, without prior NRC approval or the need to obtain a License Amendment:

- Make changes to the facility or process, as presented in the license application (as updated);
- Make changes in the procedures presented in the license application (as updated);
- Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval will be necessary prior to implementing a proposed change, test or experiment if the change, test or experiment would:

1. Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
2. Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system or component important to safety previously evaluated in the license application (as updated);
3. Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
4. Result in any appreciable increase in the consequences of a malfunction of any structure, system or component previously evaluated in the license application (as updated);
5. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
6. Create a possibility for a malfunction of any structure, system or component with a different result than previously evaluated in the license application (as updated);
7. 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 EA or technical evaluation report or other analyses and evaluations for license amendments; and
8. For purposes of this paragraph as applied to this license, structure, system or component means any structure, system or component which has been referenced in a staff SER, TER, EA, or EIS and supplements and amendments thereof.

Additionally, the licensee does not require a license amendment if the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or final SER, TER, and EIS or EA. This would include all supplements and amendments, and technical evaluation reports, EAs, EISs issued with amendments to this license.

5.2.3 Safety and Environmental Review Panel

Determination by Cameco of compliance concerning the above listed conditions is made by a SERP. The SERP consists of a minimum of three individuals. One member of the SERP will have expertise in management and will be responsible for managerial and financial approval for changes; one member will have expertise in operations and/or construction and will have expertise in implementation of any changes; and one member will be the RSO, or equivalent. Other members of the SERP may be utilized as appropriate, to address technical aspects of the change, experiment or test, in several areas, such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP procedure will be used to evaluate all major changes, experiments or tests at the facility as outlined in the SHEQMS, Volume II, *Management Procedures*. The changes may be derived from operational and/or economic considerations and can include changes dictated by regulatory requirements including state and federal agencies outside of the NRC organization. The SERP will be responsible for ensuring that any such changes result in no degradation in the essential safety or environmental commitments of Cameco. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. The committee will report their findings to the full SERP for a determination of compliance with License Condition 9.4.

The SERP will implement the following reviews during their evaluation of proposed changes to the facility operations:

Compliance Review

- The SERP will conduct a review of the most current NRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment will be necessary before initiating the change. This review will include information included in the approved license application.
- The SERP will determine if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment will be necessary.
- The SERP will review whether the change, test, or experiment is consistent with NRC's conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include any SERs, technical evaluation reports, EAs, or EISs prepared to support issuance of or amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.
- The SERP will review the change, test or experiment to assure there is no degradation in the essential safety or environmental commitments in the license application or approved reclamation plan.
- The SERP will review the proposed action to determine if any adjustment to the financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased

accordingly. The surety estimate must be approved through a license amendment by the NRC.

Upon completion of the review, the SERP will document its findings, recommendations, and conclusions in a written report. All members of the SERP will sign concurrence on the final report. If the report concludes that the action meets the appropriate performance-based license condition requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why, and what course Cameco plans to pursue. The SERP report will include the following:

1. A description of the proposed change, test, or experiment (proposed action);
2. A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified);
3. The technical evaluation of the proposed action including all applicable aspects of the SERP review procedures listed above;
4. Conclusions and recommendations;
5. Signatory approvals of the SERP members; and
6. Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the performance-based license condition will be maintained by the RSO until the NRC license is terminated. Copies of the SERP report will be distributed to the General Manager and members of the SERP.

On an annual basis, Cameco will submit a report to the NRC that describes all changes, tests, or experiments made pursuant to the performance-based license condition. The report will include a summary of the SERP evaluation of each change. Additionally, any replacement pages of the License Application and/or supplementary information reflecting changes made to the license application as a result of the performance-based license condition will also be provided with each annual report. Each replacement page will include both a change indicator for the area of change, (e.g., highlighted text in italics or underline or bold marking vertically in the margin adjacent to the portion actually changed), and a page change identification, (date of change or change number, or both).

5.2.4 Standard Operating Procedures

Written SOPs have been established for all operational activities involving source and 11e.(2) byproduct materials that are handled, processed, stored, or transported by employees. The procedures enumerate pertinent radiation safety procedures to be followed. Written procedures have also been established for in-plant and environmental monitoring, bioassay analysis, and instrument calibration for activities involving radiation safety. A copy of the written procedure is kept in the area where it is used. All procedures involving radiation safety are reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO and/or his designee(s) review the SOPs annually.

5.2.5 Radiation Work Permit

In the case that employees are required to conduct activities of a non-routine nature where there is the potential for significant exposure to radioactive materials and for which no SOP exists, a Radiation Work Permit is required. The Radiation Work Permit describes the scope of the work, precautions necessary to maintain radiation exposures ALARA, safety equipment or specialized clothing, and any supplemental radiological monitoring and sampling to be conducted during the work. The Radiation Work Permit is reviewed and approved in writing by the RSO, HPT (or qualified designee by way of specialized training in the absence of the RSO or HPT) prior to initiation of the work.

5.2.6 Facility Posting

NRC regulations in 10 CFR Parts 19 and 20 require that licensees post signs, labels, notices to employees, copies of licenses, and other items. The SHEQ staff conducts periodic surveys to ensure that these required postings are current and meet the applicable standards. NRC license conditions allow posting the entire facility with signs that state "Any area within this facility may contain radioactive material". Use of these signs at all facility entry points meets the requirements of 10 CFR 20.1902 in lieu of posting each building or room with "Radioactive Material" signs. "Airborne Radioactivity Areas" and "Radiation Areas" must be posted in accordance with the requirements in 10 CFR 20.1902.

5.2.6.1 Airborne Radioactivity Area Posting Requirements

In order to ensure that the exposure of workers and other persons to radioactive materials is ALARA, NRC regulations require that any room, enclosure, or area that contains airborne radioactive materials in excess of the applicable DAC, or the concentration of airborne radioactive materials are such that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6% of the annual limit on intake (ALI), or 12 DAC-hours, be posted as an Airborne Radioactivity Area. The determination of whether an area meets the definition of an Airborne Radioactivity Area must consider all radioactive materials present in the air. If a combination of radon daughters and airborne uranium is present in an area, their concentrations divided by the appropriate DAC should be added and the unity rule applied and compared with the criteria from 10 CFR 20.1003.

Persons entering areas posted as Airborne Radioactivity Areas must wear the proper respiratory protection as determined by the RSO under the instructions contained in the Respiratory Protection Program. Airborne Radioactivity Areas are posted with signs saying "Caution Airborne Radioactivity Area".

5.2.6.2 Posting Radiation Areas

One purpose of gamma surveys is to identify Radiation Areas so that they may be properly posted. The NRC requires that any area where the gamma exposure rates are high enough that a major portion of the body of an individual could receive a dose in excess of 0.005 rem in an hour at 30.5 centimeters (12 inches) from the radiation source or any surface that the radiation penetrates be designated and posted as a Radiation Area (10 CFR 20.1003). If the results of a gamma survey indicate dose rates at or above this level, the area must be posted as a Radiation Area. Areas where gamma dose rates are approaching 5 mrem/hour should be carefully surveyed on a more frequent basis to ensure posting requirements are met. In addition, gamma dose rates approaching 7 mrem/hour should be carefully surveyed on a more frequent basis to ensure clean out procedure requirements are met. A list of Radiation Areas should be prepared (or revised) after each survey and maintained by the RSO or designee. Regulatory Guide 8.30 recommends that the number of areas on the list be held to a manageable number. Tanks, columns, rooms, and miscellaneous items that have a known history in other areas to become a posted radiation area, will be posted as such.

5.3 Cameco Management Audit and Inspection Program

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily Radiation Safety Officer Inspections

The RSO, HPT, or trained designee conducts a daily facility inspection. The purpose of the walk-through inspection is to ensure proper implementation of radiation safety requirements and standard operating procedures.

The RSO will determine the specific areas at the facility that will be included in the daily inspection based on the potential for radiological hazards and specific license requirements. The inspection is primarily a visual inspection to ensure that process designs and procedural methods for maintaining exposures ALARA are being implemented and used correctly. During the walk through inspection, the RSO, HPT, or trained designee will document on a standard inspection form or in a log book the results of the inspection. The documentation contains the radiological/safety hazards examined.

In all areas where corrective actions are needed the appropriate employee or supervisor will be notified. A Radiation Work Permit will be issued if the RSO or designee determines a significant radiological hazard or potential hazard exists and for which there is no SOP.

Although the inspection helps ensure a satisfactory working environment, it cannot replace the employees' or supervisors' role in maintaining exposures ALARA. The walk through inspection is intended to assist both supervisory personnel and employees in maintaining an awareness of the potential radiological hazards and to institute preventative or corrective measures.

5.3.1.2 Weekly Radiation Safety Officer Inspections

The RSO and the facility manager or their designees shall perform a weekly inspection of all facility areas to observe general radiation safety practices and review required changes in procedures and equipment. In addition the following items should be reviewed:

- Housekeeping;
- Thermoluminescent dosimetry (TLD) badge usage/storage;
- Buildings secure or occupied;
- Byproduct material storage areas secure and signs posted;
- Radiological signs posted and in good condition; and
- Operator Log Book.

5.3.1.3 Monthly Radiation Safety Officer Inspections

On a monthly basis, the RSO or designee will review all monitoring and exposure data for the month. The RSO will prepare a written summary of the significant radiological protection activities including a summary of personnel exposure data, including bioassays and time weighted calculations; a summary of all pertinent radiation survey records; and a summary of daily and weekly inspection results. The monthly summary will specifically address any trends or deviations from the ALARA program, including an evaluation of the adequacy of implementation of license conditions regarding radiation protection and ALARA. The summary will provide a description of the unresolved problems and will propose corrective measures.

5.3.2.1 ALARA Improvements

Major improvements in engineering controls have continued to be explored and implemented where practical. Some of the major actions that resulted in reduced releases to the work environment and/or reduced radiation exposure are noted below as reported in the Annual ALARA audit reports:

Calendar Year 2000: Exhaust fans were relocated closer to the floor in the Satellite Facilities to reduce Rn-222 in the buildings.

Calendar Year 2001: "P-traps" located on tanks in both the plant and satellites have been extended with a clear plastic tube allowing operators to easily recognize when traps require additional water to minimize the potential escape of Rn-222. The sump located under the shaker deck has been vented through the ceiling of the plant to assist in the removal of potential Rn-222.

Calendar Year 2002: An in-depth risk screening and assessment was conducted for 17 identified potential hazards. Vacuum pumps were removed from the dryer area for ease of access to maintenance while minimizing exposures and enhancing housekeeping. The resin transfer from trailers was redesigned to include a closed bottom feed rather than an open hole in the top, minimizing escape of Rn-222 during resin transfers.

Calendar Year 2003: It was recommended that the Hammermill and associated piping systems be redesigned at the Highland CPF to minimize the release of airborne particulates during drying operations (was not implemented because the CPF was placed in standby).

Calendar Year 2004: A new dryer bag house was constructed, and Smith Ranch CPP exhaust fans and resin traps were installed. A motor activated value was installed on injection trunk lines in the header houses in the mine unit prior to bringing the mine unit on line. The motor activated value reduces the amount of injection fluid potentially released in an upset condition.

Calendar Year 2005: Improvements were made to CPP dryer A, and a drum vibrator and audible alarms were installed on Rn-222 prisms (monitors).

Calendar Year 2006: Maintenance and improvements on CPP Dryer A were made. Ventilation fans on tanks T-20 and T-21 were installed, and additional ventilation hoses were provided in the CPP. Existing overhead fans were moved closer to floor level to reduce Rn-222 concentrations in the CPP.

Calendar Year 2007: Due to an increase in radiation dosimeter readings for CPP operators, several actions were undertaken after it was realized that the malfunction of a sand filter allowed more solids to build up in tanks, creating higher exposure rates. A procedural change was made to establish an action level of 8 mrem/hour for tank cleanout and 10 mrem/hour as a tank tag out level. Cameco provided real-time alarming dosimeters to CPP operators with alarm set at 1.8 mrem/hour to alert operators that they were in an elevated radiation area. Lead shielding was recommended to be added to the bottom 3 feet of one tank in the CPP to reduce exposure rates. Time studies were conducted of CPP operators to better understand the sources of radiation doses. The frequency of sampling for Rn-222, gamma, and air particulates was increased to weekly to obtain better statistical data. The ALARA audit for 2007 lists 10 actions taken to further reduce radiation doses.

Calendar Year 2008: Fourteen actions were taken to reduce radiation exposure, including adding lead shielding to the transfer water tank T-21, performing job hazard analysis for work in the CPP, installing shaker deck ventilation, and restricting access to radiation areas.

5.3.2 Annual ALARA Audits

Cameco conducts annual audits of the radiation safety and ALARA programs. The Director of Radiation Safety and Licensing may conduct these audits. Alternatively, Cameco may use qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to provide assurance of full compliance with all radiation health protection procedures and license condition requirements. Any outside personnel used for this purpose will be qualified in radiation safety procedures as well as environmental aspects of ISR operations. Whether conducted internally or through the use of an independent audit service, the auditor will meet the minimum qualifications for education and experience for the RSO as described in Section 5.4.3.

The audit of the radiation protection and ALARA programs has been and will continue to be conducted in accordance with the recommendations contained in Regulatory Guide 8.31. A written report of the results will be submitted to corporate management. The RSO may accompany the auditor but may not participate in the conclusions.

The annual ALARA audit report will summarize the following data:

- Employee exposure records;
- Bioassay results;
- Inspection log entries and summary reports of well field and process inspections;
- Documented training program activities;
- Applicable safety meeting reports;
- Radiological survey and sampling data;
- Reports on any overexposure of workers; and
- Operating procedures that were reviewed during this time period.

The ALARA audit report will specifically discuss the following:

- Trends in personnel exposures;
- Proper use, maintenance and inspection of equipment used for exposure control; and
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

The ALARA audit report is submitted to and reviewed by the management. Implementation of the recommendations to further reduce employee exposures, or improvements to the ALARA program, is reviewed with the ALARA auditor.

An audit of the quality assurance (QA) quality control (QC) program is also conducted on an annual basis. An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited will perform the audit. The results of the QA/QC audit are documented with the ALARA Audit.

The annual ALARA audits provide a listing of procedural, engineering control, and other changes that were made during the year that were directly or indirectly related to reducing radiation exposures to workers in compliance with NRC's policy of requiring licensees to maintain radiation dose to levels that are in compliance with ALARA. Procedural changes to reduce potential worker radiation exposures were also accompanied by an increased emphasis on employee training. Areas where procedural changes were made include the areas of respiratory protection and the bioassay program.

Calendar Year 2009: Nine actions were taken to reduce radiation exposure, including replacement of the CPP Dryer A condenser bundle, upgrades to the CPP T7C agitator system, extension of the Satellite SR-2 ventilation to the roof line, improvements to CPP drum lifts and drum hoods.

Calendar Year 2010: Twelve actions were taken to reduce radiation exposure, including improving the CPP bag filter system, improving the piping system on the cooling bundles, installing shaft guards on all T-7 agitators, changing out CPP vacuum lines to stainless steel, scraped and sealed CPP-truck bay, T-6 area and resin transfer area floors to minimize contamination and promote easy cleanup.

The maximum Total Effective Dose Equivalents (TEDE) reported for workers at Smith Ranch are well below applicable standards, are consistent with doses the NRC indicates to be representative of uranium ISR facilities, and are stable over the 10-year period since the last license renewal submittal (see Section 5.8.3.5 for additional information on TEDE). External dose equivalents described above represent the largest component of the TEDE. As demonstrated by implemented actions, Cameco is committed to continually evaluating sources of worker exposures to ionizing radiation and implementing improvements in order to maintain occupational radiation exposures at levels which are in compliance with ALARA.

5.3.3 Record Keeping and Retention

The SHEQMS Volume II, *Management Procedures,* provides specific instructions for the proper maintenance, control, and retention of records that are consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR 40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents are maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation such as descriptions of spills, excursions, contamination events, etc. as well as information related to site and aquifer characterization and background radiation levels are also maintained on site until license termination. Duplicates of all significant records are maintained in the corporate office or other offsite location.

5.4 Qualifications of Personnel Conducting the Radiation Safety Program

5.4.1 Manager, Safety Health, Environment and Quality

The position of SHEQ Manager requires a Bachelor's Degree in engineering or science from an accredited college or university, or equivalent work experience, and a minimum of 5 years supervisory experience. Work experience will include industrial process/production experience, and industrial process/production management. Additionally, a minimum of 5 years of experience in environmental and safety management and operations functions will be required as well as the ability to meet the requirements of Regulatory Guide 8.31 for the position of RSO.

5.4.2 Corporate Radiation Safety Officer

The position of CRSO requires a minimum of a Bachelor's Degree from an accredited college or university in the physical sciences, biology, engineering or related discipline and must be computer literate and have at least one year's experience in environmental compliance and permitting. The position of CRSO will meet the requirements of NRC Regulatory Guide 8.31.

5.4.3 Radiation Safety Officer

In accordance with NRC Regulatory Guide 8.31, the position of RSO requires the minimum qualifications as follows:

- Education - A Bachelor's Degree or an Associate's Degree in the physical sciences, industrial hygiene, environmental technology or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium mill/ISR radiation protection.
- Health Physics Experience - A minimum of 1 year of work experience relevant to uranium mill/ISR operations in applied health physics, radiation protection, industrial hygiene or similar work.
- Specialized Training - A formalized, specialized course(s) in health physics specifically applicable to uranium milling/ISR operations, of at least 4 weeks duration. The RSO attends refresher training on uranium mill health physics every 2 years.
- Specialized Knowledge - The RSO, through classroom training and on-the-job experience, possesses a thorough knowledge of the proper application and use of all health physics equipment used in the operation, the procedures used for radiological sampling and monitoring, methods used to calculate personnel exposures to uranium and its daughters, and a thorough understanding of the ISR process and equipment used and how hazards are generated and controlled during the process.

5.4.4 Health Physics Technician

In accordance with NRC Regulatory Guideline 8.31, the HPT will have one of the following combinations of education, training and experience:

1. Education - An Associate's Degree or 2 years or more of study in the physical sciences, engineering or a health-related field, or high school diploma and a combination of experience and training.

   Training - At least a total of 4 weeks of generalized training in radiation health protection applicable to uranium mill/ISR operations.

   Experience - One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium mill/ISR operation.
2. Education - A high school diploma.

   Training - A total of at least 3 months of specialized training in radiation protection relevant to uranium mills or ISR operations of which up to 1 month may be on-the-job training.

   Experience - Two years of relevant work experience in applied radiation protection.

The RSO oversees the inspections and may designate qualified HPTs or HPTs-in-Training to complete the routine inspections. These HPTs must demonstrate correct usage of instruments, and an understanding of activity limits and radiation hazards. They must also have knowledge of the license, regulations, and Regulatory Guides. They are also required to know the SOPs for tasks they are performing.

Radiation Training administered to the HPTs is overseen by the RSO, and training is given by the RSO or designated HPT. The HPTs-in-Training must possess an excellent understanding of radiation hazards and SOPs to be able to present information about radiation safety clearly such that training recipients can understand the risks and hazards of site radiation.

5.5 Training

All site employees and contractor personnel participate in a training program covering radiation safety, radioactive material handling, and radiological emergency procedures. The training program is administered in keeping with standard radiological protection guidelines and the guidance provided in NRC Regulatory Guide 8.29, NRC Regulatory Guide 8.31, and NRC Regulatory Guide 8.13. The technical content of the training program is under the direction of the RSO. The RSO will conduct all radiation safety training. Cameco provides radiological safety instruction that includes personal hygiene, contamination surveying before eating or leaving the operating area, requirements for personal monitoring devices and respirators, housekeeping requirements, spill cleanup procedures, and emergency actions.

5.5.1 Radiation Safety Training Program Content

5.5.1.1 Visitors

Visitors to any of the Smith Ranch SUA-1548 license areas who have not received training will be escorted by on-site personnel properly trained and knowledgeable about the hazards of the facility. At a minimum, visitors will be instructed specifically on what they should do to avoid possible hazards in the area of the facilities that they are visiting. A visitors log is maintained to document the name and purpose of the visit. Contractors for CBM (North Butte and Ruth Remote Satellite facilities) operations or technicians performing maintenance at wind turbines (Smith Ranch) are required to check in and are provided instructions on what they should do to avoid possible hazards in the area of the facilities that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at any of the Smith Ranch SUA-1548 license areas will be given appropriate radiation safety training. Contract workers who will be performing work on heavily contaminated equipment will receive the same training normally required of Smith Ranch workers as discussed in Section 5.5.1.3.

5.5.1.3 Permanent Employees

All newly hired Cameco employees (and some contractors as noted in Section 5.5.1.2) will receive training as uranium recovery workers. The training program will incorporate the following topics recommended in Section 2.5 of NRC Regulatory Guide 8.31:

Fundamentals of health protection:

- Using respirators when appropriate;
- Eating, drinking and smoking only in designated areas; and
- Using proper methods for decontamination.

Facility-provided protection:

- Cleanliness of working space;
- Safety designed features for process equipment;
- Ventilation systems and effluent controls;
- Standard operating procedures; and
- Security and access control to designated areas.

Health protection measurements:

- Measurements of airborne radioactive material;

- Bioassay to detect uranium (urinalysis and in vivo counting);
- Surveys to detect contamination of personnel and equipment; and
- Personnel dosimetry.

Radiation protection regulations:

- Regulatory authority of NRC, OSHA and state;
- Employee rights in 10 CFR Part 19; and
- Radiation protection requirements in 10 CFR Part 20.

Emergency Procedures

All new workers, including supervisors, will be given instruction on the health and safety aspects of the specific jobs they will perform. This instruction is done in the form of individualized on-the-job training. Retraining is performed annually and documented.

5.5.2 Testing Requirement

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker following the training session. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until worker understanding is achieved. Workers who fail the exam are retested and test results remain on file.

5.5.3 On-The-Job Training

5.5.3.1 Radiation Safety Training

On-the-job training will be provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, plant inspections, posting requirements, respirator programs and radiation safety procedures.

5.5.3.2 Refresher Training

All permanent facility workers will also receive an annual refresher training course that includes a review of any new radiation safety regulations, site safety experience and radiation exposure trends. Radiation safety problems or subjects will also be offered for discussion during the annual refresher or at least four times per year during routine safety meetings. Safety meeting subjects and attendance records will be maintained on file at the site. Specialized instruction on the radiation health and safety aspects of jobs involving higher than normal exposure risks will be provided by the RSO, HPT and/or Supervisor.

Following initial radiation safety training, all permanent employees and long-term contractors will receive on-going radiation safety training as part of the annual refresher training program and, if determined necessary by the RSO, during monthly safety meetings. This on-going training will be used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends and other pertinent topics. Each worker who may be required to use respiratory protective equipment will receive training in the use of the specific equipment to be used. No person is allowed to use respiratory equipment until they are specifically trained in the use of the equipment.

5.5.3.3 Training Records

Records of training will be kept until license termination for all employees trained as radiation workers (i.e., occupationally exposed employees).

5.6 U.S. Department of Transportation Hazardous Materials Training

The NRC and the DOT share primary responsibility for the transportation of radioactive materials within the United States. The NRC regulations for the transportation of radioactive materials are codified in 10 CFR Part 71, "Packaging and Transportation of Radioactive Materials". DOT's hazardous materials regulations, which address radioactive materials, are codified in 49 CFR Parts 100-199. A provision in the NRC regulations, specifically 10 CFR Part 71.5, requires that NRC licensees comply with DOT's hazardous material regulations.

DOT amended their regulations in May 1992 to add new sections to 49 CFR regulations pertaining to the transportation of hazardous materials. Specifically, the change of interest adds Subpart H to 49 CFR Part 172. This section requires employers who transport hazardous materials to provide hazardous material training to any employee who directly affects hazardous material transportation safety.

A hazardous material employee is defined to include anyone who:

- Loads, unloads, or handles hazardous materials;
- Tests, repairs, marks, modifies any container or package used to transport hazardous materials;
- Prepares hazardous materials for shipment;
- Is responsible for the safety of transporting hazardous materials; or,
- Operates a vehicle used to transport hazardous materials.

It can be seen by the definition that Cameco employees transporting IX resin, yellowcake slurry or other materials meeting the definition of hazardous materials fall into this classification, and therefore, must receive training.

A hazardous materials training is required at least every three years. In addition to this, whenever procedures or conditions change, training will be provided to ensure a safe work environment. An evaluation of risks associated with hazardous materials accidents is provided in Section 7.0.

5.7 Security

Measures to secure NRC-licensed material from unauthorized removal and access are in place at all SUA-1548 license areas. In accordance with License Condition No. 10.1.7 of SUA-1548, the active mine unit well field production areas are controlled with fences and appropriate signs. All areas containing NRC source or 11e.(2) by-product materials are fenced. The main access entry points are equipped with locking or automatic gates. The operating facilities are manned 24 hours per day, 7 days per week, and in controlled and/or unrestricted areas, surveillance is maintained through the presence of the operators and workers on site. Visitors are required to check in and sign in at the office before being allowed to enter controlled access areas of any of the facilities. Also, Cameco has further increased security at the Smith Ranch CPP/main office complex by installing continuous video surveillance of outside areas.

NRC-licensed material in the form of 11e.(2) byproduct material and source material is securely stored within fenced areas at the CPP and satellite facilities. Operators perform a visual inspection at the beginning of each shift to ensure the proper storage and security of NRC-licensed material. The inspection will determine whether all NRC-licensed material is properly stored in a restricted area or, if in a controlled or unrestricted area, is properly secured. Operators will ensure that uranium loaded IX resin and by-product material are properly secured. If NRC-licensed material is found outside a restricted or controlled area, the operator will ensure that it is secured, locked and moved to a restricted area, or kept under constant surveillance by direct observation by site personnel until it can be removed to a restricted area. The results of these inspections are retained on site for review by regulatory agencies.

Cameco routinely receives, stores, uses and ships hazardous materials as defined by the DOT. In addition to packaging and shipping requirements, DOT Hazardous Materials Regulations at 49 CFR 172, Subpart I, Security Plans, requires that persons offering for transportation or transport certain hazardous materials develop a security plan. The security plan must address transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must take measures to provide personnel security by screening potential job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the security plan.

Transport of licensed/hazardous material by Cameco employees on public roads is typically restricted to transporting IX resin or yellowcake slurry from the satellite facilities to the Smith Ranch CPP or transferring contaminated equipment between company facilities. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;
- Providing the means and methods of protecting the drivers, vehicles, and cargo while on the road; and
- Establishing consistent security guidelines and procedures that will be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the trailer, access will be secured at all openings with locks and/or tamper indicators;
- Off-site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys left on or in the vehicle; and
- The vehicle will be kept in sight by an employee at all times when left unattended outside a restricted area.

These security guidelines and procedures apply to all transport employees. All driving and non-driving personnel will be expected to be knowledgeable of, and adhere to these guidelines and procedures when performing any load-related activity.

Cameco will also maintain security measures at any flammable/combustible above ground storage tanks at the Smith Ranch SUA-1548 license areas in accordance with SPCC Regulations (40 CFR 112).

5.8 Radiation Safety Controls and Monitoring

Cameco has a strong corporate commitment to and support for the implementation of the radiological control program at all SUA-1548 license areas as has been shown by Cameco's record of compliance over the past 25 years. This corporate commitment to maintaining personnel exposures ALARA is incorporated into the radiation safety controls and monitoring programs described in the following sections.

To that end, Cameco has undertaken a sampling program to evaluate a variety of radiation protection issues raised by NRC with respect to other ISR facilities. The SUA-1548 sampling plan will last for one year after which it will be evaluated in coordination with NRC to determine whether additional sampling is required or if the program can be discontinued. The sampling plan is provided in **Table 5-1, 2012 Smith Ranch Radiological Sampling Plan**. The sampling plan identifies the sample type, location, equipment frequency/duration and lower limit of detection (LLD). Additionally, the sampling plan presents objectives and purposes, components of the dose assessment and a decision matrix/path forward. The sampling plan will be updated to include the Reynolds Ranch Satellite once it becomes operational. A similar sampling plan will be developed for each of the remote satellites (North Butte, Gas Hills, and Ruth).

In summary, the sampling plan will provide site-specific data to evaluate:

- Dose to the public;
- Dose to office workers, lab workers, well field workers and well field construction personnel;
- Implications to occupational dose from ingrowth of short-lived beta-emitting isotopes;
- Implication of short-lived beta-emitting isotopes on contamination control, for both personal contamination and for release of equipment and materials for unrestricted use;
- Implications of isotope mixtures on establishing the site-specific DAC; and
- Potential for using Ra-226 concentrations in pregnant lixiviant as a component of 10 CFR 40.64 effluent reporting.

As elements of the sampling plan are completed, Cameco will provide data and propose program revisions where necessary for NRC consideration. Because the existing program will continue until the various sampling activities are complete and concurrence is reached with NRC as to appropriate program modifications, the following sections reflect current practice.

5.8.1 External Radiation Exposure Monitoring Program

5.8.1.1 Personnel Dosimetry

Program Description

10 CFR 20.1502 (a)(1) requires exposure monitoring for "adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10% of the limits in 20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 rem. External radiation exposure was monitored at the Highland facility during the period 1988 through 1993 by the use of personal radiation dosimeters, such as TLD or Optically Stimulated Luminescent dosimeter badges. All employees, except several office personnel that did not enter areas where potential exposures existed, utilized dosimeters. During the period 1988 through 1993 the monitoring data collected from the dosimeters showed that the annual dose to all workers was less than 10% of the 5,000 mrem annual limit contained in 10 CFR 20.1201(a). Therefore, consistent with 10 CFR 20.1502, beginning on January 1, 1994, individual monitoring devices, such as TLDs, were only used to monitor occupational exposures to CPF operators because they could potentially exceed 10% of the annual limit contained in 10 CFR 20.1201(a) due to the potential exposure to airborne uranium. Accordingly, it is not required that occupational exposures to external radiation be determined or recorded for other workers, although Cameco has continued to monitor some additional workers.

To ensure that potential exposures to gamma radiation remain less than 10% of the annual limit (or less than 500 mrem), the two work groups with the greatest potential for exposure (CPP operators and satellite/restoration operators) will utilize NRC approved dosimeters. Quarterly monitoring data collected from these badges will be recorded and reviewed annually to ensure that exposures do not exceed 500 mrem.

Dosimeters will be provided by a vendor that is accredited by the National Voluntary Laboratory Accreditation Program of the National Institute of Standards and Technology as required in 10 CFR 20.1501 and will have a range of 1 millirem to 1,000 millirem.

Results from personnel dosimetry will be used to determine individual DDE for use in determining TEDE.

Historical Program Results

Most Cameco workers do not require monitoring for radiation exposure since they do not have the potential for receiving 10% of the dose limits for internal or external radiation. Cameco conservatively chooses to monitor more employees than required to assure compliance with this requirement. For example, workers at the satellites and mine unit areas are only occasionally exposed to gamma-emitting piping and have little or no potential for ingesting or inhaling radioactive particulates. They may, however, be exposed to contaminated pumps and other fixtures, or spend short periods of time in header houses, or the satellites which may have slightly elevated Rn-222 and gamma levels.

Maintenance workers perform various repair and maintenance functions throughout the site, including within the CPP and satellites, during which time they may come into contact with radioactive materials. Average annual external doses to maintenance workers, as measured by personal gamma dosimeters, ranged from 26 to 150 mrem/year over the years 2002 through 2010 as shown in **Table 5-2, Average Annual Radiation Dosimeter Reading**, considerably less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring.

Operators within the satellite facilities are exposed to direct gamma radiation primarily from Ra-226 buildup in the tanks and the RO equipment used in groundwater restoration. During transfer of the IX resin, a limited amount of Rn-222 and progeny are released; but, since the resin is wet and the uranium is bonded to the outer surface of the resin there is no release of uranium or other long-lived radionuclides. After many years of airborne particulate sampling for uranium at the satellite facilities, air sampling was discontinued at the beginning of 2003, since the results demonstrated that the uranium concentrations were not significant. The average annual external dose to satellite plant workers, as measured by personal gamma dosimeters, ranged from 56 to 232 mrem/year over the time period from 2002 through 2010, less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring.

Laboratory workers routinely work with process samples and thus may have limited gamma exposure from the samples. Their average annual dose equivalent, as measured by the radiation dosimeters, ranged from 65 to 131 mrem/year over the time period from 2002 through 2010, significantly less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring (see **Table 5-2**).

While there are few workers in the CPP, this group potentially receives the highest external and internal radiation dose. Gamma radiation from the process vessels primarily due to Ra-226 buildup, Rn-222 releases within the CPP from resin transfer, and exposure to airborne yellowcake during packaging operations. During yellowcake drying and packaging, workers use respiratory protection to limit inhalation exposure. The average annual external dose equivalent to CPP workers, as measured by the personal dosimeters, ranged from 249 to 498 mrem/year as indicated in **Table 5-2** during the 2002 to 2010 time period.

Program Description

External gamma radiation surveys are performed routinely at all Smith Ranch SUA-1548 license areas. The required frequency is quarterly in potentially designated Radiation Areas (IX columns and process tanks) and semi-annually in all other areas of the CPP and satellite facilities. Surveys are performed at worker occupied stations and areas of potential gamma sources, such as tanks and filters. Cameco establishes a Radiation Area if the survey indicates that gamma radiation levels exceed the action level of 5 mrem per hour for worker occupied stations. An investigation will be performed to determine the probable source, and survey frequency for areas exceeding 5 mrem per hour is increased to the quarterly frequency. Records will be maintained of each investigation and the corrective action taken. If the results of a gamma survey identifies areas where gamma radiation is in excess of levels that delineate a "Radiation Area", access to the area will be restricted and the area will be posted as required in 10 CFR 20.1902 (a).

External gamma surveys are performed with survey equipment that meets the following minimum specifications:

1. Range - Lowest range not to exceed 100 microRoentgens per hour (μR/hr) full scale with the highest range to read at least 5 milliRoentgens per hour (mR per hour) full scale;
2. Battery operated and portable.

Examples of satisfactory instrumentation meeting these requirements are the Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent. Gamma survey instruments will be calibrated at the manufacturer's suggested interval or at least annually and will be operated in accordance with the manufacturer's recommendations. Instrument checks will be performed each day that an instrument is used.

Gamma exposure rate surveys are performed in accordance with standard operating procedures. Existing survey locations for the Smith Ranch CPP and satellites are shown on **Figure 5.2, Radiological Sampling Locations at the CPP, Figure 5.3, Radiological Sampling Locations at Satellite #2 and Selenium Plant, Figure 5.4, Radiological Sampling Locations at Satellite #3, Figure 5.5, Radiological Sampling Locations at SR-1** and, **Figure 5.6, Radiological Sampling Locations at SR-2**. Gamma survey instruments will be checked prior to each day's use in accordance with the manufacturer's instructions. Surveys will be performed in accordance with the guidance contained in NRC Regulatory Guide 8.30. Similar gamma rate surveys will be conducted at future satellites at the control room, the RO area (when being used), IX columns, and the process tank/trailer bay area.

5.8.2 Airborne Radiation Monitoring Program

5.8.2.1 Airborne Uranium Particulate Monitoring

Program Description

Airborne particulate levels at ISR yellowcake processing facilities that employ vacuum dryers are very low since there are no radionuclide emissions (see Section 4.0 for a description of the vacuum dryers). The primary potential source of airborne uranium is during yellowcake packaging. This operation will be confined to the dryer room. The room will be closed and posted as an airborne radioactivity area during packaging. In the drying and packaging areas at the CPP, the potential exists for exposure to yellowcake dust. In the slurry unloading area the potential for exposure to airborne uranium is considerably less than in the drying and packaging areas as slurry unloading is performed on a very infrequent basis. The airborne uranium sampling locations for the CPP are shown on **Figure 5.2**.

Airborne uranium particulate monitoring at the CPP and pilot building was historically performed on a monthly basis. Given the extensive data that exists for the pilot building that shows the virtual lack of airborne uranium in this area, and the fact that IX equipment and tanks have been removed, it is not necessary to further monitor this area for airborne uranium.

Airborne uranium particulates at the CPP are monitored to assess any unanticipated occurrence of uranium in the air and provide uranium airborne concentration data used in the exposure determinations for the CPP Operators and the dryer operators. The monitoring locations and frequency are as follows:

Location	Frequency
Precipitation Area	Monthly
Yellowcake Storage Area	Monthly
Dryer Room	Monthly

To estimate the routine exposure of dryer operators to uranium, a high volume sampler is set up in the yellowcake packaging area or representative samples are collected with a breathing zone sampler. Dryer operators are required to wear respiratory protection during yellowcake packaging operations because of the potential release of airborne uranium during this procedure.

Breathing zone sampling is performed during certain operational tasks to determine individual exposure to airborne uranium. Sampling is performed with a lapel sampler or equivalent. The air filters are counted and compared to the DAC using the same method used for area sampling. Air samplers are calibrated at the manufacturer's recommended frequency or at least every six months using a primary calibration standard. Air sampler calibration will be performed in accordance with standard operating procedures.

Measurement of airborne uranium is performed by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent with a Ludlum 43-10 detector or equivalent. The current efficiency of both of these instruments is 35%. Counting time is adjusted to assure the LLD is less than 10% of the site-specific DAC).

If an airborne uranium sample exceeds 25% of the DAC, the RSO will investigate the cause and the sampling frequency is increased to weekly. The investigation and any corrective actions taken are documented.

Area samples are collected at specified sample locations (see **Figure 5.2**) in accordance with standard operating procedures. These procedures implement the guidance contained in NRC Regulatory Guide 8.25. Samples are taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-I or equivalent. The sample volume will be adequate to achieve the LLD for uranium in air. Samplers are calibrated at the manufacturer's suggested interval, or semi-annually, with a digital mass flowmeter or other primary calibration standard. The results are used to determine employee time weighted exposures.

The Highland CPF dryer has not operated since 2003. Cameco anticipates installing at least two new rotary vacuum dryers at the CPF during the next renewal period. Airborne particulate monitoring will resume once the CPF renovations are completed and the facility is operational. If yellowcake slurry is not produced at the satellite facilities, airborne uranium particulate monitoring will not be required. Due to the fact that the uranium-bearing fluids at the satellite facilities are fully contained within pipes, tanks, and IX vessels, the likelihood of any significant quantities of uranium in the air is very remote. This is supported by many years of data collected at both Smith Ranch and Highland satellites that show virtually no occurrence of airborne uranium at these facilities. When yellowcake slurry production begins at the Gas Hills Remote Satellite, uranium particulate monitoring will be performed as described above since yellowcake slurry will be produced at that satellite.

Smith Ranch Site-Specific ALI and DAC

Cameco performed an analysis of the solubility characteristics of Smith Ranch yellowcake and the material was then classified according to the days, weeks, and years classification scheme of 10 CFR Part 20. The complete report, provided in **Appendix I, Smith Ranch Analysis of Day, Week, and Year Classification** includes a dosimetry interpretation.

This study showed that the yellowcake produced at Smith Ranch was primarily of solubility type D with a relatively low type W component. The resulting site specific ALI and DAC values are 0.98 µCi and 4.8E-10 µCi/ml respectively. In comparison, the 10 CFR 20 Appendix B to Part 20 ALI and DAC for uranium (nat) are 1.0 µCi and 5E-10 µCi/ml, respectively.

Historical Program Results

Airborne uranium data from the yellowcake and dryer rooms of the CPP from 1999 through 2010 have been used to assess Cameco's performance in limiting air concentrations of uranium in the workplace. **Table 5-3, Natural Uranium Concentrations in Air as a Percent Derived Air Concentration** presents data from 1999 through 2010. The average and maximum measured concentrations were, excluding the maximum measurement in 1999, well below the DAC for soluble uranium (nat) of 5E -10 µCi/ml. As indicated in the 1999 ALARA report (RAMC, 2000), an effort by site management beginning in 1999 to concentrate on housekeeping practices in the yellowcake dryer area was effective in reducing airborne concentrations. This general reduction can be seen in the average and maximum airborne uranium concentrations over the years of interest and continued downward trends in the ALARA levels can be seen. The maximum airborne concentration is generally associated with periods when yellowcake packaging is taking place. In these instances, respiratory protection is required to be worn by workers in these areas.

5.8.2.2 Radon Daughter Monitoring

Program Description

Surveys for radon daughter concentrations are conducted in the operating areas of the Smith Ranch CPP and satellites on a monthly basis at specified locations. Sampling locations are determined in accordance with the guidance contained in NRC Regulatory Guide 8.25. Radon daughter sampling locations for existing Smith Ranch (SUA-1548) Project facilities are shown on **Figures 5.2** through **5.6**. The sample locations for future satellites and remote satellites will include the control room, the RO area (when being used), IX columns, process tank/trailer bay area. Clean area surveys will be conducted in the lunch room.

Samples are collected with a low volume air pump (e.g., lapel sampler) and then analyzed with an alpha scaler using the Modified Kusnetz method described in ANSI-N13.8-1973. Routine radon daughter monitoring is performed in accordance with standard operating procedures. Air samplers are calibrated at the manufacturer's suggested interval or semi-annually with a digital mass flowmeter or other primary calibration standard. Air sampler calibration is performed in accordance with standard operating procedures.

Results of radon daughter sampling are expressed in working levels (WL) where one WL is defined as any combination of short-lived Rn-222 daughters in one liter of air without regard to equilibrium that emit 1.3 x 10^5 MeV of alpha energy. The DAC limit from Appendix B to 10 CFR 20.1001 - 20.2402 for Rn-222 with daughters present is 0.33 WL. Cameco has established an action level of 25% of the DAC or 0.08 WL. Radon daughter results in areas with an average concentration in excess of the action level will result in an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter concentration levels do not exceed the action level for four consecutive weeks.

Historical Program Results

Airborne Rn-222 progeny monitoring was conducted in the Smith Ranch facilities for the periods indicated below:

- Smith Ranch Pilot Plant 1999-2004
- CPP 1999-Present
- Satellite Plant SR-1 1999-Present
- Satellite Plant SR-2 2009-Present
- Satellite Plant No. 1 2000-Present
- Satellite Plant No. 2 2000-Present
- Satellite Plant No. 3 2000-Present
- Selenium Plant 2009-Present
- Header Houses 2000-Present

Monitoring was discontinued in the Smith Ranch pilot plant in October of 2004 as a result of a SERP (SERP report No. 2004-5; PRI, 2004) to eliminate the restricted area designation of the pilot plant. Inspections at Satellite No. 1 were changed to monthly in 2006 after the satellite was placed on stand-by and power shutdown. The inspection changes were approved by a SERP (SERP No 2005-4; PRI, 2005). Monitoring at the Selenium Plant and Satellite Plant SR-2 only began in 2009.

Rn-222 progeny monitoring is reported in units of a WL as previously described, which is any combination of Rn-222 progeny in one liter of air that would result in emission of 1.3 x 10^5 mega electron volts of potential alpha energy. The DAC for Rn-222 progeny is 0.33 WL. **Table 5-4, Radon-222 Progeny Concentrations in Air for Smith Ranch Facility Structures as a Percent of Derived Air Concentration** presents the Rn-222 progeny concentrations in air as a percent of the DAC for each monitored building. The average concentrations in all cases are well below 10% of the DAC. The maximum concentrations occasionally are above the Rn-222 progeny DAC for SR-1 in 2000 and 2001 and the CPP in 2001, but otherwise have been less than the DAC.

Occupational airborne radioactivity concentrations at Smith Ranch SUA-1548 license areas are routinely monitored at a frequency which allows for timely investigations and corrective actions, if needed, to respond to conditions or practices which result in airborne radioactivity concentrations above the action level of 25% of the DAC. Annual average air concentrations for natural uranium and Rn-222 progeny are well below this in all cases. Since 1999, there has been one case (in 1999) where the action level was exceeded for natural uranium maximum concentrations, but there have been none since that time. There were several exceedances for maximum Rn-222 progeny concentrations during the 1999 to 2003 time period at the CPP, Satellite SR-1 and Satellite No. 2, but these maximum concentrations have been below or very close to the action level from 2004 through 2010. In each exceedance case, an appropriate investigation and corrective action was performed. Additionally, the annual average air concentrations are less than the 10% of DAC criteria where occupational monitoring of airborne radionuclides is required by 10 CFR §20.1502.

Table 4-1 provides a summary of the trends in Rn-222 progeny in air since 1999. No increasing trends of workplace airborne radioactivity were identified, except at the header houses. The maximum concentration (6% of the DAC) at the header houses was recorded in 2004, but was reduced to 4% of the DAC by 2005. The decreasing trend continued through 2006 and 2007, but has slightly increased (~0.3%) during 2009 and 2010. There were several exceedances of the 25% of the DAC action level for maximum Rn-222 progeny concentrations during the 2008 to 2010 time period at the header houses. Cameco is committed to limiting occupational airborne radioactivity concentrations to levels which are ALARA.

5.8.3 Exposure Calculations

Employee exposures at the Smith Ranch SUA-1548 license areas are monitored in accordance with NRC Regulatory Guide 8.34, "Monitoring Criteria and Methods to Calculate Occupational Radiation Doses." A bioassay program consistent with NRC Regulatory Guide 8.22, Rev. 1 "Bioassay at Uranium Mills" is utilized as a means of ensuring the adequacy of the monitoring and respiratory protection programs for protection from airborne uranium dust.

Employee exposures to airborne uranium is estimated for routine and non-routine activities. As previously stated, when previously operational, the exposure to dried yellowcake at the Highland CPF was considered "insoluble" (Y-Class) because of the high temperature dryer (calciner) used. After the planned refurbishment and installation of low temperature vacuum dryers, the dried yellowcake will be considered “soluble” (D-Class). The exposure to dried yellowcake at the Smith Ranch CPP is considered "soluble" (D-Class). Exposure to any uranium that has not been through any drying process is also considered "soluble" (D-Class).

The exposure estimates are based on exposure times and the concentrations of airborne uranium as determined from routine air monitoring or non-routine air monitoring (i.e. breathing zone monitoring or specific area air monitoring). Routine exposures to uranium and radon daughters are only determined for CPP workers (central plant operators, dryer operators) as, in accordance with 10 CFR 20.1502(b)(1), they are the only workers routinely exposed to airborne radionuclides in concentrations which are likely to result in annual exposures in excess of 10% of the ALI, without respiratory protection. These potential exposures result from the need to work in the yellowcake dryer and yellowcake packaging facilities. Routine exposures are estimated using exposure times generated from annual time studies or actual occupancy times. Time studies are updated after any significant change in equipment procedures, or job functions. When the CPF becomes operational again, exposures to uranium and radon progeny will also be evaluated for operators in the process and dryer areas.

Non-routine exposures to uranium result from performing non-routine operational or maintenance tasks that have the potential for creating a significant exposure to airborne uranium. These types of exposures are monitored utilizing a Radiation Work Permit. The Radiation Work Permit specifies the types of radiological monitoring required for the task (soluble or insoluble uranium) and the protective equipment and clothing employees must wear while performing the task. The sampling results are evaluated and documented. These data, together with the employee's time in the area, is used to estimate the non-routine exposure. Each CPP worker's routine and non-routine exposure to soluble and insoluble uranium is recorded at least monthly and summarized annually.

As discussed in Section 5.8.2.2, routine employee exposure to radon daughters is determined for only CPP and satellite plant workers. Similar to non-routine uranium exposures, non-routine radon daughter exposures are monitored utilizing a Radiation Work Permit. Routine exposure times are determined by annual time studies or actual occupancy times. These time studies are also updated after any significant change in equipment, procedures, or job functions. Each CPP worker's routine and non-routine exposure to radon daughters is recorded monthly and summarized annually. Following is a discussion of the exposure calculation methods and results.

5.8.3.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium (soluble or insoluble) is performed using the intake method from NRC Regulatory Guide 8.30, Section 2. The natural uranium intake is calculated using the following equation:

$$I_u = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

where:

I_u = uranium intake, µg or µCi
t_i = time that worker is exposed to concentrations X_i (hr)
X_i = average concentration of uranium in breathing zone, µg/m^3, µCi/m^3
b = breathing rate, 1.2 m^3/hr
PF = the respirator protection factor, if applicable
n = number of exposure periods during the week or quarter

The intake for uranium is calculated and recorded. The intakes are totaled and entered onto each employee's Occupational Exposure Record. The data required to calculate internal exposure to airborne natural uranium is determined as follows:

Time of Exposure Determination

The results of periodic time studies for each classification of worker or 100% occupancy time is used to determine routine worker exposures. Exposures during non-routine work (i.e., work requiring an Radiation Work Permit) are based upon actual time.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in Section 5.8.2.1. Exposures to airborne uranium are compared to the site-specific DAC of 5E-10 µCi/ml.

5.8.3.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters are performed using the intake method from NRC Regulatory Guide 8.30, Section 2. The radon daughter intake is calculated using the following equation:

$$I_r = \frac{1}{170}\sum_{i=1}^{n}\frac{W_i \times t_i}{PF}$$

where:

I_r = radon daughter intake working level months
t_i = time that the worker is exposed to concentration W_i (hr)
W_i = average number of working levels in the air near the worker's breathing zone during time (t_i)
170 = number of hours in a working month
PF = the respirator protection factor, if applicable
n = the number of exposure periods during the year.

The data required to calculate exposure to radon daughters will be determined as follows:

Time of Exposure Determination

The results of periodic time studies for each classification of worker or 100% occupancy time are used to determine routine worker exposure times. Exposures during non-routine work (i.e., work requiring an Radiation Work Permit) are based upon actual time.

Radon Progeny Concentration Determination

Rn-222 progeny concentrations are determined from surveys performed as described in Section 5.8.2.2. The working-level months for radon progeny exposure are calculated and recorded. The working level months (WLM) is totaled and entered onto each employee's Occupational Exposure Record. Exposures to radon progeny are compared to the DAC for radon progeny from Appendix B of 10 CFR 20.1001 - 20.2401 (i.e., 0.33 WLM).

5.8.3.3 Reports of Overexposure

10 CFR 20.2203 requires that overexposure reports be made to the appropriate NRC Regional Office if the intake of uranium and/or radon exceeds the quantities specified in 10 CFR 20.1201. The following exposure limits require NRC notification:

1. Soluble Uranium - if an employee has an intake of more than 10 mg of soluble uranium in one week. This intake is in consideration of chemical toxicity.
2. TEDE - if an employee exceeds the TEDE annual limit of 5 rem. The annual TEDE is determined by summing annual doses from soluble uranium, insoluble uranium and radon.

5.8.3.4 Prenatal and Fetal Exposure

10 CFR 20.1208 requires that licensees ensure that the dose to an embryo/fetus during the entire pregnancy from occupational exposure of a declared pregnant woman does not exceed 0.5 rem. Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 rem limit. The dose to the embryo/fetus is calculated as the sum of (1) the deep-dose equivalent to the declared pregnant woman and (2) the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR 20.1502(a)(2) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to exceed a dose from external sources in excess of 10% of the embryo/fetus dose limit (i.e., 0.05 rem/year). 10 CFR 20.1502(b)(2) also requires that the licensee monitor the occupational intakes of radioactive material for the declared pregnant woman if her intake is likely to exceed a committed effective dose equivalent in excess of 0.05 rem/year. Based on this 0.05 rem threshold, the dose to the embryo/fetus must be determined if the intake is likely to exceed 1% of the ALI during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR 20.1502. In this case, Cameco will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (e.g., air monitoring, area monitoring, and bioassay). Exposure calculations will be performed as recommended in NRC Regulatory Guide 8.36 (NRC, 1992).

- External Dose to the Embryo/Fetus

The deep-dose equivalent to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of conception and will be based on the methods discussed above.

- Internal Dose to the Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception. The intake for the declared pregnant woman will be determined as discussed above.

5.8.3.5 Total Effective Dose Equivalent

In accordance with 10 CFR 20.1201, the TEDE is determined on an annual basis for each CPP and CPF worker by adding the deep dose external gamma exposures for the year to the internal exposures from radon progeny and uranium. The annual limit for the TEDE is 5 rem.

For most workers, the dose equivalent from internal exposure is very small. The minimum, maximum, and average TEDE for site workers is summarized in **Table 4-5** for the time period of 1999 through 2010. No worker has been exposed above the regulatory limit of 5,000 mrem (5.0 rem) in a year. The maximum TEDE occurred in 2001 where a worker's badge received 1,080 mrem, or 22% of the allowable limit. An investigation determined that this was the result of improper storage of the TLD badge when off site. The average TEDE for CPP workers ranged from 419 to 619 mrem during the 2002 to 2010 time period. To put this into perspective, the average US radiation worker received approximately 300 mrem per year.

NUREG 1910 (NRC, 2009) cites the occupational doses measured at the Crow Butte ISR facility in Dawes County, Nebraska (also owned by Cameco) as representative of occupational doses from an ISR facility. The highest TEDE values measured at the Crow Butte facility were 675 mrem in 2005 and 713 mrem in 2006. Those highest TEDE values are similar to the highest TEDE values listed in **Table 4-5** for Smith Ranch.

5.8.3.6 Respiratory Protection Program

Respiratory protective equipment is supplied by Cameco for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Respiratory equipment usage is in accordance with a respiratory protection program designed to implement the guidance contained in NRC Regulatory Guide 8.15 and NRC Regulatory Guide 8.31. The respirator program is administered by the RSO as the Respiratory Protection Program Administrator.

5.8.4 Bioassay Program

5.8.4.1 Program Description

The bioassay program meets the guidelines contained in Revision 1 of NRC Regulatory Guide 8.22 "Bioassay at Uranium Mills." All permanent employees that handle yellowcake submit a baseline urinalysis prior to their initial assignment at the facility. A urinalysis is also requested from all permanent employees at the time of termination of employment if they were recently involved in yellowcake processing activities. CPP, CPF and dryer operators, who are the only workers to routinely work in the yellowcake precipitation, drying and packaging areas, are required to submit monthly urine specimens for uranium analysis. Specimens are collected 2 to 4 days after the employee has left the work area (i.e., after a weekend and prior to entering the work area). Consistent with Regulatory Guide 8.22, quality control of the monthly urinalyses is assured by including one blank and two spiked samples with each month's batch of specimens. The blank and spiked samples are labeled with non-employee names in order that the contract laboratory is not aware of the particular specimens' content. Laboratory results for these specimens are compared with known values to ensure that laboratory results are accurate.

Workers potentially exposed to concentrations of uranium above regulatory limits are also required to submit urine specimens for uranium analysis 2 to 4 days following the potential exposures. Workers meeting this requirement are typically working under the direction of a Radiation Work Permit. This is required even if respiratory protection has been utilized to ensure that the respiratory protection equipment has been worn properly and that respirators are functioning as designed.

Cameco also randomly obtains, on a monthly basis, urine specimens from other workers at the facility to confirm that workers are not subject to an unknown uptake of uranium.

The contract laboratory provides immediate notification (via telephone or email) of all urinalyses exceeding 15 µg/L uranium. **Table 5-6, Actions Taken for Individual Urinalysis Results** lists the actions taken for individual urinalysis results.

5.8.4.2 Historical Program Results

Summaries of the bioassay results presented in the annual ALARA audit reports for Smith Ranch were used to evaluate the historical performance of the program to limit intakes of uranium. Elevated baseline bioassay results from new employees or contract employees are not considered here since they reflect exposures obtained from sources other than Smith Ranch. The results are presented in **Table 5-7, Bioassay Results for Smith Ranch from 1999 through 2010** for the categories of exposures listed in NRC Regulatory Guide 8.22, Table 1. In accordance with regulatory guidance, a review was conducted for all exposures greater than 15 µg/L. Discussions with the affected personnel were conducted and the most likely cause of the exposure was documented as noted in the footnotes to **Table 5-7**. The results of these investigations were presented in the annual ALARA audit reports.

Over the 12-year period (1999-2010), only 32 (0.6%) of the 4,804 samples that were taken exceeded the action level of 15 µg/L. Samples above the action level were investigated and corrective actions were taken where appropriate. The results of the investigations and corrective actions were detailed in the annual ALARA audit reports. Most of the action level exceedances occurred during 1999 through 2000 and were attributed to improper personal hygiene and improper use of personal protective equipment, poor housekeeping practices, and abnormal problems with the respirators. Appropriate corrective actions were taken, and the numbers of reported intakes have continued to remain small in number as a result of continued management attention, improved procedures, and worker training.

Qualitatively, there appears to be a clear reduction in the number of elevated bioassay samples from 1999 through 2010, and most of this reduction occurred over the course of two years (1999 and 2000). Bioassay data associated with operation of the CPF dryer during the period of interest is available for the years 2000 through 2002. During this period, 269 bioassay samples were collected from employees and contractors performing work associated with the CPF dryer. Of these 269 samples, two samples exceeded the 15 µg/L action level, which represents less than 1% of the samples collected.

Uranium intakes at Smith Ranch are closely monitored, as evidenced by the number of samples collected per year. This allows for timely investigations and corrective actions, if needed, to respond to conditions or practices which result in bioassay results above the action level of 15 micrograms/Liter.

Since 2003, five samples out of 3,160 collected (0.16%) were above the first tier action level of 15 micrograms/Liter. In each case, an appropriate investigation and corrective action was performed. Since 2003, 3,145 samples out of 3,160 samples collected (99.5%) were below the LLD of 5 micrograms/Liter. In 2009 and 2010, 1,319 samples were collected and none of the samples exceeded the 15 micrograms/Liter action level. This demonstrates that the soluble uranium intakes are limited to levels below regulatory limits (i.e., levels which are ALARA).

5.8.4.3 Bioassay Quality Assurance Program

Elements of the Quality Assurance requirements for the Bioassay Program are based on the guidelines contained in NRC Regulatory Guide 8.22, "Bioassay in Uranium Mills". These elements include the following:

- Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. The control samples are from persons that had not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 micrograms/Liter and 40 to 60 micrograms/Liter. The results of analysis for these samples are required to be within ± 30% of the spiked value. Cameco has tracked the results of the blind spike analysis and all analytical results have fallen within the acceptable range within the last 10 years.
- The analytical laboratory spikes 10 to 30% of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to Cameco. All results have been within ± 30%.

5.8.5 Administrative Action Levels

An administrative action level is set at 2.5 milligrams of soluble uranium for any calendar week. An administrative action level is set at 125 DAC-hours for exposure to insoluble uranium and/or radon daughters for any calendar quarter. If the action level is exceeded, the RSO will initiate an investigation into the cause of the occurrence, determine any corrective actions that may reduce future exposures and document the corrective actions taken. Results of the investigation will be reported to management within one month of the action level being exceeded.

The results of the personal gamma radiation monitoring from the dosimeters are evaluated on a quarterly basis and an administrative action level is set at 312 mrem per quarter. If an employee's exposure exceeds this level, the RSO will investigate the reason for the exposure and initiate corrective measures to prevent a recurrence.

The results of the bioassay program are also used to evaluate the adequacy of the respiratory protection program at the facility. An abnormally high urinalysis will be investigated both to determine the cause of the high result and determine if the exposure records adequately reflected that such an exposure may have actually occurred.

5.8.6 Contamination Control Program

5.8.6.1 General

The primary sources of potential surface contamination at Smith Ranch are associated with yellowcake precipitation, drying, and packaging activities. The recovery and elution portions of the process do not present a significant surface contamination problem except for dried spills or when special equipment maintenance is required. The primary method for control of surface contamination is instruction in, and enforcement of, good housekeeping and personal hygiene practices. Any visible yellowcake or production fluid spills are cleaned up as soon as possible to prevent drying and possible suspension into the air which could pose an inhalation hazard. Plant operators are instructed in the proper use of equipment and the prevention of spills and solution leaks at various stages of the process. Inadvertent contamination of designated "clean areas" is controlled by instructing employees not to enter such areas with clothing or equipment contaminated with radioactive materials.

5.8.6.2 Surface Contamination Control for Uranium

To ensure these administrative controls are effective in controlling surface contamination, alpha contamination surveys are performed monthly by the RSO or designee in process areas and weekly in designated clean areas. Routine surveys in the process areas of the CPP, CPF and satellite facilities consist of both a visual inspection for obvious signs of contamination and instrument surveys to determine total alpha contamination. Visible yellowcake outside the drying and packaging facilities requires prompt cleanup to minimize the potential for the material to become airborne. If the total alpha survey indicates contamination greater than 200,000 disintegrations per minute/100 centimeters^2, the area will be cleaned and resurveyed.

In designated clean areas, such as lunch rooms and offices, the target level for contamination is "nothing detectable". If the total uranium alpha survey in these areas indicates contamination in excess of 250 disintegrations per minute/100 centimeters^2 (25% of the **Table 5-8, Allowable Limits for Removal to Uncontrolled Areas**) a smear test will be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 disintegrations per minute/100 centimeters^2, the area will be cleaned promptly and resurveyed. Regulatory Guide 8.30 recommends weekly smear tests for removable activity. However, the NRC approved an alternate approach where total alpha contamination surveys are performed in clean areas on a weekly basis and smears are obtained when the total alpha contamination exceeds 25% of the limit for clean areas (i.e., 250 disintegrations per minute/100 centimeters^2). The RSO will investigate the cause of the contamination and implement corrective action to minimize the potential for a recurrence. Total alpha surface contamination levels exceeding the limits shown in **Table 5-8** will also require cleanup and investigation.

Before yellowcake drums leave the packaging area, they are washed to remove all visible yellowcake. Prior to shipment, the drums are surveyed for total alpha contamination. Although the limit for removable contamination on drums shipped in sole use vehicles is 2,200 disintegrations per minute/100 centimeters^2, a target level of 1,500 disintegrations per minute/100 centimeters^2 is used at Smith Ranch. If the total alpha survey results reveal contamination in excess of 1,500 disintegrations per minute/100 centimeters^2, a smear survey is performed. If this survey indicates contamination in excess of 1,500 disintegrations per minute/100 centimeters^2, the drums will be rewashed and resurveyed.

Yellowcake processing equipment that must be removed for maintenance or repair is thoroughly decontaminated prior to its removal from the area to prevent the possibility of contamination in the maintenance shop or other areas.

5.8.6.3 Personnel Contamination Control

Change rooms, showers and lockers for clean clothing are provided for employee use. An operable and appropriately calibrated alpha survey meter is made available for employee use at the exit of the CPP and satellite facilities and at the entrance to the lunch room at the CPP. Alpha survey stations will also be employed at the refurbished CPF. All employees are instructed in the use of the survey meter, techniques for minimizing contamination, maintaining good personal hygiene, and in basic decontamination methods. Employees are also instructed on methods and procedures for good housekeeping practices within process areas to minimize the potential for contamination of personnel and equipment. Personnel are also allowed to conduct contamination monitoring of small hand-carried items as long as all surfaces can be reached with the instrument probe and the item did not originate in yellowcake areas. All other items are surveyed as described Sections 5.8.6.2 and 5.8.6.4.

Employees working in the precipitation, drying and packaging areas, as well as those involved in process equipment maintenance or repair are provided with appropriate protective clothing and equipment. Protective clothing is laundered on site or, if a disposable type, is disposed at a facility licensed to accept such wastes.

All employees with potential exposure to yellowcake dust can shower and change clothes each day prior to leaving the site. An employee who showers and changes clothes is considered to be free of significant contamination. In lieu of showering, employees are required to survey their clothing, shoes, hands, face and hair with an alpha survey instrument prior to leaving the site. These surveys and/or showers are documented and maintained on site.

As recommended in NRC Regulatory Guide 8.30, Cameco conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. The purpose of the spot check surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

5.8.6.4 Surveys of Equipment and Materials Prior to Release to an Unrestricted Area

Program Description

The RSO, the HPT, or properly trained employees perform surveys for removable contamination as well as surveys for alpha and beta/gamma contamination of all items removed from the restricted areas with the exception of small, hand-carried items. Surveys for beta contamination are performed consistent with the recommendations of Regulatory Guide 8.30. Beta surveys are performed in specific operations that involve handling large quantities of aged yellowcake. An annual beta survey is conducted in areas that would typically be subject to residual uranium concentrate contamination, specifically, the precipitation, drying and packaging areas of the CPP and CPF. Equipment and materials to be released from the precipitation, drying and packaging areas for unrestricted use will be surveyed for beta contamination. The release limits are set as specified in *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For Byproduct or Source Materials"*, NRC, May 1987. If the equipment or material does not meet the limits, it will be decontaminated and resurveyed. The survey results are documented and maintained on site.

Surveys are performed with the following equipment:

- Total surface activity is measured with an appropriate alpha survey meter. A Ludlum Model 3 Ratemeter, or equivalent with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent.
- Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/ centimeters^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.
- Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use.

5.8.6.5 Protective Equipment and Procedures

All process and maintenance workers who work in yellowcake areas or work on equipment contaminated with yellowcake will be provided and required to wear protective clothing including coveralls, boots or shoe covers. Workers who package yellowcake for transport will also be provided gloves and respirators. Before leaving the yellowcake processing area, all workers involved in the precipitation or packaging for transport of yellowcake, will, at a minimum, monitor their hands and feet using a calibrated alpha survey instrument. In addition, spot surveys will be performed for alpha contamination at least quarterly on all workers leaving the recovery plant area. The monitoring results are documented and maintained on file.

At the CPP and satellite plants, eating is only allowed in designated lunch room areas that are separated from the process areas. Eating or smoking in the plant controlled areas is prohibited and violators are subject to disciplinary action.

5.9 Environmental Monitoring Programs

5.9.1 Quality Assurance

Cameco has established the following QA Program for all radiological, non-radiological effluent and environmental (including groundwater) monitoring programs at the Smith Ranch SUA-1548 license areas. This QA Program addresses elements discussed in NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) —Effluent Streams and the Environment."

QA comprises those planned and systematic actions which are necessary to provide adequate confidence in the results of a monitoring program. QC includes those quality assurance actions that provide a means to control and measure the characteristics of measurement equipment and processes to established requirements. Therefore, quality assurance includes QC.

The overall objectives of the QA program are:

- To identify deficiencies in the sampling and measurement processes to those responsible for these operations so that corrective action can be taken.
- To obtain a measure of confidence in the results of the monitoring programs to assure regulatory agencies and the public that the results are valid.

The first step of any reliable QA Program is a formal delineation of the organization structure, management responsibilities, and training requirements for management personnel. These items have been covered in a previous section. Other components of the program are described below.

5.9.1.1 Radiological and Environmental Monitoring Procedures

A critical step to ensure quality assurance objectives includes written procedures for various aspects of the radiological and environmental monitoring programs. Procedures for radiological and environmental monitoring programs are contained in SHEQ Manual IV-Health Physics Manual (radiological monitoring program procedures), and SHEQ Manual VI- Environmental Manual (environmental monitoring program procedures). These manuals describe the procedures used to collect samples, complete laboratory analyses and survey, calibrate equipment, evaluate data, etc. for the radiological and environmental monitoring programs. Procedures contained in SHEQ Manual IV-Health Physics Manual include the following programs:

- Airborne Radioactivity Monitoring
- External Radiation Monitoring

- Contamination Control
- Respiratory Protection
- Exposure Monitoring
- Transportation of Radioactive Materials
- Radiological Laboratory Programs

Procedures contained in SHEQ Manual VI-Environmental Manual include the following programs:

- Liquid Effluent Monitoring
- Air Monitoring
- Soil and Sediment Monitoring
- Vegetation Monitoring
- Wellfield Development and Monitoring
- Waste Management
- Topsoil Management
- Other Management Programs

5.9.1.2 Duplicative Sampling and Inter and Intra Laboratory Analyses

A good Quality Assurance Program provides provisions to ensure that contract and in-house laboratories are accurately analyzing and reporting radiologic and chemical analyses. Cameco utilizes an off-site EPA certified laboratory for all radiologic and chemical samples.

For every 20 excursion monitor well samples, a duplicate sample and a spiked sample are analyzed by Cameco's in-house laboratory. The duplication begins with original sample aliquots and allows the analyst to determine the precision of the analytical result. Standard addition spikes consist of the addition of a known amount of analyte to a duplicate sample aliquot. These spiked samples are useful in estimating the accuracy of an analytical result as well as identifying potential interferences.

In accordance with the applicable SOPs, baseline water quality samples for new wellfield areas are submitted within the required holding time to an EPA approved laboratory for filtration and preservation prior to analysis. Additionally, protocols have been established for the storage and shipment of samples, including standard chain-of-custody procedures.

5.9.1.3 Instrument Calibrations

Electronic instruments used to conduct radiologic surveys or determine the concentrations of radiologic material are calibrated by a qualified contractor on a routine basis to ensure that they are operating within specified ranges for the radionuclides being measured. In accordance with SOPs, certain instruments, such as alpha and Geiger-Mueller probes, are functionally checked with a known radiologic source on a more frequent basis (daily or weekly). Additionally, air pumps used to collect environmental or breathing air samples are routinely calibrated. Cameco only utilizes EPA approved laboratories which adhere to strict protocols so that that their electronic instruments are properly calibrated to ensure valid results. A list of the survey and monitoring instruments by manufacturer, range, sensitivity, calibration methods and frequency and planned use is detailed in **Table 5-9, Radiation Survey and Monitoring Equipment**.

5.9.1.4 In-house Laboratory QA/QC

Cameco operates and maintains an in-house laboratory for radiological and non-radiological analyses. Cameco has a laboratory-wide QA/QC program designed to assess and monitor the ongoing quality of the testing performed at the laboratory. The purpose of the QA/QC program is to identify and correct problems before they occur and if possible to determine in advance potential problem areas and institute measures for their resolution. Cameco has developed a QA Plan and all employees involved with the sampling and laboratory work flow have read and follow its guidelines. Standard Operating Procedures have been written for all analytical testing and are reviewed and updated regularly as new techniques and instrumentation become available.

5.9.1.5 Records

Records of radiologic surveys, instrument calibrations, radiological and chemical analyses, and employee exposures are retained on site under the direction of the RSO. To maintain the integrity of the program, the RSO and others, through the audit program, periodically review records to ensure that they are complete and accurate, and calculations have been done properly. These types of records are maintained on site until license termination. Critical records are periodically duplicated and stored in a second location in the case of fire or a similar type disaster. Computer programs used to determine employee exposures or other components of the program are verified with hand calculations to ensure that they are accurate.

5.9.1.6 Audits

Cameco management periodically conducts inspections and audits of the radiation safety and environmental monitoring programs to verify compliance with applicable rules, regulations, license requirements and to ensure that exposures of employees, the public, and the environment are ALARA. The Annual ALARA Audit is discussed in Section 5.3.2.

5.10 Environmental Monitoring Programs During Operations

5.10.1 Airborne Effluent and Environmental Monitoring Program

Cameco is undertaking a sampling program at Smith Ranch which will identify the sample type, location, equipment frequency/duration and LLDs. The Sampling Plan is discussed in detail in Section 5.8.

5.10.1.1 Air Particulate Monitoring

To ensure compliance with 10 CFR 20.1301, 20.1302 and 20.1501, Cameco maintains a continuous ambient air particulate monitoring program at five separate locations at Smith Ranch. The remote satellites at North Butte and Gas Hills will have air particulate monitoring stations installed early in 2012 to collect air particulate data at those locations. An additional air monitoring station will be installed at the Reynolds Ranch satellite facility prior to commencement of operations. This station will be installed to replace the current upgradient station (AS-1, Dave's Water Well). The Highland CPF and the Smith Ranch CPP have the greatest potential for airborne releases to the environment. Two of these stations (AS-4 and AS-5) were used to monitor downwind conditions of the Highland CPF but are inactive as a result of the CPF being placed in standby status in 2002. Monitoring at AS-4 and AS-5 will resume once operations begin again at the refurbished CPF.

Environmental monitoring stations AS-1, AS-2 and AS-3 are equipped with high volume air samplers and take particulate samples for analysis for uranium (nat), Th-230, Ra-226 and Pb-210. A track-etch detector and an environmental dosimeter are placed at each monitoring station for measurement of Rn-222 and gamma radiation exposure rates. All particulate samples, track-etch detectors, and dosimeters are collected periodically and sent to an accredited outside laboratory for analysis. Results of the analyses are reported to the NRC in the semi-annual reports. The results of the monitoring are summarized in **Table 5-10, Radionuclides Air Monitoring Data 2000-2010 at Dave's Water Well (AS-1) Table 5-11, Radionuclides Air Monitoring Data 2000-2010 at Smith Ranch Controlled Area-Fence Line (AS-2),** and **Table 5-12, Radionuclides Air Monitoring Data 2000-2010 at Vollman Ranch (AS-3)**. The cited tables also have graphs that illustrate the radiological data trends over time. The locations of the air monitoring stations at Smith Ranch are shown on **Figure 5.7, Smith Ranch Environmental Sampling Location Map** and are as follows:

- AS-1 (Dave's Water Well): This station monitors background conditions, upwind of both the Smith Ranch and Highland wellfields and yellowcake processing facilities.
- AS-2 (SR Controlled Area–Fence Line): This station monitors conditions downwind of the Smith Ranch CPP Controlled Area Boundary.
- AS-3 (Vollman Ranch): This station monitors the nearest downwind resident to the Smith Ranch CPP Controlled Area.
- AS-4 (Highland Controlled Area): This station monitors conditions downwind of the Highland CPF Controlled Area Boundary (when the Highland CPF is operating).
- AS-5 (Fowler Ranch): This station monitors the nearest downwind resident to the Highland CPF Controlled Area (when the Highland CPF is operating).
- AS-6 (Reynolds Ranch Satellite): This station will monitor conditions downwind of the Reynolds Ranch satellite area once the facility is constructed and becomes operational.

The CPF and CPP have the greatest potential for airborne releases to the environment compared to the satellites where only resin transfer occurs. AS-2 was selected as the probable location of highest exposure to the public from emissions from the CPP while AS-3 is selected as the nearest resident which is approximately 7.3 kilometers (4.5 miles) downwind of the CPP.

Monitoring results for AS-4 and AS-5 are not included in the analysis because the CPF was not incorporated into the license until 2003 and has been in standby status since September 2002. Monitoring is not required at these locations while the CPF is not operating, per License Condition 11.6 of the NRC Source Materials License SUA-1548.

Passive Rn-222 track-etch detectors are placed at the monitoring stations and exchanged periodically for analysis of Rn-222 by an accredited outside laboratory. The net Rn-222 concentration is obtained at a location by subtracting the value obtained at AS-1 (Dave's Water Well [background location]) from the value obtained at the other two locations of interest, AS-2 (CPP Controlled Area Fence Line) and AS-3 (Vollman Ranch, the nearest downwind resident). Ra-222 was measured quarterly from the last half of 1999 through 2004 and semi-annually from 2005 to the present. For consistency, the data from the quarterly measurements of Rn-222 were averaged to yield semi-annual concentrations, and those concentrations were used for comparison and data analysis purposes. The data processing did not have an impact on the results, but less temporal resolution by going from quarterly to semi-annually.

All of the Rn-222 concentrations measured at AS-2 and AS-3 were at or below the value listed in 10 CFR 20 Appendix B for Rn-222 without daughters present, except at AS-2 during the first half of 2007. On June 6, 2007 a routine check of the monitoring station revealed that the Velcro securing the Track-Etch Rn-222 detector failed, and the detector had fallen out of its holder and was lying face-up on the ground. The result from this detector was abnormally high (1.85×10^{-8} µCi/ml) when compared to historical data from this location. This datum was therefore considered suspect and not included in the analysis.

Monitoring location AS-2 is located downwind of the CPP controlled area boundary fence line. This is considered the location where a member of the public could be exposed to the highest concentration of airborne radionuclides. Since this is well within the licensed boundary, Cameco maintains control over the long-term use of this area and does not permit any use involving high occupancy by members of the public. Thus the monitoring data represent maximum exposure conditions for short-term occupancy by the public, with exposure times considered to be a few hours per year or less.

Vollman Ranch (AS-3) located within the well field license boundary as shown in **Figure 5.7** is the nearest resident to and downwind of the CPP. It is unreasonable to assume that members of the public would have an occupancy time within the license area greater than a small fraction of that of Vollman Ranch residents. Other exposed people include an occasional hunter, person servicing a nearby wind farm, and other members of the public spending a few hours per year as they use the public roads. The residents of Vollman Ranch are known to use the ranch as their principal residence and workplace.

The net annual Rn-222 concentrations are presented in **Table 5-13, Net Rn-222 Concentrations at Monitoring Locations AS-2 and AS-3**. The net concentrations are derived by subtracting the concentrations at the background location from the measured values at the monitoring location for the sampling period. The net annual Rn-222 concentrations are compared to the NRC effluent concentration (EC) Guidelines in the table. As can be seen from the table, the annual average net concentrations for these two locations are all less than or equal to 5% of the EC. The table also reveals that several net values for the years prior to 2005 are negative, indicating that the values of the Rn-222 concentration measurements at the background location were higher than those at AS-2 and AS-3. This might be explained by there being another possible source of Rn-222 in the area, such as the nearby coal mine and power plant, or perhaps the negative results are just statistical fluctuations obtained when two nearly equal numbers are subtracted, each having a statistical uncertainty. An analysis of the particulate data for these locations reveals that in general, all monitoring station results show higher concentrations of uranium particulates for the years prior to 2003. The NRC attributed the elevated Pb-210 concentrations in early 2001 to emissions from the nearby operating coal strip mine and power plant. Because Pb-210 is formed in the atmosphere from the decay of airborne Rn-222, one can assume that a source of Pb-210 would also be a source of Rn-222.

The effluent concentration limit (ECL) used for compliance purposes by Cameco are those listed in 10 CFR 20 Appendix B, Table 2 for the radionuclides of concern. The limits and their likely solubility class are 3E-12 μCi/ml for U(nat) (Class D), 2E-14 μCi/ml for Th-230 (Class W), 9E-13[3] μCi/ml for Ra-226 (Class W), 6E-13 μCi/ml for Pb-210 (Class D) and 1E-8 μCi/ml for Rn-222 without daughters present. As noted above, a sampling plan is being implemented that will directly measure radon daughters at these locations so that the implications of old natural radon with daughters, versus freshly produced operational radon with more limited daughters and the choice of 10 CFR 20 Appendix B Table 2 may be rendered moot.

The program complies with guidance in NRC Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills". The LLD for the air particulate sampling program is specified as 1×10^{-16} μCi/ml for uranium (nat), Ra-226, and Th-230; LLD for Rn-222 is 2×10^{-10} μCi/ml; and the LLD for Pb-201 is 2×10^{-15} μCi/ml.

Since the primary effluent from the CPP is Rn-222 and its progeny (including Pb-210), it is not surprising that the concentrations of radioactive particulates are near background levels and small compared to the NRC ECL. The only measureable net particulate concentration of significance is Pb-210, which is a decay product of Rn-222. The net annual average data for Pb-210 for the fence line (AS-2) and Vollman Ranch (AS-3) locations is given in **Table 5-14, Net Lead-210 Concentrations at Monitoring Locations AS-2 and AS-3** along with the percent of the ECL Guideline. The data show that for the years 2004-2008, the average annual concentration of Pb-210 was less than 1% of the ECL. For the years prior to 2004, the average net concentrations varied significantly, from 15% to 17% of the ECL. The average concentration at the fence line was less than that measured at the background location for 3 of the 4 years. These data show that the Pb-210 emissions are very low and the concentrations are well within acceptable limits. The NRC agreed with Cameco that the elevated Pb-210 concentrations at Vollman Ranch in 2001 probably resulted from effluent from the nearby operating coal strip mine and/or power plant (NRC, 2001e).

The concentrations of the other radionuclides of concern (natural uranium, Ra-226, and Th-230) all were measured to be a small fraction of the ECL without subtracting the background concentrations. Therefore no useful information could be obtained from this data other than to conclude that the concentrations are near background and do not contribute significantly, if at all, to public dose from site operations.

The monitoring program at Smith Ranch is effective in monitoring potential airborne effluent releases and gamma exposure rates resulting from site activities and is consistent with the recommendations contained in NRC Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills". The results of this program show that airborne releases of radionuclides are well below the ECL which are contained in 10 CFR 20 Appendix B and used for compliance purposes by Cameco. The gamma exposure levels are well below the 0.05 rem per year requirement contained in 10 CFR 20 Subpart D. To show the extent of the airborne monitoring program, Cameco has collected over 300 samples for particulates, Rn-222 and gamma analysis.

Net Rn-222 air concentrations were shown to not be significantly different for the AS-2 and AS-3 sampling locations and are well below the ECL. There appears to be an increasing trend in Rn-222 concentrations at the AS-1 (Dave's Water Well-Background) in 2008 and 2009 but this trend is likely due to the same off-site source mentioned above for Pb-210 since Pb-210 is a decay product of Rn-222. A similar increasing trend for net Rn-222 concentrations at the AS-2 and AS-3 locations in 2008 and 2009 was also noted, but the net Rn-222 concentrations had declined at AS-1, AS-2 and AS-3 in 2010.

Net annual gamma exposures were below the 0.05 rem (50 mrem) requirement contained in 10 CFR 20 Subpart D for all measured locations. Significant positive trends were observed at the background locations at AS-1 and AS-3. A negative trend was observed for net exposure rate data collected at the AS-2 location, but the net gamma concentrations have increased at AS-2 since 2006. The analysis supports the conclusion that impacts from off-site sources are being measured at the monitoring stations.

All data presented here suggests that air effluents at Smith Ranch are below regulatory requirements and in most cases are near or identical to background concentrations. The data show that Cameco has and continues to keep environmental impacts from site operations to levels that are compliant with applicable regulations and that are ALARA.

5.10.1.2 Soil and Vegetation Sampling at Air Particulate Monitoring Stations

Annual soil and vegetation sampling were performed at Smith Ranch and Highland prior to 2000. Based on an NRC inspection that stated that the license did not require annual soil and vegetation sampling (IR 40-8857/99-02), the sampling program was terminated. Therefore there is no data to present.

5.10.2 Surface Water Monitoring Programs

5.10.2.1 Smith Ranch

A total of 10 surface water monitoring points at stock ponds within the Smith Ranch license area are sampled by Cameco. Quarterly sampling of Sage Creek and the stock ponds for analysis of natural uranium and Ra-226 is conducted when adequate water exists to permit sampling. The dewatering of the Bill Smith underground mine during the 1970s created a discharge into Sage Creek drainage and the stream was flowing at that time because of the dewatering. Samples were collected during that time frame upstream and downstream to verify no discharge of contaminants, but these discharges are no longer occurring and dry conditions have limited sampling since that time.

The 10 stock pond monitoring points were added August 18, 2003 as a part of Amendment No. 5 (NRC, 2003) that combined the Smith Ranch and Highland operations and added remote satellite facilities at North Butte and Ruth. Also, sampling of the effluent from the CPF was discontinued in the third quarter of 2002 when the facility was placed on standby status. Sampling and analyses are conducted quarterly and reported in semi-annual effluent environmental monitoring reports that are provided to the NRC. The current monitoring points are shown on **Figure 5.7**. The surface water samples are analyzed for natural uranium and Ra-226. The sampling points are located as follows to evaluate potential impacts from ongoing mining operations:

- SW-1 (Stock Pond): This location is closest to Mine Unit 15 (MU-15) and samples are collected when water is available;
- SW-2 (Stock Pond): This location is closest to Mine Unit 4 (MU-4) and samples are collected when water is available;
- SW-3 (Stock Pond): This location is closest to Mine Unit 2 (MU-2) and samples are collected when water is available;
- SW-4 (Stock Pond): This location is closest to Mine Unit 1 (MU-1) and samples are collected when water is available;
- SW-5 (Stock Pond): This location is closest to Mine Unit J (MU-J) and samples are collected when water is available;
- SW-6(Stock Pond): This location is closest to Mine Unit F (MU-F) and samples are collected when water is available;
- SW-7 (Stock Pond): This location is closest to Mine Unit D (MU-D) and samples are collected when water is available;
- SW-8 (Stock Pond): This location is closest to Mine Unit H (MU-H) and samples are collected when water is available;
- SW-9 (Stock Pond): This location is closest to Mine Unit H (MU-H) and samples are collected when water is available; and
- SW-10 (Stock Pond): This location is closest to Mine Unit I (MU-I) and samples are collected when water is available.

Surface water monitoring results collected at Smith Ranch since the last license renewal are provided in **Table 5-15, Surface Water Monitoring Historical Review** which summarizes the quarterly monitoring data that have been provided in the semi-annual Reports. These reports are submitted in compliance with 40 CFR §40.65 and provide information on the quantity of radionuclides that may have been released in unrestricted areas in liquid and gaseous effluents during the preceding six month period. The results in **Table 5-15** show that samples were often not collected, for that period, because the sampling location was dry and, in some limited cases, frozen during winter months. This is expected given the ephemeral nature of drainages and cold winter climate in the license area. Also, 18% of samples collected (49 out of 259 through the fourth quarter of 2010) were non-detectable for Ra-226 and 7% of samples collected (20 out of 259 through the second quarter of 2010) were non-detectable for natural uranium. The analytical detection limit for natural uranium is 2.0×10^{-10} µCi/ml and 2.0×10^{-11} µCi/ml for Ra-226. A review of the monitoring data show that concentrations of natural uranium measured since 1999 ranged from below analytical detection limits to 2.2×10^{-7} µCi/ml. Concentrations of Ra-226 ranged from below analytical detection limits to 1.1×10^{-8} µCi/ml. (see **Table 5-15**).

In all cases, measured concentrations of natural uranium and Ra-226 (as tabulated in **Table 5-15** were less than the 10 CFR 20, Appendix B, ECL of 3E-7 µCi/ml and 6E-8 µCi/ml, respectively, for natural uranium and Ra-226 during the monitoring periods. These ECLs provide a conservatively safe level for the public assuming that a member of the public was continuously exposed to these concentrations throughout the year. Concentrations of uranium in the surface water monitoring samples are comparable to the concentrations in most natural waters in the region, which range from 0.0001 to 0.01 parts per million (mg/L) (Heakin, 2000). While any trends would be difficult to ascertain given the intermittent nature of the data, the average concentrations of uranium over the last decade are typically more than an order of magnitude less than the ECL. Likewise, average concentrations of Ra-226 over the last decade are typically two orders of magnitude less than the ECL.

5.10.2.2 North Butte Remote Satellite

The limited surface water supplies within and adjacent to the North Butte Remote Satellite area are used for livestock and wildlife watering. Even during wet years, Willow Creek at the south end of the satellite license area only flows for a couple of months. During dry years, such as 1988, there is essentially no flow during the entire 12 month period. Stock reservoirs in the area provide additional sources of water for livestock and wildlife. Environmental sampling locations are at the North Butte Remote Satellite, shown on **Figure 5.8, North Butte Environmental Sampling Location Map**.

Surface water grab samples will be collected on a quarterly basis, if water is present, from stock reservoirs that are sufficiently close to the operation to be subject to drainage from potentially contaminated areas or mine unit leaks or spills. Additionally, surface water grab samples will be collected at one upstream and downstream location on a quarterly basis, if water is present, from drainages sufficiently close to the operation to be subject to surface drainage from potentially contaminated areas or mine unit leaks or spills. As these drainages are ephemeral and flow only in response to snow melt or precipitation events, samples will be collected opportunistically when water is flowing. All surface water samples will be analyzed for uranium, Ra-226 and Pb-210. Surface water samples were collected at 15 locations in June 2011. The majority of the samples were collected from standing water in ephemeral ponds and drainages. The results of the baseline monitoring are discussed in Section 6.0 of the ER.

5.10.2.3 Gas Hills Remote Satellite

The effects on surface water quality and quantity will be minimal at the Gas Hills Remote Satellite. With the exception of West Canyon Creek, most drainages throughout the satellite license area are ephemeral and flow only intermittently in response to spring runoff or occasional strong thunderstorms. Environmental sampling locations at the Gas Hill Remote Satellite are shown on **Figure 5.9, Gas Hills Environmental Sampling Location Map.**

At least four surface water sample sites will be routinely monitored during the operations at the Gas Hills Remote Satellite. These include the following:

1. Cameron Spring station which is located south of Mine Unit No. 1 in the SE1/4 of the SE1/4, Section 2, T32N, R90W;

2. Section 23 Stock Pond, a small constructed pond near the northern end of Mine Unit No. 1, located in SW1/4 of the NE1/4, Section 32, T33N, R89W; and
3. Two locations in West Canyon Creek which flows through a portion of Mine Unit No. 4. WCC-1 station is located in the upstream reach south of the Mine Unit 4 boundary. WCC-2 station is located further downstream within Mine Unit 4.

Cameron Spring is located hydrologically and topographically upgradient from Mine Unit No. 1 and should not be affected by the ISR operations. A grab sample will be collected annually and analyzed for uranium and Ra-226. An estimate of flow will be made at the time each sample is collected. WCC-1, 2 and Cameron Spring have established gauging stations in place so that stream flow measurements can easily be taken

The stock pond in Section 23 is located between Mine Unit No. 1 and No. 2 and will receive runoff from the southwest portion of the Mine Unit No. 2 area. Starting with the commencement of mine unit pattern installation in the southwest portion of Mine Unit No. 2, this pond will be sampled quarterly and a grab sample will be analyzed for uranium and Ra-226. An estimate of water volume will be made at the time each sample is collected.

The two established West Canyon Creek surface water monitoring stations described in the Gas Hills WDEQ Appendix 6 will be grab sampled quarterly starting at the time well field installation activities begin in Mine Unit No. 4. Flow measurements will be made at the time the samples are collected. Each sample will be analyzed for uranium and radium-226.

5.10.2.4 Ruth Remote Satellite

Surface water (Dry Fork of the Powder River and stock reservoirs) is present at the Ruth Remote Satellite, but the operational surface water sampling locations have not been determined at this time. As such, a surface water monitoring program has not yet been developed. The Dry Fork of the Powder River is classified as an intermittent stream within the satellite license area. The stream flows mainly in response to snow melt and convective rainstorms; however, the alluvium is partially saturated and supports phreatophytic vegetation such as cottonwood trees and willows. A surface water monitoring program was implemented by Uranerz for the Ruth R &D operation starting in March 1980 and continued on a quarterly basis until 1985 when the program was discontinued after regulatory approval of the aquifer restoration.

5.10.3 Environmental Groundwater Monitoring Programs

5.10.3.1 Operational Groundwater Monitoring

Cameco has developed a carefully planned hydrologic monitoring program to ensure that production fluids are contained within the defined production zone during wellfield operation. If production fluids exit the production zone, increases in the concentration of the UCL parameters at the affected monitoring wells are inevitable. If this situation occurs, and concentrations of the UCL parameters meet the defined excursion criteria, an excursion has occurred, and certain regulatory and operational procedures are followed.

The "M," "MO," "MS" and "MU" or "MD" wells are sampled twice each month at approximately two week intervals, but not less than 10 days apart, and are analyzed for the UCL parameters. Sampling and statistical methods to determine UCL parameters and concentrations are discussed in Section 3.4. In the event of unforeseen conditions (e.g. safety concerns, equipment malfunction, electrical problems, wells lacking sufficient water, adverse weather conditions, unsafe ground conditions or inaccessibility, aggressive wildlife or wildlife concerns, etc.) and a well(s) is missed in a given sampling round, the information not collected will be considered missing data. Trends of specific data points are indicators of the status of a wellfield. If a sample cannot be taken from a well, the data collected in at least the two previous sampling rounds from that well will be used in conjunction with the remaining well field data to determine the status of the wellfield.

If the trend analysis shows a missed sample might have been significant, (i.e., indicating a trend towards or away from a potential excursion), water level measurements will be used, if available. NRC and WDEQ will be verbally notified within 24 hours of Cameco becoming aware of missing the sample(s). Since wells are sampled twice a month with at least 10 days between sampling events, the missed well(s) will be sampled at the next scheduled interval, conditions permitting. Written notification will be submitted within 15 days of the verbal notification and will include a trend analysis, using two previous sampling rounds and the most recent sample, for each missed well, and a description of actions being taken to prevent an excursion.

Prior to collecting each sample, static water levels are measured and recorded. Water quality samples are obtained by pumping the monitoring wells with permanently installed submersible pumps. To assure that water within the well casing has been adequately displaced and formation water is sampled, wells are pumped a certain amount of time, based on the particular well's performance. A minimum of one casing volume of water will be removed from the well prior to sampling.

Prior to sampling, the electrical conductivity (corrected to 25°C), temperature, and pH are measured at periodic intervals and recorded to demonstrate that water quality conditions have stabilized and ensure that formation water is sampled. All data for each well are periodically reviewed to ensure that both sampling and analytical procedures are adequate. Water quality samples are analyzed for the UCL parameters, usually within 48 hours of sampling, at the on-site laboratory. All analyses are performed in accordance with EPA approved methods.

Cameco has developed and implemented an excursion detection and control program that complies with NRC and WDEQ requirements. An excursion is determined to have occurred at a monitor well if any two of the three UCL values are exceeded in a regularly scheduled sampling event. If an excursion is indicated during a routine sampling, a verification sample is taken within 24 hours of the receipt of the results from the initial sampling event. If the results of the second sampling event indicate an excursion occurred, the excursion will be considered confirmed. If the results from the first and second sampling events provide conflicting information as to whether an excursion has occurred, the third sample will be collected within 24 hours of the receipt of the results from the second sampling event. The results of the third sample will determine whether a confirmed excursion status exists. If confirmatory sampling results are not complete within 30 days of the initial sampling event that indicated that an excursion might be present, the excursion will be considered confirmed for the purpose of meeting NRC and WDEQ reporting requirements.

During an excursion, all monitor wells on excursion status will be sampled at least once every seven days and analyzed for the UCL parameters and uranium. If an excursion is not controlled within 30 days following confirmation, each affected well will be sampled and analyzed for the parameters in Table Op-7 from the Smith Ranch WDEQ Operations Plan. Additionally, LQD Rules and Regulations Chapter 11, Section 12(d)(i) require that excursion samples be analyzed for antimony, barium, beryllium, conductivity, copper, lead, mercury, nitrate, pH, and thallium. The WDEQ may waive the analysis of specific parameters if, based on historical groundwater sampling data, the parameter(s) is not considered likely to occur as a result of ISR activities.

5.10.3.2 Smith Ranch Satellite

This section describes the groundwater environmental monitoring program that has been approved for Smith Ranch and will be performed at the Reynolds Ranch Satellite and the North Butte, Gas Hills and Ruth Remote Satellites. Excursion and restoration groundwater monitoring programs are described in Sections 3.0 and 6.0, respectively.

Operating livestock and domestic wells within 1 kilometer (0.6 mile) of operating mine units at Smith Ranch have historically been sampled quarterly for uranium and Ra-226. Since the last renewal, an additional nine mine units started operating resulting in an increase in the number of livestock and domestic wells that are sampled quarterly. **Table 5-16, Domestic and Livestock Wells in Smith Ranch Groundwater Monitoring Program** summarizes the location and use of each well in the groundwater monitoring program at the time of this license renewal request. The wells are identified as: GW-1 through GW-6, GW-8 through GW-18, and GW-20. The locations of these wells are shown on **Figure 5.7**.

Concentrations of uranium and Ra-226 from the livestock and domestic wells are compared to the ECL presented in 10 CFR Part 20, Appendix B. The limits presented in 10 CFR Part 20 are applicable to the assessment and control of dose to the public, and are equivalent to the radionuclide concentrations which, if ingested continuously over the course of a year, would produce a TEDE of 0.05 rem. These ECLs are 6E-8 µCi/ml for Ra-226 and 3E-7 µCi/ml for natural uranium. Concentrations of uranium have exceeded the ECLs three times at one well, GW-5, which is located between mine units J and K. These exceedances are summarized in **Table 5-17, Uranium Results for GW-5 Which Exceeded Effluent Concentration Limit**. No other results have exceeded the ECLs. The results of the groundwater monitoring program indicate that Smith Ranch well field operations have not impacted aquifers encountered at the depths of the wells, which range from approximately 46 to 213 meters (150 to 700 feet) bgs. A discussion of the occurrence of uranium in the groundwater at GW-5 is provided below.

As documented in the July 1 through December 31, 2004 semi-annual report for SUA-1548, water well GW-5 is located in an area with shallow natural uranium mineralization, along with other naturally occurring radioactive minerals. These areas are referred to as the "Snow Claims", which have a zone depth from approximately 15 to 36 meters (50 to 120 feet) (this was verified on the downhole geophysical logs from drilling deeper zones that intersected the "E" sandstone from surface down to 36 meters [120 feet] in this area). Well GW-5 has a depth of approximately 30 meters (100 feet), which falls in this mineralized zone. Due to the shallow nature, portions of the mineralized zone may dry out seasonally, potentially causing uranium to oxidize, and as a result increase its solubility in water. Therefore, the higher uranium concentration in this well is naturally occurring due to the uranium mineralization in the shallow aquifer in which GW-5 is completed. The higher uranium concentrations at this well are not likely from the ISR operations due to the great distance to the nearest wellfield operating at the time (approximately 0.3 kilometers [0.5 miles] from MU-F), and the known natural occurrence of uranium in these shallow ore bodies.

5.10.3.3 North Butte Remote Satellite

There are 10 livestock wells or springs within the North Butte Satellite license area or within 2 kilometers of the license boundary. The water from these wells is not suitable for human consumption, and is used for livestock watering only. The residents at the Pfister Ranch haul their drinking and cooking water to their house. Quarterly groundwater samples will be collected from the well (Beck Well) at the Pfister Ranch once operations commence.

Groundwater samples will be collected quarterly from all operating domestic and stock wells located within 2 kilometer of operating mine units. Samples obtained from these wells will be analyzed for dissolved and suspended uranium, Ra-226 and Pb-210. Groundwater samples were collected from seven wells in June 2011. The well designation and locations are provided in **Table 5-18, Livestock Wells in North Butte Groundwater Monitoring Program.**

5.10.3.4 Gas Hills Remote Satellite

There are seven livestock wells or springs (see Section 5.10.2.3) within the license area or within 2 kilometers of the license boundary. At this time, Cameco has not developed an operational sampling plan for groundwater locations within 1 kilometer of the license boundary. It should be noted that the Carol Shop well (Carol Shop No. 1) was used to provide water to the Carol Shop when conventional mining was conducted. This well was completed in a non-uranium bearing portion of the production aquifer and is located in the SE1/4 of the NW1/4, Section 28, T33N, R89W. Currently, Cameco is evaluating the need to plug and abandon this well and drill a new well in a different aquifer. Apparent high Ra-226 concentrations in the water will limit the usage of this water as a drinking water/showering source for the Carol Shop. The springs will be sampled during operations as described in Section 5.10.2.3.

5.10.3.5 Ruth Remote Satellite

There are 11 livestock wells or springs within the license area or within 2 kilometers of the license boundary. At this time, Cameco has not developed an operational sampling plan for these wells. There are numerous CBM wells near the Satellite license area. Currently, the CBM produced water is being conveyed through underground pipelines to Salt Creek for surface discharge.

5.10.4 Wastewater and Land Application Monitoring Program

5.10.4.1 Soil and Vegetation Monitoring at Land Application Areas

To assist in assessing impacts of irrigating treated wastewater at the Smith Ranch Satellite No. 1 and Satellite No. 2 Wastewater Land Application Facilities (Irrigation Areas) the irrigation water, soil, and vegetation are monitored for various constituents including uranium Ra-226. This monitoring program has been in place since the start of each facility. Results of the monitoring program are reported to the NRC in the semi-annual reports. Results of the monitoring program are also reported to the LQD.

The monitoring programs for the Satellite No. 1 and Satellite No. 2 Wastewater Land Application Facilities are shown in **Tables 3-8** and **3-9**, respectively. The Monthly Grab samples are used to monitor the radium treatment system at each Satellite to assure that the barium chloride treatment system is reducing Ra-226 to acceptable concentrations (less than the ECL of 60 pCi/L [6.0-8 μCi/mL]). Monitoring data collected throughout the life of the project shows that the treatment system is very effective in reducing Ra-226 concentrations to levels below the ECL.

The results of monitoring data for the radium treatment system at Satellite No. 1 for the period 2000 through June 2004 shows a mean Ra-226 concentration of 2.51 E-8 μCi/mL which is 42% of the ECL. The Satellite No. 1 Land Application Facility has not received treated water for disposal since the Satellite No. 1 suspended operation in September 2003. The results of monitoring data for the radium treatment system at Satellite No. 2 for the period 2000 through 2010 shows a mean Ra-226 concentration of 5.72 E-9 μCi/mL, which is 10% of the ECL. Monitoring data for the Satellite No. 3 treatment system, which has only been operational since January 1999, shows a mean Ra-226 concentration of 2.20 E-8 μCi/mL (37% of the ECL) for the period 2000 through December 2010. Radium treatment sampling for the Selenium Treatment Facility began in July 2010. Results of the monitoring data for the radium treatment for the period of July 2010 through June 2011 shows a mean concentration of 4.37 E-9 μCi/mL which is 7% of the ECL. The 10 CFR 20, Appendix B ECL for Ra-226 is 6.0 E-8 μCi/mL. All waste water from Satellites 2 and 3 are now treated for radium and selenium removal at the Satellite 2 Radium Treatment Plant prior to land application at Land Application Facility 2.The irrigation fluid quality has been monitored at both irrigation facilities since irrigation operations started. Review of the irrigation fluid monitoring results at the Satellite No. 1 facility, for the period 2000 through June 2004, shows the following mean concentrations of uranium and Ra-226 (weighted by volume of water applied):

Uranium (nat): 0.20 mg/L or 1.35 E-7 μCi/mL

Ra-226: 4.3 pCi/L or 4.3 E-9 μCi/mL

Results of this monitoring program at the Satellite No. 2 facility for the period 2000 through 2010 show the following mean concentrations of uranium (nat) and Ra-226 (weighted by volume of water applied):

Uranium (nat): 0.50 mg/L or 3.4 E-7 μCi/mL

Ra-226: 45.0 pCi/L or 4.5 E-9 μCi/mL

The concentrations of uranium and Ra-226 within the treated wastewater applied at both irrigation facilities are within the range of concentrations predicted in the information submitted to the NRC for use of these facilities.

The monitoring programs for the Satellite No. 1 and Satellite No. 2 Wastewater Land Application Facilities also require that soil samples be collected annually in August at depths of 0-15.2 centimeter and 15.2 to 30.5 centimeters (0 to 6 inches and 6 to 12 inches) to assess impacts of irrigation on the irrigated soil. Results of the soil monitoring for uranium and Ra-226 at the Satellite No. 1 and Satellite No. 2 facilities are summarized in **Table 5-19, Mean U-nat and Radium-226 in Soil at Satellite No. 1 Irrigation Area 1 for Period 2000-2010** and **Table 5-20, Mean U-nat and Radium-226 in Soil at Satellite No. 2 Irrigation Area 2 for Period 2000-2010**, respectively.

A review of the soils data for the Satellite No. 1 facility shows an increasing trend in natural uranium concentrations within the 0-6 inch soil depth, compared to a background range of 6.89 E-7 to 4.0 E-6 μCi/g (1.0 to 5.9 milligrams/kilogram). The data obtained from 2000 to 2010 shows a mean natural uranium concentration of 8.06 E-5 μCi/g (11.8 milligrams/kilogram) for the 0 to 15.2 centimeters (0 to 6 inches) soil depth. The Ra-226 data for the same time period and same depth shows a background range of 9.35 E-7 to 4.0 E-6 μCi/g (0.9 to 4.0 pCi/g) and a mean concentration of 1.94 E-6 μCi/g. There is no discernible increase in Ra-226 concentrations, which ranges from 1.08 to 4.5 E-6 (1.6 to 6.6 pCi/g) and a mean of 1.91 E-6 μCi/g. No problems are therefore anticipated in meeting soil radionuclide release criteria.

A review of the natural uranium concentration data for the 15-30 centimeter (6 to 12 inch) soil depth at the Satellite No. 1 facility shows only a minimal increase above background. Since no discernible increase in Ra-226 concentrations have been observed at this same depth, no problems are anticipated in meeting soil radionuclide release criteria.

The higher concentrations of uranium in the near surface soil (0-15 centimeter depth) is attributed to the uranium attaching to soil particles and being more concentrated due to evaporation of soil water near the surface. If deemed necessary at decommissioning, it would be possible to reduce the near surface concentrations by deep plowing and mixing the soil.

A review of the data for the PSR-2 facility, which has not been in operation as long as the PSR-1 facility, shows that uranium is also increasing in the near surface soil (0 to 15 centimeter depth). The data obtained from 2000 to 2010 shows a natural uranium mean concentration of 5.94 E-6 µCi/g (8.8 milligrams/kilogram) which is minimally above the background range of 8.0 E-7 to 7.72 E-6 µCi/g (1.2 to 11.4 milligrams/kilogram). Data for the 15 to 30 centimeter (6 to 12 inch) depth shows no discernible increase in soil uranium concentrations compared to background ranges.

A memorandum prepared by Golder Associates, in August 2011 indicates that soils under irrigation at Satellite No. 2 have experienced slight uranium concentration (~0.18 mg U/kg soil per year) increases since data started being collected in 1993 (see **Appendix J, Purge Storage Reservoir No. 2 Shallow Groundwater Characterization Plan**). **Appendix J** indicates that the trend is not non-significant at the a-0.05 level (p=0.23) using a regression analysis of concentration as a function of time. Since the soil uranium concentrations have remained consistently less than the EPA MCL-based Soil Screening Level of 14 mg/kg (EPA 2011), which is substantially more stringent than the Wyoming Voluntary Remediation Program's soil cleanup level (WDEQ, 2011) of 49 mg/kg soils that is based on the EPA risk-based Soil Screening Level. While the Soil Screening Levels are not cleanup standards, they are guidelines that suggest whether chemical-specific concentrations at a given facility warrant further investigation. Golder discusses that were the current trend of increasing soil uranium concentration to continue, the soils under irrigation would not be predicted to reach the MCL-based Soil Screening Level until the year 2039. Given the projected future agricultural use of the land, Cameco believes that these comparisons provide assurance that the current practices, even with the modest increases in uranium concentrations observed, provide adequate environmental, health, and safety protection.

A review of the Ra-226 data for both soil depths at the Satellite No. 2 facility shows that concentrations have not exceeded the background range of radium-226 concentrations. Because no discernible increase in Ra-226 has been determined, or is expected, no problems are anticipated in meeting soil radionuclide release limits.

The vegetation at both irrigation facilities is also monitored on an annual basis, in August of each year, to determine the potential accumulation of radionuclides in the vegetation. Monitoring of the vegetation started at the Satellite No. 1 facility in 1991 while monitoring of the Satellite No. 2 facility commenced in 1996. The mean uranium and Ra-226 concentrations in vegetation for the Satellite No. 1 and Satellite No. 2 irrigation facilities are included in **Table 5-21, Mean U-nat and Radium-226 Concentrations in Vegetation at Satellite No. 1 Irrigation Area for Period 2000-2010** and **Table 5-22, Mean U-nat and Radium-226 Concentrations in Vegetation at Satellite No. 2 Irrigation Area for Period 2000-2010**, respectively. In 1998, the LQD requested that the radionuclide and other parameters start being analyzed on a dry weight basis, instead of a wet weight basis.

A review of the data for the Satellite No. 1 irrigation facility shows variability in the uranium concentrations within the vegetation during the period 2000 through 2010. The background uranium concentration levels range from <1.00 E-5 to 1.00 E-2 µCi/g (<0.01 to 14.77 milligrams/kilogram) with a mean detectable concentration of 1.38 E-3 µCi/g (2.03 milligrams/kilogram). As depicted in **Table 5-21** the highest uranium concentrations occurred in 2000, 2001 and 2004. The uranium concentration for vegetation in 2005 also appears to be elevated, but is suspect as the "background" sample concentration also showed anomalously high uranium concentrations greater than the facility sample. The vegetation data, in subsequent years, shows a sharp declining trend in uranium concentrations until 2009 when an increase in uranium concentration is noted.

A review of the Ra-226 data obtained for the vegetation at the Satellite No. 1 facility shows that radium-226 concentrations remain very close to the range of background concentrations.

A review of the data for the Satellite No. 2 irrigation facility also shows some variability in uranium concentrations within the vegetation with levels generally higher than background. The background uranium concentration levels range from <1.10 E-6 to 2.30 E-3 μCi/g (<0.002 to 3.40 mg/kg) with a mean detectable concentration of 5.86 E-4 μCi/g (0.87 mg/kg). The mean uranium concentration for the period of 2000 through 2010 is 1.32 E-2 μCi/g (19.43 mg/kg).

A review of Ra-226 concentrations in the vegetation at the Satellite No. 2 facility shows that levels are slightly elevated compared to background concentrations. The background radium-226 concentration levels range from 4.40 E-6 to 2.50 E-4 μCi/g with a mean value of 7.49 E-5 μCi/g. The mean Ra-226 concentration for the period of 2000 through 2010 is 1.46 E-4 μCi/g.

5.10.4.2 Radium Treatment Sampling

Cameco collects grab samples each month to ensure that the Ra-226 treatment systems are adequately treating wastewater from Satellites 2 and 3 and the Selenium Treatment Plant prior to discharge into PSR-2. No samples are collected from the Satellite 1 radium treatment system because Satellite 1 has not operated since 2003. The monthly Ra-226 grab samples for Satellite 2 and 3 are collected at the discharge points of the radium treatment system at each facility. Monitoring data collected throughout the life of the project shows that the treatment system is very effective in reducing Ra-226 concentrations to levels below the ECL (6.0E-9 μCi/ml) for Ra-226. None of the samples from Satellite 2 and 3 have exceeded the ECL since May 2001. Currently, the effluent from Satellites 2 and 3 is treated for Ra-226 and selenium at the Selenium Treatment Plant at Satellite 2 and the effluent discharges to PSR-2. The Ra-226 monitoring at the Selenium Treatment Plant began in July 2010 and Ra-226 effluent concentrations have remained below the ELC. Results of the radium treatment sampling are provided in **Table 5-23, Radium-226 Concentrations from the Radium Treatment Systems at Satellites 1, 2 and 3 and Selenium Treatment Plant for the Period 2000 through 2010.**

5.10.4.3 Irrigation Fluid Sampling

Cameco monitors the treated irrigation fluid that is disposed of at both irrigation facilities (Irrigation Areas 1 and 2) in accordance with the approved license application and the WDEQ Wastewater Land Application permits. Irrigation Areas 1 and 2 receive treated effluent from Satellites 1 and 2, respectively. Effluent from Satellite No. 3 is treated at the Selenium Treatment Plant and is land applied at Irrigation Area 2. The grab samples are collected at the pump suction line for the irrigator pivot during each month of operation and analyzed for various parameters, including calcium, magnesium, sodium, potassium, sulfate, bicarbonate, chloride, TDS, SAR, pH, arsenic, barium, boron, selenium, uranium (nat) and Ra-226.

As previously stated, Satellite 1 has not operated since 2003. Between January 2000 and September 2003, 45.8 hectare-meters (371 acre-feet) of water has been treated and discharged at Irrigation Area 1. The average selenium concentration of the applied water was 0.59 milligrams/Liter, which is near the EPA drinking water standard (0.5 milligrams/Liter) for selenium. The average Ra-226 concentration was 4.3E-9 μCi/ml was maximum concentration during this period was 1.7E-8 μCi/ml. The average uranium (nat) concentration was 0.20 milligrams/Liter (1.4E-7 μCi/ml) and the maximum concentration was 0.67 milligrams/Liter (4.5E-7 μCi/ml). The ECL for uranium (nat) is 3E-7 μCi/ml.

Between January 2000 and June 2011, 175.3 hectare-meters (1,421 acre-feet) of water has been treated and discharged at Irrigation Area 2. The average selenium concentration of the applied water was 0.57 milligrams/Liter, which again is near the EPA drinking water standard (0.5 milligrams/Liter) for selenium. The average Ra-226 concentration was 4.5E-8 μCi/ml was maximum concentration during this period was 2.1E-6 μCi/ml. The average uranium (nat) concentration was 0.50 milligrams/Liter (3.4E-7 μCi/ml) and the maximum concentration was 1.1 milligrams/Liter (7.6E-7 μCi/ml). Results of irrigation fluid sampling at Irrigation Areas 1 and 2 are provided in **Table 5-24, Effluent Monitoring for Irrigation Area 1** and **Table 5-25, Effluent Monitoring for Irrigation Area 2**.

5.10.4.4 Soil Water

In accordance with the approved SUA-1548 license and the WDEQ Wastewater Land Application Facility permits, Cameco collects soil water samples at the irrigation areas (Irrigation Area 1 and 2) in June of each year and analyzes them for various parameters, including uranium and Ra-226. In 1999 pore water samples were collected from the lysimeters at the 0.6, 1.2, and 1.8 meter (2, 4, and 6-foot) depths at Irrigation Area 1. The results of the 1999 sampling showed increased Ra-226 over the previous year; however, compared to historical data since 1991 the value was within the range of previously reported values. Between the years 2000 and 2002 there was insufficient water at the 0.6 and 1.2 meter (2 and 4-foot) lysimeters and samples could not be collected. Samples were collected at the 1.8 meter (6-foot) lysimeter and a comparison of the data showed no significant changes or trends. In 2003, samples were collected at all three depth intervals showing no significant changes. During the years between 2004 and 2010 no samples were collected due to insufficient water attributed to drought conditions and cessation of land application in 2003.

Since 2000, sufficient water has not been available to produce a sample at any of the lysimeters located at Irrigation Area 2. The lack of water was again attributed to lack of precipitation and limited irrigation. Cameco is currently evaluating other options other than the suction lysimeters to collect the soil water samples. Results of the soil water monitoring at Irrigation Area 1 are provided in **Table 5-26, Satellite 1 Land Application Facility (Irrigator No. 1) Annual Soil Water Data.**

5.10.4.5 Waste Disposal Well Monitoring

Smith Ranch is permitted for ten Class I UIC injection wells to dispose of excess water generated by both mine unit and yellowcake processing operations. As of August 2011, eight of the ten wells have been installed and are operable. The two remaining wells to be constructed include SRHUP #7 and SRHUP #8. Cameo has an existing Class I UIC permit which is currently in the renewal process for North Butte. The North Butte Remote Satellite will ultimately have four Class I UIC wells. The installation of these wells will be staged to be installed as needed for operation and restoration requirements. Cameco is currently conducting a drilling program at the Gas Hills Remote Satellite to evaluate the efficacy of deep well injection. As part of the WDEQ, Underground Injection Control Program requirements, Cameco is required to monitor the water quality of the fluids injected into the waste disposal wells. The waste samples are analyzed for TDS, total alkalinity, ammonia, uranium, Ra-226 and pH.

5.10.4.6 Evaporation Ponds

The evaporation ponds at Smith Ranch are sampled on a semi-annual basis. Each pond sample is analyzed for bicarbonate, calcium, chloride, sodium, sulfate, TDS, uranium (nat), Ra-226 and Th-230. Cameco has SOPs in place that detail the monitoring programs for these ponds. To date, sample analyses have remained below UIC permit requirements.

Each lined holding pond at the Smith Ranch CPP is constructed with a leak detection system consisting of a network of perforated pipes in a sand layer beneath the liner with the pipes draining to a collection sump. Should a leak in the liner occur, the water will flow through the sand, enter a perforated pipe, then flow to the sump. Cameco has SOPs in place that detail the monitoring program for the leak detection system. The monitoring program for the lined ponds includes either a fluid level sensor in each pond sump with an alarm displayed at the CPP or a daily inspection of each sump by an operator. The evaporation ponds are inspected daily-for visual indications of leaks or embankment deterioration by an individual instructed in proper inspection procedures. The pond inspections are recorded and initialed by the inspector.

As discussed in other sections of this TR, if water is detected in any leak detection system sump, it will be sampled and analyzed for chloride and conductivity. If analyses indicate a pond leak, and the analyses are confirmed, the NRC and LQD will be notified by telephone or email within 24 hours after receiving the confirming analyses, and the water level in the pond with the indicated leak will be lowered by transferring the contents to another cell. If water continues to flow to the sump, samples will be collected every 7 days and analyzed for chloride and conductivity. Once per month a sample will be analyzed for bicarbonate, uranium and sulfate. A written report will be filed with the appropriate agencies within 30 days after the notification of the suspected leak and every 30 days thereafter until the leak is repaired. The reports will include the available analytical data, the corrective actions taken, and results of the actions.

A freeboard of at least 0.9 meters (3 feet) will be maintained in each pond to prevent loss of solutions by wave action and to allow for holding the contents of another pond on a temporary basis in the event of a leak.

During operation of PSR-1, a shallow monitor well, located southwest of the PSR-1 was monitored at least weekly for potential seepage from the reservoir. Monitoring ceased when operations at PSR-1 ceased in 2003. Water levels are measured on a quarterly basis and groundwater samples are required on a semi-annual basis from the two shallow monitoring wells located adjacent to PSR-2. Cameco conducts quarterly sampling of both wells. Shallow Wells No. 1 and No. 6 are located adjacent to the south and east sides of the reservoir, respectively. In addition, four new monitoring wells have recently been installed around the perimeter of PSR-2 for a supplemental internal investigation regarding potential seepage from the PSR into the subsurface.

Two surge ponds will be constructed at the North Butte Remote Satellite. Initially, two evaporation ponds will be constructed at the Gas Hills Remote Satellite with four more potentially to be built in stages as development progresses. Leak detection monitoring will commence once the remote satellites are operational.

5.10.5 Reporting Procedures

5.10.5.1 Semi-Annual Report

Pursuant to 10 CFR 40, Section 40.64, a report will be submitted to the NRC on a semi-annual basis outlining the results of the effluent and environmental monitoring programs and any other information required by license condition.

5.10.5.2 Annual Report

As required by W.S. 35-11-411, Cameco will submit an annual report to the WDEQ/LQD. The report shall contain the following information:

1. Maps showing locations of all wells installed in conjunction with the ISR activity and areas where groundwater restoration has been achieved or is taking place or planned to take place within the next year. The map also shows areas where production is expected to commence during the next year.
2. The total quantity of recovery fluid injected and the total quantity of recovery fluid extracted during the annual reporting period for each mine unit including a description of how these quantities were determined.

3. Water quality monitoring program results including a map and description of excursions, if any that occurred during the period, their location and extent.
4. An updated potentiometric surface map for all aquifers that are or may be affected by the ISR operation.

In addition to the above information, Cameco will use the annual report as the mechanism to update or revise the mine plan as operations progress. The annual report will contain the bond estimate for surface and aquifer restoration for the current and following year's operations. The NRC receives a copy of the WDEQ annual report.

5.10.5.3 Mine Unit Data Submittals

Prior to the commencement of lixiviant injection into a new mine unit, certain baseline information will be collected. This information will be summarized in a baseline data package (Hydrologic Testing Document) for submittal to the LQD for their approval of operations in the new mine unit. The package will also be submitted to the NRC for review. The specific information included in Hydrologic Testing Document is provided in Section 3.3.

5.10.5.4 Non-Routine Reports

In the event that a report of a non-routine incident becomes necessary, Cameco will follow specific reporting procedures for that incident as identified by the particular regulatory agency. In most cases, both the WDEQ and NRC are notified by telephone or e-mail within 24 to 48 hours of verified monitor well excursions, pond leakage, significant spills, tank ruptures, or any other incidents that would trigger the reporting requirements provided in 10 CFR 20, Subpart M. Written reports will follow such telephone reports within the timeframes discussed in this LRA, or by other requirements imposed by the regulatory agency.

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6.0 Groundwater Quality Restoration, Surface Reclamation and Facility Decommissioning Plans

Section Summary: This section encompasses groundwater restoration of wellfields subsequent to production and decommissioning and reclamation of facilities after restoration approval. While the overall restoration plan and process described in Section 6.1 has not significantly changed, aspects of it have, which are discussed below. The established aquifer exemptions have been summarized and listed in Section 6.1.1. Section 6.1.2 focuses on groundwater restoration criteria which is the same as previously approved; however, RTVs for various wellfields have been included which are new with this submittal. Updated restoration schedules and water balances have been developed for Smith Ranch and the North Butte and Gas Hills Remote Satellites and are presented in Section 6.1.3. Section 6.1.4 addresses groundwater restoration methodology, which has been revised and updated to clarify the steps necessary for successful groundwater restoration for all SUA-1548 license areas and includes new discussions regarding the use of bioremediation and selenium treatment. Section 6.1.5 identifies the monitoring requirements during restoration which have been approved by the NRC in past submittals. Section 6.1.6 includes a commitment by Cameco to submit a final groundwater restoration report of findings to regulatory agencies. A history and status of restoration activities at Smith Ranch site is presented, by wellfield, in Section 6.1.7 and 6.1.8. Section 6.1.9 addresses a new proposed 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 sureties, which is not a new topic, but updated surety estimates for Smith Ranch and the remote satellites have been incorporated.

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 mine unit, or a portion of a mine unit, falls below the predetermined economic recovery limit, continued extraction of uranium will cease. Once this economic recovery limit has been reached, the mine unit is taken out of production and placed into groundwater restoration. In accordance with 10 CFR 40.42(d), once a decision has been made to permanently cease lixiviant injection in a particular wellfield, Cameco will notify NRC and initiate groundwater restoration within 60 days of making the restoration decision. 10 CFR 40.42(h)(1) specifies that groundwater restoration within a wellfield must be completed within 24 months after restoration activities have been initiated. If restoration in a wellfield requires more than 24 months to complete, Cameco will notify the NRC and request an alternate schedule for completing restoration. It should be noted that, 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 by consideration of the following:

- 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 decay over a longer time period; and
- Other site-specific factors on a case-by-case basis, such as the regulatory requirements of other government agencies, lawsuits, groundwater restoration activates, 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. The purpose of the aquifer exemption is to protect groundwater adjacent to the mining zone. 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 any mobilized constituents from affecting aquifers adjacent to the ore zone. Aquifer exemptions have been received by Cameco for all of the facilities licensed under SUA-1548 as follows:

- Smith Ranch: Monitor well ring of each mine unit (EPA, August 1990)
- Highland: Monitor well ring of each mine unit (EPA, June 1987; September 1991)
- 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 ¼ mile, also including any additional 40 acre parcel intersected by the ¼ mile zone; EPA excluded from the exemption a ¼ mile buffer around the Carol Shop well because records showed that it was used as a source of drinking water (EPA, February 2001). The State Engineer Records show that the well was permitted for miscellaneous use (Nov. 25, 1977). The water quality on the well indicates that it should not be used for drinking water and Cameco Resources 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. However, if after employing 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. The restoration criteria for the groundwater in a mine unit is based on the baseline water quality data established for each mine unit from the wells completed in the planned Production Zone (i.e., MP-Wells), on a parameter-by-parameter basis.

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. To characterize water quality in the mineralized zone, MP wells are sampled as part of the mine unit testing program. Two separate samples collected at least two weeks apart from the MP wells are analyzed for the parameters listed in **Table 3-4**. Two additional samples collected at least two weeks apart are sampled for the following list of parameters:

Alkalinity	Selenium
Chloride	Uranium
Conductivity	Radium 226
Sulfate	Arsenic*
TDS	Fluoride*
pH	
*Arsenic and fluoride are deleted from the above list of parameters if the previous two analyses show that arsenic and fluoride are below detection limits.	

Sample collection, preservation and analysis are in accordance with approved sampling and analysis plans.

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 screened visually to identify obvious outliers. These values are then evaluated utilizing 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.

Based upon statistical analysis of the baseline water quality parameters, RTVs are established. 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. The calculated RTVs are presented in **Table 6-1, Smith Ranch Restoration Target Values**. Cameco is calculating RTVs for all of the other mine units in production at Smith Ranch. At all of 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, consistent with the ALARA principle, Cameco will apply for

ACLs consistent with the detailed requirements of Criterion 5B(5) and 5B(6) of Appendix A to 10 CFR Part 40 which if approved by NRC will provide 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 in nature. 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 and the North Butte and Gas Hills Remote Satellites are based on one pore volume of groundwater sweep (GWS) and eight pore volumes of water being extracted, treated and re-injected during clean water injection. The water balances for Smith Ranch and Highland utilize actual deep disposal well injection rates and show that for Mine Units 1, C, D/D ext where restoration is currently underway, 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) as may be modified by NRC agreement to a request for delay of groundwater restoration under 10 CFR 40.42(f), should such a request be made by Cameco. 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. Additionally, 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. The additional time it takes to accomplish these pre-restoration activities may trigger a request by Cameco to delay the start of restoration under 10 CFR 40.42(f).

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. Based upon past experience, Cameco has developed realistic restoration schedules for the various mine units at Smith Ranch, including Highland and Reynolds Ranch. These schedules are 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). Therefore, in accordance with 10 CFR 40.42(i), Cameco is requesting approval of the schedules referenced above as an alternate restoration schedule for the Project.

6.1.4 Groundwater Restoration Methodology

Historically, the restoration program at SUA-1548 has involved three phases of restoration processes, including:

- GWS;
- Groundwater extraction and treated water injection (typically reverse osmosis (RO) treatment with permeate injection); and
- Addition of a chemical reductant.

These phases were used to restore Mine Units A and B at Highland. Again as discussed in other sections of this TR, Cameco is actively researching the efficacy of bioremediation as a primary or secondary groundwater restoration technique and these efforts are currently in the research and development phase. Following is a description of each restoration phase.

6.1.4.1 Groundwater Sweep

GWS consists of pumping affected groundwater within the production zone without re-injection of water. This process causes an influx of natural background quality water from the perimeter of the production area (i.e., cone of depression), which sweeps the affected portion of the production zone with groundwater of background quality. The plume of affected groundwater near the perimeter of the production area is also drawn further inside the boundaries of the mine unit. GWS has to be implemented with caution, as an excessive cone of depression can cause undesirable movement of groundwater (incursion) into other active restoration areas and/or operating mine units in the same formation.

Groups of mine unit patterns undergoing GWS can be operated simultaneously while other pattern groups are being injected with treated water. In this way, restoration is advanced progressively through the mine unit, pattern group by pattern group. The water recovered from the GWS activity is routed through the IX circuit to remove uranium and is then either disposed directly to the deep disposal wells or is further treated by RO to reduce TDS, and other treatment methods to remove Ra-226 and selenium and disposed via land application. In some instances, treated water produced during GWS can be used as make-up water thereby reducing overall water consumption.

As GWS continues, it becomes less effective in reducing the concentrations of certain parameters. At this point, treatment and re-injection of the groundwater being removed (i.e., clean water injection) is necessary to accelerate the restoration process. Because GWS is more consumptive than, and not as effective as, clean water injection, it may be used in conjunction with clean water injection to add flexibility to the restoration program. It is anticipated that up to one pore volume of GWS will be utilized during the groundwater restoration process.

Cameco anticipates that the use of GWS will be limited or not used at all at future SUA-1548 restoration efforts. A conservative estimate of one pore volume of GWS has been incorporated into the various restoration schedules.

6.1.4.2 Treated Water Injection

Treated water injection involves the pumping of affected groundwater and re-injection of treated aquifer water or water from other water sources that are of similar quality. This restoration technique increases flow rates and reduces the concentration of certain parameters, such as TDS, thereby accelerating the rate of restoration. The source of the treated water may originate from:

1. RO;
2. Electro dialysis reversal;
3. IX;
4. Water extracted from a mining unit that is in a more advanced state of restoration;
5. Water being exchanged with a new mining unit; or
6. A combination of the above sources.

Historically, the treatment process at Smith Ranch has been RO treatment with reinjection of permeate enhanced with a chemical reductant.

The time required to complete treated water injection depends on the initial water quality within the mine unit patterns being restored. Typically, more time is 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 a small number of patterns at any one time before advancing to the next pattern area(s). It is anticipated that an average of five to eight pore volumes of clean water injection will be utilized for each mine unit to achieve groundwater restoration.

Completion of the treated water injection phase in each pattern is determined by monitoring the reduction in concentration of selected water quality parameters to their final RTV. Chloride, alkalinity, and sulfate concentrations are typically good indicators of the effectiveness of the formation sweep. Historically, this methodology has proven to be very effective at Smith Ranch. The uranium concentration is reduced during treated water injection, but may not be adequately reduced until chemical reductant addition, and possibly biological remediation, has been completed.

6.1.4.3 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 utilized as necessary on individual mine units or on a pattern-by-pattern basis.

The use of bioremediation and/or introduction of chemical reductants into the formation may be effective in reversing the ISR process by 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 which are present. The food that best stimulates biological remediation is determined by performing microcosm studies. A microcosm is an artificial, simplified ecosystem that is used to simulate and predict the behavior of the natural ecosystem under controlled conditions.

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). Prior to introducing a biologic reductant Cameco will submit a proposal to the NRC and LQD for review and concurrence including:

- The stated goal of the bioremediation. Such a goal may not only include the removal of metals, but will also present other 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 specific 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).

Historically at Smith Ranch, Cameco has used sodium hydroxide ($NaOH$) and potassium hydroxide (KOH) for pH adjustment, although other pH adjusting chemicals may also be used. This step may be combined with groundwater treatment and re-injection or as the final stage of injection.

6.1.4.4 Waste Water 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) ten Class I deep disposal injection wells permitted (eight of which have been drilled), which will allow the disposal of excess water generated by both mine unit and yellowcake processing operations. In addition to the deep disposal wells, Purge Storage Reservoir No. 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 dissolved selenium. The Satellite No. 2 Selenium Treatment Facility treats water from Satellites No. 2 and 3 for the removal of selenium, thereby allowing a selenium- free stream to be discharged into Purge Storage Reservoir No. 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 Purge Storage Reservoir No. 2 such that continuous inflow to the reservoir can occur during the winter months when land application cannot take place.

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 with one of them currently being installed (January 2012). Additional disposal wells will be permitted and installed as required. The anticipated total number of UIC disposal wells required over the life of the North Butte Satellite is four wells. Two surge ponds will be maintained at North Butte to store waste water from the satellite facility prior to deep well injection. The design of the ponds meets the guidance provided in NRC Regulatory Guide 3.11, "Design, Construction and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" 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 to determine if a receiver formation is available and if so, to determine the 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, "Design, Construction and Inspection of Embankment Retention Systems at Uranium Recovery Facilities" and the standards provided in 10 CFR Part 40, Appendix A, Criterion 5(A).

The waste water 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 utilized again once Ruth becomes operational. Deep well injection may also be utilized.

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, the baseline characterization of the MP-wells of that mine unit is reviewed and each MP well is sampled and analyzed for the parameters in **Table 6-2, Groundwater Restoration Monitoring Parameters**. This sampling effort will characterize an "end of injection" water quality average. To track the progress of restoration, the MP-wells, in areas where active restoration activities are occurring, 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 that unforeseen conditions (such as snowstorms, flooding, equipment malfunction, etc.) occur, the NRC and LQD will be contacted if the well(s) cannot be monitored within seven days of the target sampling date. Depending on the results of initial sampling at the beginning of restoration, other specific 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 at these wells prior to sampling.

6.1.5.2 Restoration Stability Sampling

Following regulatory concurrence that groundwater restoration has been achieved in a particular mine unit and, unless otherwise approved by the agency, a one-year stability monitoring period is completed to demonstrate that the restoration standard has been adequately maintained. The following groundwater restoration stability monitoring program is performed during the one year stability period:

1. Routine excursion monitoring for alkalinity, chloride and conductivity at all perimeter, overlying and underlying monitor wells will continue until restoration is approved by the NRC.
2. The MP-wells will be sampled at the beginning of the stability period and quarterly thereafter. LQD, NRC and/or Cameco may determine that additional stability sampling rounds beyond the first five may be necessary. Samples will be analyzed for the parameters in **Table 6-2**.
3. All wells on excursion status must be restored to 10 CFR 40, Appendix A Criterion 5B(5) standards as part of the restoration process.

In the event that unforeseen conditions (such as snowstorms, flooding, equipment malfunction, etc.) occur, the NRC will be contacted if any of the M-wells or MP-wells cannot be monitored within seven days of the scheduled sampling event.

6.1.6 Determination of Restoration Success

At the end of the stability period, the stability monitoring data will be evaluated to determine the success of the groundwater restoration effort. A report will be completed summarizing the results of the restoration program. The restoration results will be compared with the RTVs. The report will also provide the results of the stability monitoring program. The report will be submitted to the regulatory agencies for their review and approval. The acceptance of the mine unit restoration and stability success will be based on the ability to meet the goals of the restoration program and the lack of significant increasing trends during the stability monitoring period.

After concurrence from the WDEQ and NRC that appropriate 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.

6.1.7 Smith Ranch Restoration History

6.1.7.1 Mine Unit 1

Mine Unit 1 produced from 1997 to 2006. Restoration began in September 2006 and 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.

6.1.7.2 Mine Unit-4/4A

Mine Unit 4/4A produced from September 1999 to December 2010. Restoration began in 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.

6.1.8 Highland Restoration History

6.1.8.1 Mine Unit A

Mine Unit A was 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. In November 2003, LQD conditionally approved the restoration after concluding that the restoration effort used BPT and the groundwater had been restored to its class of use. Although fate and transport modeling predicted that the down gradient groundwater would be protected through natural attenuation, as a condition of approval of the groundwater restoration in Mine Unit A, the LQD required that a long-term monitoring (LTM) plan be developed down gradient of the restored mine unit.

Final pore volumes (PV) of groundwater extracted and/or treated and reinjected were as follows:

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

Note that pursuant to a 1996 discussion with WDEQ, it was agreed that a PV is equivalent to 3.7 hectare-meters (30 acre-feet) of water.

The NRC approved the Mine Unit A restoration on January 15, 2004 but agreed that additional monitoring would be required to validate the fate and transport model. The LTM plan was approved by the agencies and implemented in June 2004.

The LTM has been ongoing since that time. Final approval of Mine Unit A restoration by NRC was received in March 2005. All of the Mine Unit A wells have been plugged and abandoned in accordance with applicable rules and regulations. Cameco provided plug and abandonment notification to WDEQ in the 3rd and 4th Quarter Reports in 2005.

The LTM does not contain predicted attenuation values, but rather how the concentration of Ra-226 and redox sensitive elements will decrease over time as the restored groundwater moves toward and through the more reducing environment.

MP-4 and 1-21 are wells located and 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, 1-21, and LTM-4. Recent LTM data indicate that the predicted values from the LTM are accurately showing that natural attenuation is occurring. The predicted values of the perimeter monitor wells are Fe = <0.1 mg/L; Mn = 0.04 mg/L (-60-yrs); Se = <0.0001 mg/L; uranium (nat) = <0.001 mg/L; and Ra = 8 pCi/L (-60-yrs). Concentrations of these same parameters downgradient of MP-4 show that all values are similar for Fe, Mn, Se, and Ra-226. Uranium is slightly higher than the predicted values. However, the uranium numbers are well below the baseline level of 0.05 mg/L at LTM-4 which is located inside the monitor well ring.

Additional information related to Mine Unit A Restoration can be found in the January 15, 2004 correspondence from B. Kearny to G. Janoskco, RE: Smith Ranch-Highland Uranium Project, Docket No. 40-8964, SUA1548, "A-Wellfield Groundwater Restoration Information"

6.1.8.2 Mine Unit B

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 related to Well BM-42 which had been on excursion most probably due to damage to the well casing. After discussions with LQD, it was agreed that Well BM-42 had been restored to class of use.

Because of WDEQ concerns related to elevated arsenic concentrations in Wells MP-14, MP-21 and MP-22, an additional six months of stability sampling was conducted. The additional sampling results showed that the arsenic concentrations were declining and that the mine unit average was less than the drinking water standard. An additional round of samples collected in October 2006 demonstrated groundwater quality stability within the mine unit. WDEQ approved Mine Unit B restoration on April 2, 2008.

Final PVs of groundwater extracted and/or treated and reinjected were as follows:

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

Cameco requested NRC approval of Mine Unit B restoration under cover letter dated June 26, 2009. NRC rejected the request on September 29, 2010 stating that the well BM-42 was reportedly on excursion status and that the mine unit had been pumped during the stability period. The NRC had stated in NRC Regulatory Issue Summary 2009-5 regarding: (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 for uranium and other constituents are elevated above baseline concentrations and the limits from Criterion 5B of Appendix A. Cameco intends to submit to the NRC an ACL application during the first quarter of 2012 so that the Mine Unit B restoration can be evaluated and approved under 10 CFR Part 40, Appendix A, Criterion 5 (C).

Additional information related to Mine Unit B restoration can be found in the reports entitled "Mine Unit B Groundwater Restoration Report" submitted to NRC under cover dated June 26, 2009, and "Mine Unit B Groundwater Stability Report" submitted to LQD under cover dated May 5, 2005.

6.1.8.3 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

Construction of a groundwater IX recirculation loop between the northern portion of Mine Unit C and Satellite No. 2 was completed in July 1999. Recirculation of Mine Unit C groundwater began in August 1999. The purpose of this recirculation loop was 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 decarbonator was installed for this purpose at Satellite No. 2 and began operating on March 7, 2003. 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 have an adverse effect on the precipitation of uranium by keeping dissolved uranium mobilized. 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

Two RO units were installed in Satellite No. 2 in January 2006. The third RO unit installation was completed in February 2006. All of the RO permeate was passed through the decarbonator. On April 10, 2009 the use of RO units was discontinued in order to proceed with the complete Mine Unit C Bioremediation Project. LQD approved the discontinued use of the RO units under cover letter dated April 3, 2009.

Bioremediation Project

Bioremediation is a restoration method that was proposed by Cameco to assist in groundwater restoration activities. Bioremediation had previously been used in Mine Unit B to successfully lower the selenium concentration in the groundwater. The bioremediation program utilized in Mine Unit B achieved selenium concentrations averaging 0.009 mg/L at the end of active groundwater restoration.

Based on the success of the Mine Unit B Bioremediation Program, further laboratory experiments were conducted to identify better food sources that could be used in the restoration of future mine units. The idea was that a better food source 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 showed that two potential food sources worked better for stimulating the growth of the naturally occurring bacteria and accelerated the reduction of selenium, uranium, and other redox sensitive ions. Limited bioremediation testing, using the new food, began in February 2006. Plugging problems were experienced using straight 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 and cheese whey would relieve some of the plugging problems experienced with the use of straight cheese whey. Cameco requested approval from WDEQ to proceed with bioremediation throughout all of Mine Unit C. WDEQ approved the request and the program began with injection of substrate on April 20, 2009. The bioremediation effort did not perform as expected in reducing uranium concentrations, and the bioremediation project ended in January 2010. A final report was submitted to WDEQ under cover dated March 5, 2010. The report indicated 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 hydrological access to the aquifer because of inoperative wells in portions of the mine unit (failed wells), clogging of wells during the course of organic carbon addition, and the existence of an adjacent underground mine drift. A secondary problem was oxygen contamination coming from the use of forced draft de-carbonation and from wells pumping off. The report concluded that the plugging problem appeared to be limited to the well bore and that in many instances jetting and swabbing had restored flow to the wells. The concentration of selenium plunged early in the experiment and remained low throughout the project.

The WDEQ reviewed the final report and provided comments under cover dated April 12, 2010. Cameco's response to WDEQ comments were submitted during the 3rd Quarter of 2010. The final restoration plan for Mine Unit C was submitted to LQD on February 23, 2011. Discussions between WDEQ and Cameco are continuing.

Restoration in Mine Unit C is continuing as of January 2012.

6.1.8.4 Mine Units D and D-Extension

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. Preparations for groundwater restoration in Mine Unit D began in the winter of 2009 with upgrades in infrastructure.

Between June 2010 and April 2011, Cameco completed installation of 35 replacement wells in the mine unit. These mine units have been in active restoration since April 2011.

6.1.8.5 Mine Unit E

Mine Unit E is currently 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.

6.1.9 Proposed Restoration Program

The restoration program methods going forward through the next renewal period will be similar to the current program. Cameco will continue to research groundwater restoration methods to improve efficiency and timing of the restoration process. Some examples include:

Disposal Well Capacity Improvements

To provide additional waste water capacity, Smith Ranch has added three additional deep disposal wells and has two additional wells permitted that will be installed if needed. This will provide a total of ten disposal wells available for waste water disposal.

Additionally, Smith Ranch will be installing a buried waste water transfer pipeline system which allows waste water to be transferred from all SUA-1548 facilities, except the Reynolds Ranch Satellite, to any disposal well. Storage tanks at each disposal well site will provide surge capacity for the system.

Waste Water Treatment Improvements

Anti-scalant reagents are being added to the waste water to decrease membrane fouling and increase the efficiency of the RO system by reducing the volume of brine production from 25% to 15%, or less. Other research will be conducted to endeavor to increase RO efficiency and decrease waste water volume.

Production and Restoration Time Frame Improvements

A key issue in the effort to decrease the time required to restore a mine unit is the time it takes to complete uranium recovery from a mine unit. Minimizing the time required to complete the recovery phase will shorten the restoration effort because of the following reasons:

- The amount of oxygen that is added to the aquifer is reduced. Excessive oxygen consumes pyrite and other minerals that can be useful in re-imposing reducing conditions within the aquifer during restoration.
- The concentration of the complexer injected into the formation is reduced. Dissolved carbon dioxide can remain in the aquifer for long periods of time and results in a pH well below that of the pre-production value. The presence of carbon dioxide and/or bicarbonate can create geochemical conditions that can keep uranium soluble in groundwater. Additional

investigation will be performed to try and increase the effectiveness of the vacuum degassers.

Any decrease in the amount of reagents added during the uranium recovery process assists in decreasing the time it takes to restore a mine unit.

Just as a rapid extraction phase of an ISR project assists in restoration effectiveness, so does a timely initiation of restoration at the conclusion of production for the following reasons:

- Oxygen is quickly consumed when addition of the gas ends, but oxidized solids (such as ferric oxyhydroxide) can slowly continue to dissolve uranium long after oxygen injection has ended. The addition of a chemical reductant early in the restoration phase may stop this process and assist in the removal of uranium from the restoration water stream more quickly and efficiently.
- Complexing agents are given more of an opportunity to diffuse into less permeable sections of the formation the longer the mine unit restoration is delayed. The diffusion of lixiviant into tighter sections (lower hydraulic conductivity) of the formation results in a longer final restoration effort because it is harder to hydraulically sweep the lixiviant from tight areas of the formation.

Cameco has added additional equipment and resources to improve the performance of the restoration process. Cameco will continue to monitor and review the restoration process to improve timeliness of production and restoration s.

Bioremediation Improvements

Lessons learned from the initial bioremediation project in Mine Unit C are:

- Poor hydrologic sweep was experienced because of inoperative wells, clogged wells and the pre-existing underground mine drift underlying the wellfields.
- The post program analysis showed that several areas within Mine Unit C had not received sufficient sweep during the RO sweep phase of restoration.
- Oxygen contamination during restoration from wells pumping off and the implementation of the forced draft decarbonator caused a short circuiting of the bioremediation process thereby allowing the bacteria to preferentially use oxygen as an electron acceptor.
- A poor choice of organic substrate aggravated the problems with well screen plugging.

It is imperative that future bioremediation programs include the following:

- More thorough laboratory and small scale in-the-ground testing needs to be conducted before initiating a large scale project.
- All wells should be inspected and repaired or replaced before starting restoration.
- A careful assessment of the substrates to be used needs to be performed prior to implementation of a large scale project, including experiments on a smaller scale (pattern size experiments) with more careful monitoring of the physical, hydrological, and chemical parameters during the experiment.

- Identification of other factors that may affect the outcome of the experiment such as the influence of the Mine Unit C underground drift on the mine unit's hydrology, changes in the geology of the area, etc.

Cameco plans to perform small bioremediation field tests. These tests will provide additional information that will improve the bioremediation process so that it can become a major tool in the restoration tool box. Cameco also plans to collaborate with the University of Wyoming and Los Alamos National Laboratories to perform investigations on restoration methodology improvements.

6.1.10 Ruth Restoration History

The restoration of the Ruth R&D project began in February 1984 and continued through December 1984. During this restoration phase the TDS were reduced in the affected groundwater using a phased plan incorporating reverse osmosis 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

In all cases, the goal of surface reclamation is to return all disturbed areas to their pre-ISR land use of livestock grazing and wildlife habitat (i.e., unrestricted use) unless an alternative use is justified, in concurrence with the landowner desires and approved by the NRC and WDEQ. For example if the landowner desires to retain certain roads or buildings, this will be addressed with the regulatory agency. 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.

As stated in Section 6.1, 10 CFR 40.42 requires timely groundwater restoration and decommissioning/surface reclamation of all uranium recovery facilities, including ISR facilities. The following sections describe in general terms the planned decommissioning activities and procedures for SUA-1548. Prior to 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 at least 12 months prior to the planned commencement of final decommissioning. The final decommissioning plan will include a description of structures and equipment to be decommissioned, a description of planned decommissioning activities, a description of methods used to ensure protection of workers and the environment against radiation hazards, a description of the planned final radiation survey (benchmark analysis) and an updated, detailed cost estimate.

6.2.2 Well Plugging and Abandonment

Following regulatory concurrence by both WDEQ and NRC that groundwater restoration has been successful within a mine unit or for the license area as a whole, all wells will be abandoned in accordance with applicable State and Federal regulations. Typical abandonment procedures will include:

1. A drill rig or hose reel will be used for well plugging to ensure that the well is properly sealed from bottom to top.
2. The abandonment material may be neat cement slurry, sand-cement grout, bentonite chips or other plugging materials which will prevent the movement of fluids into or between unauthorized zones or water-bearing strata.

3. 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.
4. 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 two feet of the surface.
5. 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.
6. A cement or concrete hole plug will be placed in the top of the casing. If cement is used to plug the well to within 0.9 meters (3 feet) of the surface, a concrete plug will not be required.
7. 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 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.
8. 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.
9. 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).
10. 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 will then be abandoned as described in 1 through 10 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

The primary surface disturbances associated with ISR are the sites for processing facilities. Surface disturbances also occur during the well drilling program, pipeline installations, road construction, and header house construction. These disturbances however, involve relatively small areas and have very short-term impacts. Disturbances associated with drilling, mine unit construction and pipeline installation are normally limited, and are reclaimed and seeded in the same season. Vegetation is normally 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. Since ISR does not create major changes in the natural topography, no major re-contouring is anticipated, and the existing ground topography will closely mirror the final ground topography.

Areas to be topsoiled will first be treated with a harrow, chisel plow or conventional disk to relieve compaction. Stockpiled and salvaged topsoil will be replaced on the final ground surface. If necessary, the replaced topsoil will be disked to create a proper seed bed. Topsoil will be placed in a single lift to avoid compaction. On slopes of 4H:1V or flatter, topsoil will be placed along the contour. 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. Topsoil thicknesses will generally be uniform and reflect the approximate thickness of topsoil originally available at the locality being reclaimed. This replacement depth will be determined on site by Cameco. Typically the adjacent undisturbed surface will be augured to determine topsoil depth and the existing undisturbed ground will be smoothly transitioned into the disturbed ground following replacement of the topsoil. The reclamation area will not be left as a "hole", nor will it be super-elevated above the existing ground surface. All salvaged topsoil will be utilized for reclamation purposes.

Once the surface reclamation activities are completed, the area will be seeded with the approved seed mix. Seeding is typically performed using a drill seeder or may be hand broadcast if the area is small.

Typically, seeding is completed during the fall seeding window (October 15 to frozen ground conditions). If spring seeding is required, seeding is typically performed no later than April 15 of each year. Seeding is completed in the spring or fall during the year in which the topsoil is replaced. Ideally the two operations will occur consecutively.

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 any 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, will be appropriate for use during 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 all 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 may be reusable, depending on its age and functionality, as well as the buildings. Alternatives for the disposition of the buildings and equipment are discussed in this section.

All process or 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 other unrestricted use by others; or
4. If the equipment or materials cannot be decontaminated to unrestricted release criteria, disposal at a NRC licensed disposal facility.

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 a NRC licensed disposal facility. Cement foundation pads and footings will be broken up and transported to a solid waste disposal site or to a NRC-licensed disposal facility if contaminated, or, if approved by the regulatory agencies and surface owners, buried on site.

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 centimeters^2
- Average total alpha contamination of 5,000 disintegrations per minute/100 cm^2 over an area no greater than 1 meter^2.
- Maximum total alpha contamination of 15,000 disintegrations per minute /100 cm^2 over an area no greater than 100 centimeters^2.

Decontamination of surfaces will be guided by the ALARA principle to reduce surface contamination to levels as far below the limits as practical. Non-salvageable contaminated equipment, materials, and dismantled structural sections will be transported to a 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 tank located at any facility will be closed in accordance with Wyoming Statute 35-11 Article 14 (Wyoming Storage Tank Act of 2007). The WDEQ/ Storage Tank Program will be notified of the proposed closure and Cameco will arrange to have environmental samples collected after the closure, if needed.

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.

- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the, equipment will be washed down to permit safe handling.
- The 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 in barrels for delivery to the disposal facility.
- Contaminated buried main trunk lines and sump drain lines will be excavated and removed for transportation to a NRC licensed disposal facility.
- Contaminated HDPE liners and any contaminated soils underlying the surge ponds and reservoirs will be excavated and removed for transportation to a 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 a NRC licensed disposal site. Cameco currently has a contract disposal agreement with Denison Mines (USA) Corp. for disposal at the White Mesa Mill near Blanding, Utah. 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 all 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.

On April 12, 1999, the NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The 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 utilize RESRAD Version 6.4 or later versions to calculate radiation doses and cancer risks, if any, to the existing population groups and derive cleanup standards for radioactively contaminated soils. The benchmark modeling will be performed and submitted with the decommissioning plan required by License Condition 9.11 of SUA 1548.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance was published as Appendix E to NUREG-1569. This guidance discusses acceptable models and input parameters. This guidance and site-specific parameters will be utilized in the modeling efforts.

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 all groundwater restoration, facility decommissioning and surface reclamation activities, including the off-site disposal of 11e(2) byproduct material.

License Condition 9.5 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. 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, an updated financial surety package is submitted for NRC approval at least 90 days prior to the commencement of construction activities. In addition to coordinating submittal of the annual updates to both agencies (NRC and WDEQ), Cameco 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 (Aug 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

Rio Algom Mining Corp. 1991. Letter to WDEQ-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.

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

US Environmental Protection Agency. 1989. Letter to WDEQ concurring with groundwater classification and aquifer exemption boundary for Section 14 Amendment Area.

US Environmental Protection Agency. 1991. Letter to WDEQ concurring with groundwater classification and aquifer exemption boundary for West Highland Amendment Area.

US Environmental Protection Agency. 2001. Letter to WDEQ concurring with groundwater classification and aquifer exemption boundary for Gas Hills.

US Nuclear Regulatory Commission. 1984. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct or Source Materials.*

US Nuclear Regulatory Commission. 2008. Letter to Power Resources, Inc.: *Compliance with 10 CFR 40.42's Timely Decommissioning Requirements,* ML081480293.

US Nuclear Regulatory Commission. 2008, Letter to PRI discussing compliance with timely decommissioning requirements.

Wyoming Department of Environmental Quality. 1987. Letter to EPA confirming ground Water Classification for Mine Units A and B.

Wyoming Department of Environmental Quality/Land Quality Division, Guideline No. 12, 2010: *Standardized Reclamation Performance Bond Format and Cost Calculation Methods.*

7.0 Potential Environmental Effects

Section Summary: This section addresses potential environmental impacts resulting from construction and development at all SUA-1548 license areas. Many of the impacts and effects were previously reviewed and approved for the Smith Ranch site, but those same impacts and effects are considered here in relation to the remote satellite areas. Section 7.1 deals specifically with environmental impacts associated with construction activities at the project sites, (air, noise, land use, surface water, etc.) while Section 7.2 focuses on environmental effects associated with operations (fugitive dust, wildlife, visual impacts, and so on). Radiological effects are presented in Section 7.3 and accounts for all project areas. Section 7.4 describes non-radiological effects which have been reviewed in prior license renewals. Section 7.5 presents potential accidents resulting from operations, which have been previously reviewed and approved; however, two new aspects, range fires and associated risks of CBM operations, have been included in Sections 7.5.4 and 7.5.6 respectively.

7.1 Site Preparation and Construction Activities

The major site preparation and construction activities associated with the Smith Ranch SUA-1548 license areas will include the following:

- Construction of new satellite IX plants, offices and maintenance facilities at Reynolds Ranch, North Butte, and Gas Hills;
- Construction of surge ponds and deep disposal wells at the North Butte Remote Satellite;
- Construction of evaporation ponds and disposal wells at the Gas Hills Remote Satellite;
- Construction of new deep disposal wells at Reynolds Ranch;
- Construction of new mine unit wellfields at all facilities;
- Construction of power lines and pipelines to service the Reynolds Ranch Satellite, North Butte Remote Satellite and Gas Hills Remote Satellite;
- Design and development of the Ruth Remote Satellite; and
- Grading and construction of access roads, as required.

The site preparation and construction activities for the Ruth Remote Satellite will include many of the above referenced tasks, but the specific details for the development of Ruth have not been finalized. As such, specific details regarding disturbance areas and other impacts for the Ruth Remote Satellite are not provided in this LRA.

Site preparation and construction activities will include topsoil salvaging, site clearing and leveling, building erection, and access road construction. The impacts from wellfield construction activities, including the construction of injection, production, and monitor wells are discussed in Section 7.2 because these are ongoing activities at Smith Ranch. This section discusses the short term impacts of initial site preparation and satellite IX plant construction where they differ from the impacts of operations.

Environmental impacts of construction of the satellite facilities are estimated based on studies conducted by Cameco. The impacts are also projected based on experience with the current operation and the impacts that have been associated with this type of construction at Smith Ranch and associated Highland facilities since 1987.

The area contained within the Smith Ranch contiguous license area, including the Reynolds Ranch satellite, totals approximately 16,200 hectares (40,000 acres). Based on recent calculations of actual and potential disturbed areas for the rest of the Project life (BLM, 2011), construction and operation activities associated with the development of mine unit wellfields and additional satellite facilities will disturb a total of approximately 760 hectares (1,880 acres), or less than 5% of the total area. Cameco estimates that more than 87% of the total disturbed mine unit wellfield acreage (approximately 660 hectares [1,630 acres]) will be short term disturbance (one year or less). Final reclamation of all areas disturbed will occur during final decommissioning activities for each mine unit. The planned schedule for construction, production, restoration, and decommissioning is presented in Smith Ranch WDEQ Permit Attachment 1A.

It is anticipated that a total of approximately 160 hectares (400 acres) (wellfields, buildings, pads and roads) will be disturbed during the operational life of the North Butte Remote Satellite. Since restoration, final reclamation and interim surface stabilization occur contemporaneously with development and production, it is expected that no more than approximately 69 hectares (170 acres) will be disturbed at any single point in time. Surface disturbances will include construction of access roads, wellfields, underground pipelines and utilities, facility site grading, construction of surge ponds, and contouring for control of surface runoff. All areas disturbed will be reclaimed during final decommissioning activities.

From the 1950s to the early 1980s, much of the surface area within and adjacent to the Gas Hills Remote Satellite license area was extensively mined for uranium employing conventional underground and surface mining methods. Of the approximately 3,455 hectares (8,538 acres) within the Gas Hills license boundary, approximately 15%, or 518 hectares (1,281 acres), have been previously disturbed by underground and/or surface mining activities. Approximately half of the land surface within proposed Mine Unit 5 and portions of proposed Mine Units 2, 3 and 4 have been disturbed by previous conventional mining and subsequent reclamation. Additionally, exploration drilling and associated access road construction completed since the 1950s has disturbed much of the remaining surface within the proposed mine units. Many of the historical drilling access roads still exist.

At least 14,000 exploration boreholes have been drilled within the Gas Hills Remote Satellite license area since the 1950s. It is estimated that this previous drilling disturbed approximately 105 hectares (260 acres), or 27% of the area contained within the five proposed ISR mine units (approximately 393 hectares [972 acres]). Between 1996 and 2011, 897 boreholes and 20 wells have been completed by Cameco at the Gas Hills Remote Satellite using existing roads to reach the drilling site.

At least 14 historical open-pit or underground mining operations were located within and adjacent to the Gas Hill Remote Satellite license area. Detailed information on historic disturbances and reclamation activity is illustrated on the WDEQ Permit Appendix D1-Land Use Plates D1-E and D1-W. Known areas of underground workings include the Thunderbird Shaft west of Mine Unit 5 between Mine Units 3 and 5 (Plate D1-E) and the Atlas Mine Workings west of Mine Unit 3 (Plate D1-W). Areas previously disturbed by mining are summarized in WDEQ Permit Appendix D6-Hydrology Table D6-1-1 and outlined on Plate D6-1.

Modern open-pit and limited underground mining have occurred in the West Gas Hills area (Pathfinder and Umetco), the Central Gas Hills area (Pathfinder), and the East Gas Hills area (Federal American Partners and Umetco). The Veca, A-8, PC, B2/B3, Atlas/Peach, Thunderbird, Rox, and Tee Pit areas were reclaimed between 1989 and 1992 under WDEQ's AML program. Reclamation is ongoing at Umetco's East Gas Hills Mine (WDEQ Permit No. 349C) and Pathfinder's Central Lucky Mc Mine (WDEQ Permit No.

356C). The Two States, Area 9, and Blackstone Slot were reclaimed by AML between 1992 and 1998. The Buss Pit (WDEQ Permit No. 438) had been reclaimed by Cameco (PRI) by 1995.

Cameco estimates that 70% of the total disturbed area (approximately 371 hectares [916 acres]) at the Gas Hills Remote Satellite will be short-term disturbance (one year or less) associated with mine unit construction. The remaining 30% of disturbed acreage (approximately 159 hectares [393 acres]) will be long-term disturbance associated with proposed evaporation ponds, wastewater deep disposal injection wells, mineral processing and water treatment facilities, mine unit header houses, pump stations and access roads. These disturbances will remain for the life of the Gas Hills Remote Satellite. For the projected 25-year operational life of the Gas Hills Remote Satellite, it is estimated that approximately 159 hectares (393 acres) of the approximately 3,455 hectares (8,538 acres), or 5%, will be unavailable for wildlife habitat use until final reclamation. At the end of the Gas Hills Remote Satellite operations, the entire 3,455 hectares (8,538 acres) will be returned to the pre-ISR mining use of wildlife habitat and livestock grazing.

Due to the relatively minor nature of disturbances created by ISR, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, surge/evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which require replacement and contour blending during reclamation. The existing contours will only be interrupted in small, localized areas. Changes in the surface configuration caused by construction and installation of operating facilities and constructed access roads will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. These surface impacts are unavoidable and will last for the duration of the operation, until final decommissioning. Mitigation measures for land surface impacts are discussed in Section 5.0 of the ER.

7.1.1 Potential Air Quality Effects of Construction

Construction activities at the SUA-1548 facilities including Smith Ranch and the North Butte, Gas Hills, and Ruth Remote Satellites will cause minimal effects on local air quality. Effects to air quality include increased suspended particulates from vehicular traffic on unpaved roads, and diesel emissions from construction equipment and drill rigs. The application of water to unpaved roads reduces the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be minimal but long term since maintenance, employee, delivery and drilling vehicles will be present at the sites for the life of the project. Estimated fugitive dust emissions during construction of ISR facilities are less than 2% of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and less than 1% for PM_{10} (NRC, 2009). There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the new satellite facilities. This increase in TSP will be greatest during the site preparation phase of each satellite facility. All areas disturbed during construction are revegetated with the exception of facility pad areas, roads, and areas covered by the pond liners. Of these, the only significant source of TSP is dust emissions from unpaved roads. A discussion as to specific regulatory issues associated with air quality impacts of the operation is presented in Section 7.2.1.

7.1.2 Potential Land Use Impacts of Construction

As discussed in Sections 2.2.2, 2.4.2, and 2.5.2 rangeland, pasture and wildlife habitat are the primary land uses within the SUA-1548 license areas and the surrounding 3.2 kilometers (2 miles) review area. CBM wells and infrastructure are also located on rangeland throughout the North Butte and Ruth license areas. Surface disturbance within a mine unit does not occur all at once but is sequenced over several years, depending on the uranium production rate and the availability of mine unit development and construction equipment and personnel. Long-term fencing will be constructed around the mine unit production facilities and processing satellites primarily to prevent sheep and cattle from interrupting production activities and damaging surface installations (production and injection well heads) while still allowing wildlife forage.

The Reynolds Ranch Satellite license area encompasses approximately 3,351 hectares (8,280 acres), of which approximately 1,748 hectares (4,320 acres) are split estate (private surface overlaying federal minerals), 294 hectares (726 acres) are BLM surface and minerals, 1,052 hectares (2,600 acres) are fee lands and minerals, and 259 hectares (640 acres) are state lands. Approximately 9% of the surface estate in the project area is managed by the BLM, 83% privately owned, and 8% state, while the mineral estate is 61% federal, 31% private, and 8% state. The total land disturbance for the Reynolds Ranch Satellite, including wellfields, facilities and roads, will be approximately 158 hectares (390 acres), with approximately 46 hectares (114 acres) that would be completely removed from wildlife habitat use until final reclamation. Approximately 5 hectares (12 acres) of BLM-administered surface would be completely removed from wildlife habitat use until final reclamation.

The North Butte Remote Satellite license area contains approximately 409 hectares (1,010 acres). The proposed mining units will occupy approximately 125 hectares (308 acres) of which approximately 75 hectares (185 acres), or 60%, will be directly disturbed by ISR related activities during the approximate 15-year life of the operation. Construction of the satellite building and associated structures at the North Butte Remote Satellite will encompass approximately 6 hectares (15 acres). As a result of site preparation and construction, use of the land as rangeland and pasture will be excluded from the area that is under development. CBM facilities within and adjacent to the North Butte Remote Satellite license area will not be affected. Considering the relatively small size of the areas impacted by satellite and mine unit wellfield construction activities, the exclusion of grazing from the satellite and mine unit areas over the course of the development and operation of the facility will have an insignificant impact on local livestock production.

The Gas Hills Remote Satellite license area contains approximately 3,440 hectares (8,500 acres), which is primarily BLM administered surface. Based on the current production plan, a total of approximately 607 hectares (1,500 acres), or less than 20% of the total area within the license boundary, will be disturbed in phases over the approximate 25-year life of the operation. Because wellfields are reclaimed and vegetated after installation, these areas will be available for wildlife forage throughout the life of the operation. All wellfield areas are fenced to keep out livestock that could damage well heads or other wellfield equipment. Acreages that will be excluded from wildlife forage and cattle grazing for the life of the operation include the existing Carol Shop, which will be refurbished for the ISR process and groundwater restoration equipment. Construction of the Alternative Satellite building and associated structures will encompass approximately 4.1 hectares (10 acres). The evaporation ponds will exclude approximately an additional 2 hectares (5 to 6 acres).

The Ruth Remote Satellite license area contains approximately 572 hectares (1,414 acres). Currently, two buildings and two lined evaporation ponds from the 1981 R & D operation remain on-site. Topsoil has been stockpiled adjacent to the building disturbance area and the evaporation ponds. A Plan of Operations has not been developed for Ruth so the estimated total land disturbance area from future ISR operations is not known at this time. Cameco will be developing design and operational plans for this satellite operation during the next renewal period and will provide them to NRC upon completion.

7.1.3 Potential Surface Water Impacts of Construction

When storm water drains off a construction site, it can carry sediment and other materials that can potentially impact lakes, streams and wetlands. The EPA estimates that 20 to 150 tons of soil/acre is lost every year to storm water runoff from construction sites. For this reason, storm water runoff is controlled by the WDEQ NPDES (WYPDES) regulations. Construction projects exceeding 2 hectares (5 acres) are required to have a large construction storm water permit. The two hectares of disturbance does not have to be contiguous. Construction projects of between 0.4 and 2 hectares (1 and 5 acres) are required to have a small construction storm water permit. Currently, North Butte *(WYR104286)* and Smith Ranch *(WYR104157)* have authorization under large construction (North Butte) and large industrial (Smith Ranch) general WYPDES permits. If required, Cameco will seek a modification of the Smith Ranch permit to include the additional Reynolds Ranch satellite license area. A large construction permit (WY103870) for the Gas Hills Remote Satellite was issued to Cameco on August 24, 2008, but the permit expired in March 2011. Cameco was recently reissued the Gas Hills permit effective December 9, 2011; the permit expires March 2016. Prior to construction activities, Cameco will obtain a WYPDES permit for the Ruth Remote Satellite.

Construction activities at SUA-1548 facilities to date have had a minimal impact on the local hydrological system. Construction activities are conducted under LQD and WQD permitting regulations for control of construction storm water discharges contained in Chapter 2, WDEQ, WQD Rules and Regulations. Cameco is required by WDEQ to implement procedures that control runoff and the deposition of sediment to nearby surface water features during construction activities. Administrative and engineering controls implemented by Cameco during initial site preparation and construction of future satellite facilities and related infrastructure are expected to ensure that surface water impacts remain minimal.

7.1.4 Potential Population, Social and Economic Impacts of Construction

The potential population, social and economic impacts of construction is discussed in Sections 3.10 and 7.3 of the ER. Overall, the Smith Ranch SUA-1548 license area has and will continue to provide positive benefits to the local communities and the State of Wyoming.

7.1.5 Potential Noise Impacts of Construction

Sections 3.7 and 4.7 of the ER provide a summary of the potential noise impacts at the Smith Ranch (SUA-1548) license areas. The cited sections in the ER also describe a noise study conducted by Cameco at Smith Ranch and provide a discussion of the nearest receptors and potential impacts at each facility. The noise study conducted at Smith Ranch evaluated the noise levels from the various equipment common to ISR operations.

Increased vehicle travel and the operation of construction equipment at the Reynolds Ranch Satellite and at the North Butte, Gas Hills and Ruth Remote Satellite facilities during the construction phase of the project could result in a slight increase in noise impacts to residents. Noise from construction would not be generated during nighttime hours. *(The decibel A filter is widely used. dB(A) roughly corresponds to the inverse of 40 dB (at 1 kHz) equal-loudness curve for the human ear. Using the dBA-filter, the sound level meter is less sensitive to very high and very low frequencies. Measurements made with this scale are expressed as dB(A))** Construction activities typically occur over an 8 to 12-hour work day, 5 days/week. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic, (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise.

The EPA has compiled data regarding the noise generating characteristics of typical construction activities, both with and without the use of equipment mufflers. These data, which represent composite construction noise, are presented in **Table 7-1, Noise Range Levels of Typical Construction Equipment**. These noise levels would diminish rapidly with distance from the construction site at a rate of approximately 6 dBA[1] per doubling of distance. For example, a noise level of 84 dBA measured at 15 meters (50 feet) from the noise source to the receptor would reduce to 78 dBA at 31 meters (100 feet) from the source to the receptor, and reduce by another 6 dBA to 72 dBA at 61 meters (200 feet) from the source to the receptor (EPA, 1971). According to the tests conducted by Cameco and assuming a worst case noise source (PVC chipper), the calculated noise level at a location 3 kilometers (2 miles) from the noise source would be 77 dBA.

Construction of the new satellites and mine units at Smith Ranch and the North Butte, Gas Hills and Ruth Remote Satellite license areas will require all of the equipment listed in **Table 7-1** with the exception of a pile driver. Drilling rigs will also be utilized during the construction phase of the project. Layne Christensen Company conducted an in-house occupational health noise analysis for a TH-75E reverse circulation, air rotary drilling rig. The TH-75E, manufactured by Ingersoll Rand, is a top head drive, reverse circulation, air rotary drilling rig capable of drilling over 762 meters (2,500 feet) into the earth. The drill rig uses an eight-cylinder, 600 HP deck mounted Cummins KTA-19C engine for drilling purposes. It is coupled to an Ingersoll Rand 1,000/350 screw type air compressor. Sound levels (85 to 90 dBA) recorded next to the drilling rig were reported to be above the OSHA/MSHA action levels. The above mentioned drilling rig would be similar to those utilized at the Smith Ranch SUA-1548 license areas, and the noise levels would be comparable.

7.2 Potential Effects of Operations

7.2.1 Potential Air Quality Impacts of Operations

Past and current operations at Smith Ranch have resulted in minimal air quality emissions. This will likely be true of operations at the Reynolds Ranch Satellite and the North Butte, Gas Hills and Ruth Remote Satellites. Because the operation is primarily indoor activities and interior modifications are made to existing buildings, air impacts from construction are considered to be minimal and or temporary. Installation of mine unit wellfields is an on-going part of the operation and has been considered in the fugitive dust calculations for operational conditions.

Air pollutants such as NOx will be emitted from drilling equipment and other vehicles. The NRC completed an air quality study for the Environmental Impact Statement for the Nichols Ranch ISR Project to estimate NOx emissions (NRC, 2011; NUREG 1910 Supplement). The NRC calculated drilling rig emissions for the proposed Nichols Ranch ISR Project wellfield development activities at 8.0×10^{-3} metric tons (8.8×10^{-3} Tons)of NOx per well, which was several orders of magnitude less than the NOx emissions from wells drilled to support oil and gas exploration and production.

Historically, emissions from ISR operations are significantly lower than conventional mining and milling operations. The primary source of emissions from ISR facilities like the Smith Ranch SUA-1548 license areas will be fugitive dust from vehicular traffic on unpaved access roads and in the wellfield areas, and minor emissions from the processing plant and associated equipment. It has been estimated that a total of approximately 344 metric tons/year (368 tons/year) of air particulates are emitted from the operations activities at the Smith Ranch license areas at full scale production (excluding the Ruth Remote Satellite). More than 99% of this total is from estimated fugitive dust emissions, calculated as worst case without any dust control measures applied. The emissions from the Reynolds Ranch Remote Satellite are estimated to be an approximately additional 36 metric tons/year (40 tons/year). The fugitive dust emissions directly correlate with the license area size; that is the fugitive dust emissions are higher for the Gas Hills Remote Satellite compared to the North Butte Remote Satellite. Fugitive dust emissions from the remote satellites are estimated to range from 100 to 130 metric tons (110 to 140 tons)/year. The proposed road upgrades at the North Butte and Gas Hills (AML and Dry Creek Roads) should reduce the fugitive dust emissions.

A breakdown of the emissions from Smith Ranch is as follows:

Process Facility

Actual air emissions from the CPP are very minimal as the processes are aqueous in nature. There will be minor emissions from hot water heaters used in the precipitation circuit, and the two hot oil heaters associated with each vacuum dryer unit. Additionally, emissions from the outside hydrochloric and/or sulfuric acid tanks were estimated for this application and found to be negligible. There are no non-radioactive process air emissions from the satellite facilities, as only the IX process takes place at these locations. In summary, the air emissions from the CPP are:

1. Dryer hot oil heaters – 0.065 metric tons/year (0.072 ton/year) SO_2
2. Hot water boiler -0.155 metric tons/year (0.171 ton/year) SO_2
3. Acid tanks (HCl and H_2O_2) – negligible

The EPA considers sulfur dioxide to be a major air pollutant that can have significant impacts upon human health. Additionally, the concentration of sulfur dioxide in the atmosphere can influence the habitat suitability for plant communities as well as animal life. However, the sulfur dioxide releases during the operation of the current Smith Ranch facilities have been negligible, at 0.22 metric tons/year (0.24 tons/year). Listed Hazardous Air Pollutants (HAP) are not released to the atmosphere during operations.

Fugitive Dust

Fugitive dust from vehicular traffic on unpaved roads is the primary emission associated with the Smith Ranch SUA-1548 operations. Fugitive dust is released by traffic on the main access roads, the secondary access roads to the satellites, and traffic within the mine unit areas. Fugitive dust is also generated from trucks transporting IX resin, yellowcake slurry, chemicals, etc. to process facilities, and deliveries of supplies. Employee travel on unpaved roads to the various operating units is also a significant component of the total fugitive dust emissions. Wellfield traffic, including drilling rigs, water trucks, pipe trucks and geophysical logging trucks provides the largest contribution to fugitive dust emissions.

The fugitive dust (PM_{10}) estimates were calculated using the methodology provided in EPA's AP-42 publication (EPA, 1995). The non-SI (metric) units in the following equations were maintained for consistency with the publication. For reference, the metric conversion from lb/vmt (vehicle mile travelled) to grams (g) per vehicle kilometer travelled (vkt) is as follows:

$$1\text{lb/vmt} = 281.9\ \text{g/vkt}.$$

Two equations are provided in EPA Publication AP-42, *Section 13.2.2 Unpaved Roads* as follows:

$$E = k \times \left(\frac{s}{12}\right)^{a} \left(\frac{W}{3}\right)^{b} \times \left(\frac{365-p}{365}\right) \qquad (1)$$

$$E = \left[\frac{k\left(\frac{s}{12}\right)^{a} \times \left(\frac{S}{30}\right)^{d}}{\left(\frac{M}{0.5}\right)^{c}} - C \right] \times \left[\frac{365-p}{365}\right] \qquad (2)$$

Where:

E= emission factor (lb/vmt)
C = emissions factor for 1980s fleet exhaust, brake wear and tire wear
a = 0.9 (Industrial Roads, 1.0 Public Roads)
b = 0.45 (Industrial Roads)
c = 0.2 (Public Roads)
d = 0.5 (Public Roads)
k = particle size multiplier –assumed 0.36 (particle ≤10% µm)
s = silt content of road surface material (%) – assume 10%
S = mean vehicle speed (mph)
W= mean vehicle weight (tons)
p = number of days with at least 0.01 inches of precipitation per year – assume 100 days.

Equation 1 is used to estimate emissions from vehicles travelling on unpaved surfaces at industrial sites such as secondary access roads, wellfield roads and other minor roads. Equation 2 provides an estimate of emissions from publicly traveled roads which include unpaved roads to the license area and the main access road at the ISR facility. Reasonable weights were assumed for the various vehicles, and to be conservative, the vehicles were assumed to be fully loaded the entire trip. Again, the most significant emissions source was wellfield traffic followed by employees commuting to the ISR facilities. A summary of the estimated annual fugitive dust emissions (PM_{10}) in metric tons is provided below.

Facility	Employee Travel	Drilling Support	Construction	Operational Support	Operational Supply Support Deliveries	Transport of Resin/Yellowcake Slurry	Total Emissions
Smith Ranch	0	102.7	8.0	30.1	0	0.4	141.2
North Butte	34.5	42.1	5.8	12.5	0.5	1.4	96.9
Gas Hills	54.0	41.4	8.5	12.5	1.5	12.2	129.8

The fugitive dust emission estimates are well below the allowable limits of the State of Wyoming. Actual fugitive dust releases during operations are reduced by use of water spray bars on drilling rig water service vehicles.

7.2.2 Potential Noise Impacts of Operations

Noise-generating activities in the CPP, CPF, Smith Ranch satellites and the North Butte Remote and Gas Hills Remote Satellites facilities are or will be primarily indoors, thus minimizing off-site sound levels. Wellfield equipment (e.g., pumps, compressors) would also be expected to be contained within structures (e.g., satellite facilities), minimizing sound levels to off-site receptors. Administrative and engineering controls are used to maintain noise levels in work areas below OSHA standards, and are mitigated by use of personal hearing protection. Traffic noise from commuting workers, truck shipments to and from the facility, and facility equipment is localized, limited to roads and highways in the vicinity of Smith Ranch SUA-1548 facilities, access roads within the sites, and access roads in the wellfields.

Noise levels from a particular source decline as distance to the receptor increases. Other factors, such as the weather and reflecting or shielding, also help intensify or reduce the noise level at any given location. A commonly used rule of thumb for roadway noise is that for every doubling of distance from the source, the noise level is reduced by about 3 dBA at acoustically "hard" locations (i.e., the area between the noise source and the receptor is nearly complete asphalt, concrete, hard-packed soil, or other solid materials) and 4.5 dBA at acoustically "soft" locations (i.e., the area between the source and receptor is earth or has vegetation, including grass) (EPA, 1974). Noise from stationary or point sources is reduced by about 6 to 7.5 dBA for every doubling of distance at acoustically hard and soft locations, respectively. Noise levels may also be reduced by intervening structures; generally, a single row of buildings between the receptor and the noise source reduces the noise level by about 5 dBA, while a solid wall or berm reduces noise levels by 5 to 10 dBA. The topography of the area will also serve to reduce the noise levels.

The primary source of noise impacts during ISR operations is from drilling for wellfield delineation and monitoring well or production/injection well completion. The anticipated noise levels for a drilling rig are provided in Section 7.1.5.

7.2.3 Potential Land Use Impacts of Operations

As discussed in Sections 2.2.2, 2.4.2, and 2.5.2 rangeland/pasture and wildlife habitat are the primary land uses within the SUA-1548 license areas and within the surrounding 3 kilometer (2 mile) buffer area. CBM facilities and infrastructure are also located on rangeland throughout the North Butte and Ruth Remote Satellite license areas. As with site preparation and construction, use of some of the land surface as rangeland will be excluded during the life of the project. Existing and potential CBM facilities will not be affected. Considering the relatively small size of the area impacted by operations, the exclusion of grazing from these areas over the life of the Smith Ranch SUA-1548 license will have an insignificant impact on local livestock production.

Areas near the Smith Ranch license area are slated for exploration oil and gas drilling into the Niobrara Shale. However, with new directional drilling capabilities, multiple oil and gas wells can be drilled from one drill pad, thereby minimizing surface disturbance and interference with ISR operations. It is not anticipated that the ISR activities at Smith Ranch will impact potential oil and gas drilling and/or exploration activities. The target formation (Niobrara Shale) for drilling is significantly deeper than the uranium-bearing zone where the ISR operations are producing from and the uranium-bearing zone and Niobrara Formation are separated by the thick, marine Pierre Shale. Finally, although the Niobrara play has been successful in the Colorado Denver-Julesburg (D-J) Basin, economic oil and gas production potential from the Niobrara Shale in the Powder River Basin is still debatable.

Several oil and gas companies have begun enhanced oil recovery (EOR) programs at existing oil fields in Converse County. After receiving recent (2011) environmental approval, Australia-based Linc Energy will start EOR at its Wyoming oilfields by injecting carbon dioxide into the South Glenrock B Unit 34 in the Powder River Basin. The carbon dioxide initially will be delivered to the field by trucks until a pipeline is built to provide long-term dependable supplies and maintain lower operating costs. These operations will occur at existing oil wellfields and Cameco's Smith Ranch operations will not affect these activities.

7.2.4 Potential Geology and Soil Impacts of Operations

7.2.4.1 Geology Impacts of Operations

Geological impacts from ISR operations at all SUA-1548 operations have been and are expected to remain minimal. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the target sandstone is approximately 1%. Also, ISR does not remove any of the formation material from the aquifer thereby negating any potential for subsidence. Finally, once production and restoration operations are completed, groundwater levels will return to near original conditions under a natural gradient.

7.2.4.2 Potential Soil Impacts of Operations

LQD Rules and Regulations Chapter 11, Section 4(a)(iii) stipulates that procedures required in Chapter 3, Section 2(c)(i) through (iii) be used to ensure the protection of topsoil and subsoil from excessive compaction, degradation, and wind and water erosion where stockpiling of topsoil and subsoil is necessary. These regulations require that Cameco perform ISR activities in a manner that minimizes topsoil damage and controls the amount of sediment lost to wind and water erosion. Surface drainages must be diverted around the operation in an erosionally stable manner and meet certain minimum design standards.

All suitable topsoil is salvaged from construction of access roads, wellfield staging areas, building sites (including satellite buildings and header houses), permanent storage areas, designed impoundment sites, chemical storage sites and all other areas subjected to repetitive vehicular traffic. The topsoil is placed in long-term stockpiles.

All stockpiles, regardless of size, are provided with erosion and sediment control. Such controls may include toe ditches, wattles, etc. Large stockpiles may also be sprayed with a tackifier to inhibit soil erosion. Topsoil stockpiles are seeded using either hydroseeding or crimp mulching as soon as possible after construction with the approved permanent seed mix to minimize loss of erosion (see Section 6.2.4). To further minimize erosion, a fast growing cover crop may also be interseeded with the permanent seed mix on topsoil stockpiles. Interseeding is typically conducted using a broadcast method of seeding. In accordance with LQD Rules and Regulations Chapter 3, Section2(c)(i)(D), permanent topsoil stockpiles are identified with a highly visible sign with the designation "Topsoil" in letters at least 15.2 centimeters (6 inches) high.

7.2.5 Potential Cultural Resource Impacts of Operations

In accordance with NRC, WDEQ and Wyoming State Historic Preservation Office (SHPO) requirements, cultural resource surveys have been conducted on lands comprising the SUA-1548 license areas (see Sections 2.2.4, 2.3.4, 2.4.4, and 2.5.4). These surveys have been approved by the BLM, WDEQ LQD, NRC and SHPO. A discussion of the historic and cultural resource studies conducted at the SUA-1548 license areas is provided in Sections 3.8 and 4.8 of the ER. The studies are also provided in Appendix D-4 of the WDEQ permits for Smith Ranch, North Butte and Gas Hills. The studies for the Ruth Remote Satellite are provided in Section 7 (Appendix "D-3", Archaeology) of the Supportive Information for WDEQ Permit to Mine Application and U.S.N.R.C. Source Material License Application. Cameco's primary mechanism for mitigation of impacts to cultural resources is avoidance of the identified features. To ensure that no unapproved disturbances of cultural resources occurs, License Condition 9.9 of SUA-1548 requires that any work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts will be inventoried and evaluated in accordance with 36 CFR Part 800, and no further disturbance of the area will occur until Cameco has received authorization from the NRC to proceed.

7.2.6 Potential Visual and Scenic Impacts

The Smith Ranch license area is located on private land, with the exception of small parcels of land within the license area which are public lands and are administered by either BLM or the State of Wyoming. The North Butte Remote Satellite license area is entirely on private land and is not managed by any public agency to protect scenic quality. The majority of the Gas Hills Remote Satellite license area is administered by the BLM; although several tracts of private land are within the license area. The Ruth Remote Satellite license area contains BLM and private lands. The BLM has inventoried visual resources of all lands within the boundaries of their respective field offices, including private lands, with their Visual Resource Management (VRM) system. A discussion of the visual and scenic resources and potential impacts and mitigation efforts for the SUA-1548 license areas is provided in Sections 3.9 and 4.9, respectively, of the ER. In general, any adverse effects that do occur will be mitigated through the use of non-contrasting building colors and a timely mine unit wellfield reclamation program.

7.2.6.1 Groundwater Consumption

Cameco has conducted detailed groundwater modeling to assess potential cumulative impacts resulting from ground water consumption associated with ISR activities at Smith Ranch and the North Butte and Gas Hills Remote Satellites. The results of the impacts analysis are presented in Section 4.4 of the ER.

For the Smith Ranch SUA-1548 project, the most significant groundwater impact will be the withdrawal and disposal (deep injection, land application and/or evaporation) of approximately 3,106 hectares-meters (25,180 acre-feet) of groundwater over the life of the operation. This volume represents approximately the same amount of water produced (dewatered) from the Kerr-McGee Bill Smith underground uranium mine (*located within the Smith Ranch license area*) between 1974 and 1982 and discharged to surface streams. In the case of Smith Ranch SUA-1548 operations, most of the water removed from the wellfield production zone is returned to the groundwater aquifer after treatment. The remaining water removed from the formation (approximately a 1% bleed) is disposed through deep well injection, land application or evaporation.

For the Smith Ranch license area, the consumptive use of groundwater for the remaining life of the operation is estimated to be approximately 2,050 hectare-meters (16,607 acre-feet). Of this amount, approximately 47 hectare-meters (383 acre-feet) are estimated to be from future processing of IX resin at the Highland CPF. The anticipated consumption at the Reynolds Ranch satellite is 105 hectare-meters (855 acre-feet). A portion of the 1% bleed stream may be used in various plant processes, such as eluant make-up, filter backwash, resin washes, plant wash down and other process purposes. The portion of the bleed stream used for these purposes will also be disposed of in the waste disposal system.

The results of the ground water modeling predict that the maximum drawdown in the affected aquifers in the vicinity of Smith Ranch will be approximately 6 meters (22 feet) over the 33 year model period.

For the North Butte Remote Satellite, the greatest volume of water used will occur during the groundwater sweep phase of groundwater restoration at each mine unit. Based on the anticipated production rate and the waste minimization program at the facility, it is estimated that the maximum annual volume of treated groundwater requiring disposal will be approximately 276 million liters (73 million gallons) (529 Liters/minute or 140 gallons per minute average). The deep well injection volume for the life of the satellite operation is estimated to be 273 hectare-meters (2,213 acre-feet). The operational phase will result in a wellfield bleed stream of approximately 1% of the recovery flow, or about 95 to 227 Liters/minute (25 to 60 gallons per minute) being removed from the groundwater system ("A", "B" and "C" sand members of the North Butte production sand). This approximate 1% bleed stream will ultimately be disposed of through deep well disposal.

The estimated groundwater consumption at the Gas Hills Remote Satellite is 39 hectare-meters (318 acre-feet)/year. For a projected 20 year project life, approximately 785 hectare-meters (6,360 acre-feet) of groundwater will be consumed. As will be the case at the other remote satellites, the greatest volumes of water used will occur during the groundwater sweep phase of groundwater restoration at each mine unit wellfield. This approximate 1% bleed stream will ultimately be disposed of development evaporation ponds and potentially deep well disposal.

The results of the ground water modeling at the Gas Hills Remote Satellite predict maximum drawdowns in the production aquifer of 3 meters (10 feet) at the permit boundary during years eight and nine, corresponding with the period of maximum groundwater withdrawals.

The Ruth Remote Satellite will be operated similar to the North Butte and Gas Hills Remote Satellites. The groundwater consumptive use at Ruth will be determined once an operational plan, including a water balance, is developed for the remote satellite.

7.2.6.2 Impacts on Ore Zone Groundwater Quality

During ISR operations, water quality impacts are usually of greater concern than water consumption impacts because water consumption during production is relatively small. The potential impacts to groundwater quality is primarily from the lixiviant which includes (1) the addition of sodium bicarbonate, carbon dioxide and oxygen to the groundwater, (2) the addition of chloride to the groundwater by IX recovery processes, and (3) the interaction of these chemicals with the mineral and chemical constituents of the production zone. The result is that during production, the concentration of most of the naturally occurring dissolved constituents will be appreciably higher than their concentrations in the native groundwater.

Groundwater withdrawal and reinjection will occur throughout the project life and is a critical component of the production and restoration operations. There will be short term impacts to the quantity and quality of the groundwater within the production zone on a wellfield-by-wellfield basis. Over the long term, the groundwater concentration of some parameters within the production zone may vary slightly compared with initial conditions; however any changes are minimal and will not alter the potential use category of these waters as defined by the WDEQ. Even so, NRC and WDEQ regulations require the post-restoration groundwater quality to meet the primary standard of baseline conditions or if not attainable, apply to the agency for alternate concentration limits (NRC) or a declaration that the water meets the pre-ISR quality of use category (WDEQ).

7.2.6.3 Potential Groundwater Quality Impacts from Accidents

Lixiviant Excursions

Water quality impacts in adjacent aquifers from ISR activities are related to the identification, control, and clean-up of excursions. During production, injection of the lixiviant into the production zone aquifer results in a temporary degradation of water quality compared to pre-operational conditions. Movement of this water out of the production zone and to the monitor well ring results in an excursion. Excursions of production fluid can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, or hydrofracturing of the ore zone or surrounding units. Past experience at Smith Ranch has shown that when proper steps are taken in monitoring and operating mine unit wellfields, excursions, if they do occur, can be controlled and recovered in a timely manner, and that serious impacts on the groundwater are prevented.

Excursions of lixiviant at ISR facilities have the potential to impact adjacent aquifers with radioactive and trace elements that have been mobilized by the ISR process. The historical experience at Smith Ranch and other ISR uranium operations indicates that the selected excursion indicator parameters and UCL allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733 (NRC, 2001), significant risk from a horizontal or vertical excursion would occur only if it persisted for a long period without being detected.

As previously stated, both WDEQ and NRC require restoration of affected groundwater in the production zone following production activities. Cameco is required by NRC to return the groundwater in the production zone to baseline water quality conditions as the primary goal with the standards in 10 CFR Part 40, Appendix A, Criterion 5B as the secondary standards. Constituent concentrations higher than outlined in Criterion 5B will require an alternative concentration limit (ACL) application. The production zone aquifer must be classified and exempted by the WDEQ and the EPA from protection under the Safe Drinking Water Act before ISR activities can occur. One of the criteria for exemption is that the water is not currently used, nor in the future be used, as an underground source of drinking water (USDW) and will not be used as USDW in the future. By restoring the exempted aquifer, Cameco ensures that adjacent, non-exempted aquifers will not be affected in the future.

Successful groundwater restoration has been demonstrated using the methods discussed in Section 6.0. Therefore, long-term impacts on groundwater quality are expected to be minimal.

7.2.6.4 Potential Groundwater Impacts from Spills

The potential for impacts to groundwater and surface water at the SUA-1548 license areas as a result of an uncontrolled release of process liquids due to a header house, well or pipeline leak during operations is low because there is limited occurrences of surface water at any of the sites. Additionally, the nearest aquifer underlying the surface at any of the sites is greater than 30 meters (100 feet) below the surface. Should such a release occur, the greatest impact would be to the surrounding soil. With a slow leak that remains undiscovered or a catastrophic failure, a shallow excursion is one potential impact. The potential environmental impacts from spills and mitigative measures are discussed in further detail in Section 7.5.

7.2.6.5 Potential Groundwater Impacts from Pond Leaks

Leaks from ponds and reservoirs have the potential to impact shallow groundwater aquifers. The Smith Ranch SUA-1548 license areas have several ponds which include the east and west storage ponds at the CPP the two purge storage reservoirs at Highland. Surge ponds will be constructed at the North Butte Remote Satellite, and evaporation ponds will be constructed at the Gas Hills Remote Satellite.

Section 3.10 provides a summary of storage pond leak events occurring at the Smith Ranch-Highland operation since the previous license submittal and associated design and/or operational changes to reduce the frequency of leak events. Liner leaks, or seepage in the case of PSR-2, are the primary causes of leakage of fluids into the unsaturated zone. Cameco will be installing deeper monitoring wells at PSR-2 to determine if the shallow aquifer underlying the PSR has been impacted. Lessons learned at Smith Ranch and Highland have been applied to the pond designs for the North Butte and Gas Hills Remote Satellites.

7.2.7 Potential Surface Water Impacts of Operations

7.2.7.1 Potential Surface Water and Wetlands

The potential impacts to surface waters as a result of operations at the SUA-1548 license areas are considered to be minimal and temporary. There is, however, the potential for impacts to occur during mine unit wellfield construction and reclamation activities. The majority of the surface water at SUA-1548 license areas are ephemeral, but surface water is present at the Gas Hills Remote Satellite (West Canyon Creek and Cameron Spring) and North Butte Remote Satellite (Willow Creek and stock ponds). Constructed stock ponds which are tributary to Sage Creek and Box Creek are present at Smith Ranch. The potential for impacts to surface water at these locations is low. During production, restoration, and after reclamation, the surface will be vegetated to minimize temporary effects to surface water quality.

The physical presence of the surface facilities, including the wellfields and associated structures, access roads, satellite IX buildings, office buildings, pipelines, CPP, and CPF facilities and other structures associated with the ISR process are not expected to significantly change peak surface water flows because of the relatively flat topography of the drainages at the sites, the low regional precipitation, the absorptive capacity of the soils, and the small area of disturbance relative to the large drainage area within and adjacent to the license areas. In areas where these structures may affect surface water drainage patterns, diversion ditches and culverts are used to prevent excessive erosion and to control runoff. In areas where runoff is concentrated, energy dissipaters are used to slow the flow of runoff to minimize erosion and sediment loading in the runoff.

7.2.7.2 Potential Surface Water Impacts from Sedimentation

During mine unit wellfield construction and reclamation, the potential loss of vegetation to those activities may cause increased opportunities for erosion and potential movement of sediments into drainages. Contouring and use of BMP are used to minimize the potential effects of erosion. Upon completion of construction and reclamation, and as soon as feasible considering Wyoming growing seasons, revegetation work is completed using either temporary (cover crop) or permanent (native seed) mix, or a combination of approved permanent and temporary seed to stabilize the soil and minimize erosion due to runoff.

7.2.7.3 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as excessive storm water runoff in impacted soil areas or a release of process fluids due to a leak. Section 7.5 discusses measures to prevent and control spills. Process buildings and chemical storage areas are or will be constructed with sumps or secondary containments, and a regular program of inspection and preventive maintenance is performed.

7.2.8 Potential Impacts to Terrestrial and Aquatic Ecology

7.2.8.1 Vegetation

No T&E species have been documented within the Smith Ranch SUA-1548 license areas. Therefore, no impacts are anticipated.

As with any surface disturbing activity, weeds will opportunistically occur and periodically need to be controlled. At the Smith Ranch site, weeds, predominantly Canadian thistle (*Cirsium arvense*) are sprayed with a registered herbicide once per year, typically in late spring or early summer, or as advised by the herbicide's application instructions. Areas sprayed include road cuts and fills, areas around buildings and fences, and other isolated areas within and around recently constructed wellfields that have been disturbed by construction and operations activities. The herbicide spraying is performed by a certified applicator in accordance with BLM and county weed and pest requirements. The same weed control measures will be implemented at the North Butte, Gas Hills, and Ruth Remote Satellites.

7.2.8.2 Wildlife

Compared with conventional surface mining, ISR poses a lower level of impact on wildlife, especially big game species such as deer and antelope. This is primarily because the area of disturbance is limited and temporary. Heavy equipment, such as large earth excavators and haul trucks, are not used, and the number of people involved in an ISR operation is significantly less than a conventional mine. Pronghorn antelope are frequently seen grazing within the operational wellfield areas at Smith Ranch.

Adverse impacts to wildlife as a result of the Smith Ranch SUA-1548 license areas activities will be minimal for the following reasons:

1. No important big game migration routes or crucial winter habitats have been identified during surveys performed to date;
2. ISR activities disturb relatively small amounts of land surface at any one time;
3. Areas disturbed by mine unit construction or operations activities will be revegetated after mine unit well pattern construction and will be available for wildlife use throughout the project life; fencing will be used only to keep livestock out of active production/restoration areas;
4. Livestock restrictive fencing will be limited to relatively small areas and will not significantly impede wildlife movements; and,
5. Vehicular traffic will be limited with reduced speed limits utilized for safety purposes and to decrease the likelihood of vehicle and wildlife collisions.

To avoid adverse impacts to any raptor, migratory birds of high federal interest (MBHFI) or T&E species, the primary mitigative action will be avoidance. Whenever possible, Cameco will avoid performing ground disturbing activities, including drilling and construction activities within certain areas during active nesting or breeding times. Time and area restrictions around raptor nests, sage grouse leks and mountain plover nests will be in accordance with the WDEQ, Wyoming Game and Fish Division (WGFD) and US Fish and Wildlife Service (USFWS) specifications, which currently are as follows:

Sage grouse leks: Avoid ground disturbing activities within 0.4 kilometer(0.25 mile) of any active sage grouse lek year-round. Avoid such activities within 3 kilometers (2 miles) of any active lek between March 15 and June 30. For leks within the core area, mitigative actions will be determined in consultation with the WDEQ, WGFD and USFWS.

Raptor nests: Avoid ground disturbing activities within the USFWS Wyoming Ecological Services recommended species specific spatial and seasonal buffers of any active raptor nests.

Mountain plover nests: Avoid ground disturbing activities within 0.4 kilometers (0.25 mile) of any nesting mountain plover nest between April 10 and July 10 of each year.

If it is determined that avoidance will not be possible, Cameco will consult with WDEQ, WGFD and the USFWS prior to initiation of any ISR activities. Based on this consultation, Cameco will prepare and execute a mitigation plan.

New power lines are constructed in a manner that minimizes potential electrocution hazards to raptors by following the guidance in "Suggested Practices for Raptor Protection on Power Lines - The State of the Art in 2006," by the Avian Power Line Interaction Committee, 2006.

The CPP, CPF satellites and mine unit wellfield facilities are fenced, primarily to prevent sheep and cattle from interrupting production activities. Any constructed ponds that contain process fluids are fenced to prevent both livestock and large game animals from accessing the areas. Fences are constructed utilizing the guidance provided in WDEQ Guideline No. 10 such that impacts to wildlife are minimized. These same measures will be implemented at the Reynolds Ranch Satellite, and the North Butte, Gas Hills and Ruth Remote Satellites.

As is the case at the Smith Ranch ponds and purge storage reservoir, it is anticipated that the surge ponds at the North Butte Remote Satellite and the evaporation ponds at the Gas Hills Remote Satellite will not attract long-term residence of water fowl because they will not contain any food source or shoreline vegetation for hiding or nesting. There are numerous, more attractive water bodies in the areas that will provide food and hiding/nesting vegetation. These include small stock ponds in and around the site. Other than short, transient migratory stop-overs, Cameco does not anticipate that water fowl will inhabit the surge or evaporation ponds long enough to be impacted. Cameco will monitor water fowl activities in the area of these ponds and will implement additional mitigative action should it become necessary. Such actions may include propane cannons, netting over the ponds, brightly colored pennants, etc. Cameco will consult with WDEQ, WGFD and USFWS in developing water fowl mitigative action plans if the above actions are not successful.

7.2.8.3 Fish and Macroinvertebrates

No aquatic habitat exists at any of the SUA-1548 license areas that will support fish or macroinvertebrates. Therefore, no impacts from construction or operations to fish or macroinvertebrates can occur. The wetland inventory was updated in 2011 at Smith Ranch and will be added to the Smith Ranch WDEQ Appendix D11 as an addendum. During the June 2011 survey, Hayden-Wing Associates, LLC identified 19 potential wetland sites at Smith Ranch.

Potential wetlands were delineated in 2010 at the North Butte Remote Satellite license area during the confirmatory vegetation survey and are discussed in the North Butte WDEQ Appendix D11, which includes a wetlands determination letter from the US Army Corps of Engineers (COE). Aquatic habitats in these wetlands may harbor macroinvertebrates.

A jurisdictional wetlands delineation for the Gas Hills Remote Satellite area has not been conducted. However, approximately 11 hectares (28 acres) of potential wetlands were mapped based on the presence of wetland vegetation. Potential wetlands that occur within the license area were delineated based on vegetative characteristics and are shown on the Gas Hills WDEQ Appendix D8-Vegetation Plates D8-1E and D8-1W. Most of this wetland vegetation exists along and within the stream channel of West Canyon Creek, but wetland vegetation also occurs along the margins of Cameron Spring Reservoir and several small seeps which issue from the base of the Beaver Divide near the southern boundary of the license area. Aquatic habitats in these wetlands may harbor macroinvertebrates. Disturbance of wetlands and potential aquatic habitats within the production areas will be avoided, whenever possible.

A jurisdictional wetlands delineation for the Ruth Remote Satellite license area has not been conducted to date. As described in the Supportive Information for WDEQ Permit to Mine Application and U.S.N.R.C. Source Material License Application, Volume 1, Section 13, electrofishing was conducted in potholes in the Dry Fork drainages. Ephemeral, standing water up to 1.5 meters (5 feet) deep has been documented in the potholes. Results of the electrofishing showed that a small population of plains and fathead minnow were present along with an unidentified species of catfish. Overall, the aquatic habitats for fish and macroinvertebrates at the Ruth Remote Satellite are limited.

In general, disturbances of wetlands within the limits of proposed production areas will be avoided. However, should it become apparent that a potential wetland area may become affected by the operation a mitigation plan will be developed for approval by WDEQ and the USACE. The most likely type of disturbance would be a road and/or pipeline crossing. Prior to disturbance of any potential wetland area, the USACE will be contacted for a jurisdictional wetland determination and approval of a mitigation plan by WDEQ and USACE. Wetland information and/or mitigation plan approvals will be submitted with the Hydrologic Testing Package for each mine unit, if needed.

7.3 Radiological Effects

Exposure pathways to radiological materials at ISR operations are considerably different from pathways associated with conventional uranium mining and milling methods. The environmental advantages of ISR are two-fold. First, the majority of the radioactive daughter products remain underground and are not removed with the uranium. Second, for the production of yellowcake, the use of modern vacuum dryers reduces the potential for radiological air particulate releases typically associated with conventional uranium milling facilities to insignificant levels (FEIS, NUREG-1508, 1997).

As a general matter, ionizing radiation is ubiquitous throughout the United States and, according to the National Council on Radiation Protection and Measurement (NCRP), the average background radiation dose to a member of the public in the United States is approximately 300 mrem/year. Dose from naturally occurring sources, which is the largest potential source of public radiation dose within the ambit of NRC's definition of "background radiation," is highly variable (i.e., it can vary by as much as a factor of ten across the country). Dose from "background radiation" results from cosmic radiation sources such as cosmic rays from the sun and supernova explosions and from anthropogenic (human) activities, such as global fallout and surface nuclear weapons testing, internal dose from ingested or inhaled radionuclides, terrestrial gamma doses, and the largest percentage of dose, which is from radon and its decay products. Indeed, the largest everyday anthropogenic activity causing releases of radon into the atmosphere is farming. As a result, it can be said with confidence that members of the public are exposed to radiation dose all of the time and that, depending on a person's geographic location, exposure can vary greatly.

Since the drying and packaging operations at the CPP, as well as those that will be conducted at the refurbished CPF, are conducted under vacuum, the only expected routine emission for the Smith Ranch CPP will be radon gas released from the IX columns and tanks within the buildings and minor releases from the wellfields and surge/evaporation ponds. Radon, a decay product of Ra-226, is dissolved in the lixiviant as it travels through the ore to a production well where it is brought to the surface. The concentration of radon in the production solution and estimated releases are calculated using the methods found in NRC Regulatory Guide 3.59 (NRC, 1987). The details of and assumptions used in these calculations are found in Section 7.3.3.

MILDOS-Area, a dispersion model approved by NRC, is used to model radiological impacts on human and environmental receptors (e.g. air and soil) using site specific radon release estimates, meteorological and population data, and other parameters. The estimated radiological impacts resulting from routine site activities are compared to applicable public dose limits as well as naturally occurring background levels.

MILDOS-Area modeling results for the SUA-1548 license area were included in the 2003 NRC License amendment combining SUA-1511 with SUA-1548 and incorporating the Ruth and North Butte licenses into SUA-1548. The effects of radon releases from wellfields, satellites, CPP, and ponds during production and restoration were modeled with the use of MILDOS-Area for estimating potential radiological impacts caused by air emissions. The 1997 version of the model allows comparison of specific receptor site air concentrations with the ACLs given in 10 CFR 20. The annual population doses computed by MILDOS-Area for the period of maximum emissions of radon indicated a dose of 0.3 person-rem/year from operational activities to persons living within 80 kilometers (50 miles) of the site. Nearby receptors were also assessed using MILDOS-Area. The highest radon WL at a license boundary receptor with access to an unrestricted area was 7.99E-05 WL compared to an ACL of 1.10E-03 WL. The Total Effective Dose was predicted to be 2.24 mrem/year at this receptor (downwind of the CPP).

MILDOS-Area modeling results for the Reynolds Ranch satellite were included in the 2004 NRC Amendment (SUA-1548). The effects of radon release from proposed wellfields and satellite during production and restoration were modeled. The maximum annual Total Effective Dose from the Reynolds Ranch satellite was predicted to be 4 mrem/year at the nearest occupied, downwind residence during the estimated period of maximum production activity. This dose is well below the 10 CFR 20 limit of 100 mrem/year.

MILDOS-Area modeling results for the Gas Hills Remote Satellite were documented in the PRI, Gas Hills Amendment Application for NRC Materials License SUA-1511 dated June 1998. The modeling showed that the expected Rn-222 concentrations at the site boundaries and downwind human receptors would be less than the effluent release limit in 10 CFR 20, Appendix B. The MILDOS evaluation did not include Mine Unit No. 5 because there was insufficient data available to determine whether it will contain economically recoverable reserves. Once sufficient data is available, and prior to production development in Mine Unit No. 5, a MILDOS evaluation will be performed to include the Mine Unit No. 5 area as a source location. Additional MILDOS modeling will also be completed if operational parameters such as production flow rates, for example, change from that modeled in 1998. Cameco has installed a meteorological station at Gas Hills and data obtained from this station can be utilized for future radiological modeling efforts.

MILDOS-Area modeling has not been completed for the Ruth Remote Satellite. Permit to Mine Application and U.S.N.R.C. Source Material License Application, Volume 1, Section 14 contains MILDOS modeling results only for North Butte because Uranerz would be processing the uranium loaded resin at North Butte. In any event, MILDOS-Area modeling will need to be completed at Ruth once the mine plan has been developed.

MILDOS-Area modeling was performed for the North Butte Remote Satellite in 2011 and the modeling results are discussed in subsequent sections of this TR. The effects of radon release from the proposed wellfields and satellite during production and restoration were modeled. The MILDOS-Area modeling also incorporated the radiological effects of adjacent ISR operations (Hank, Moore Ranch and Nichols Ranch) as inputs to the North Butte modeling efforts. The North Butte MILDOS report and output data are provided in **Appendix K, Radiation Doses from Cameco's North Butte Expansion Area In-situ Uranium Leaching Operations.**

With the addition of Reynolds Ranch and revised water balance, additional MILDOS-Area modeling was performed for the Smith Ranch operations and the 2011 modeling results are discussed in subsequent sections of this TR. The effects of radon release from the proposed wellfields and satellite during production and restoration were modeled. The MILDOS-Area code used weather data from the Glenrock

Coal Company which was the most representative weather data for the Smith Ranch license area at the time. A meteorological station has recently been installed at Smith Ranch, but the station has not collected enough data to be useful for the MILDOS-Area modeling. After a year's worth of data have been collected from the station, it will be evaluated to determine if the site-specific data is comparable to the regional data used in the modeling. The Smith Ranch MILDOS report and output data are provided in **Appendix L, Radiation Doses from Cameco's Smith Ranch and Reynolds Ranch In-situ Uranium Leaching Operations.**

7.3.1 Potential Exposure Pathways

There are no routine particulate emissions from the SUA-1548 licensed operations. Liquids released from the facility are treated on site to reduce the concentrations of uranium and radium to those acceptable for release to unrestricted areas as specified in 10 CFR 20 Appendix B Table 11.

The only avenue, which is considered a potentially significant radiological exposure pathway for the project, is the release of radon to the atmosphere.

As mentioned earlier, atmospheric radon is the predominant pathway for impacts on human and environmental media. Impacts of radon releases can be expected in all quadrants surrounding the facility, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, radon itself has very little radiological impact on human health or the environment. Radon has a relatively short half-life (3.8 days), and its decay products are short lived, alpha emitting, non-gaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. As **Figure 7.1, Human Exposure Pathways for Known and Potential Sources from the SUA-1548 Project** shows all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted.

The satellite facilities have pressurized downflow IX columns and RO equipment to process restoration solutions. Within the pressurized columns, the radon will remain in solution and be returned to the formation. It will not be released to the atmosphere. There will be minor releases of radon during the air blow down prior to resin transfer to the resin trailer. The air blow down and the gas released from the vent during column filling are vented to the sumps that are vented to the atmosphere. It is estimated that less than 10% of the radon contained in the process solutions will be vented to atmosphere. The remainder will remain in the groundwater.

7.3.2 Potential Exposures from Water Pathways

The solutions in the production zone aquifer are controlled and adequately monitored to ensure that migration does not occur. The overlying and underlying aquifers are also monitored.

The North Butte Remote Satellite facility will have double-lined surge ponds that will be used to store waste water, prior to deep well injection. Double-lined evaporation ponds will be constructed at the Gas Hills Remote Satellite. The surge/evaporation ponds will be double-lined with impermeable synthetic liners. There will be a leak detection system installed to provide a warning if the primary liner develops a leak so that immediate action can be taken to repair the source of the leakage before it becomes a major problem. The ponds, therefore, are not considered a source of liquid radioactive effluents.

The primary method of waste disposal at the SUA-1548 facilities is deep well injection. Land application is also utilized at Satellite No. 2 at the Smith Ranch license area. The wells are constructed under a permit from the WDEQ and meet all requirements of the EPA UIC program.

The CPP, CPF and satellite facility processing buildings are constructed on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and be pumped to the wastewater disposal circuit. The curbed pad will be of sufficient size to contain the contents of the largest tank should it rupture. Since no routine liquid discharges of process water are expected, there are no definable water related pathways. All current and future SUA-1548 satellite facilities are or will be constructed with secondary containment features. ALARA analyses of waste disposal facilities is discussed in Section 4.0.

7.3.3 Potential Exposures from Air Pathways

7.3.3.1 Source Term Estimates for MILDOS-Area Modeling

Smith Ranch

The source terms used to estimate radon releases from Smith Ranch and the Reynolds Ranch Satellite, include five wellfields at Smith Ranch, eight wells fields at Reynolds Ranch and resin transfers at the satellite buildings and CPP. The MILDOS-Area modeling assumed that all of the wellfields would operate simultaneously. Shipments of resin will be transported to Smith Ranch from off-site facilities and MILDOS-Area was utilized to estimate the radiological effects of this activity. Finally, the MILDOS-Area simulations were used to estimate the radiation effects at Smith Ranch from the operations at Reynolds Ranch and vice versa. The parameters used to characterize and estimate the radiation releases are provided in **Table 7.2, Parameters Used to Estimate and Characterize Source Terms at Smith Ranch.** These variables are used to calculate the source terms provided on page 5 of the MILDOS output reports. The MILDOS report for Smith Ranch-Reynolds Ranch is provided in **Appendix L**.

North Butte Remote Satellite

The source terms used to estimate radon releases from the North Butte Remote Satellite include three wellfields in production, one restoration wellfield, one new wellfield in development, and resin transfers at the satellite building. The radiological effects of adjacent ISR operations (Hank, Moore Ranch and Nichols Ranch) were included as inputs to the North Butte modeling efforts. The parameters used to characterize and estimate releases are provided in **Table 7.3, Parameters Used to Estimate and Characterize Source Terms at North Butte Satellite.** These variables are used to calculate the source terms provided on page 5 of the MILDOS output reports. The MILDOS report for North Butte is provided in **Appendix K**.

Production Releases

As outlined in Faillace, et al, 1997, no particulate materials are released from the production wellfield because the process streams, from production and injection wells to IX columns in the satellite facility, are in a closed-loop circuit. The primary radioactive emission from the process streams of the production wellfield is radon. In the natural environment, radon emanates continuously in the ground and migrates though the rock or soil by diffusion and convection. The primary movement of radon in groundwater is by advection, rather than diffusion. In an ISR production wellfield, the radon released from the orebody is readily removed by the process water (lixiviant) moving through the wellfield by injection and process wells. The 3.8 day half-life of radon allows it to circulate along with the process water over a fairly long period before it decays.

The general equation describing the change in radon concentration in the process water of a wellfield can be expressed as:

$$V\frac{dC_{Rn}}{dT} = fS - (L+v)VC_{Rn} - (F_p + F_{i)}C_{Rn} \quad (1)$$

where

V = volume of water in circulation (L),
C_{Rn}= Rn-222 concentration in the process water (pCi/L),
f = fraction of radon source carried by circulating water (dimensionless),
S = radon source (pCi/d),
L = decay constant of Rn-222 (0.181/d),
v = rate of radon venting from piping and valves during circulation (1/d),
F_p= purge rate of treated water (L/d), and
F_i = water discharge rate from resin unloading of IX column (L/d).

The balance of the fraction of the radon source carried by circulation water accounts for any radon in the production area that is not swept into the injection/production well loop and remains trapped in the ore zone. The purge or bleed in the production wellfield is necessary to maintain hydraulic capture of the lixiviant and prevent migration of the production fluid outside of the production zone. The MILDOS-Area modeling used the estimated purge rates provided in the water balance for each facility. An upper bound purge rate was also modeled as part of a sensitivity analysis to determine a more conservative (overestimate of the actual dose rate) estimate of the radiation dose rates.

The radon source term, S, can be expressed as

$$S = 10^6 xLE[Ra]ADP \quad (2)$$

where

10^6 = unit conversion factor (cm^3/m^3),
E = emanating power of active ore zone (dimensionless),
[Ra] = Ra-226 concentration in ore zone (pCi/g),
A = area of ore zone or (m^3),
D = average thickness of ore zone (m), and
P = bulk density of ore material (g/cm^3).

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

$$F_i = N_i V_i P_i \quad (3)$$

where

Vi = volume of IX column (L),
Ni = number of IX column unloadings per day, and
Pi = porosity of IX resin material (dimensionless).

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

$$C_{Rn} = \frac{10^6[Rn]ADPELf}{(L+v)V + F_p + F_i} \quad (4)$$

When the pressure is released during purging or during resin transfer, radon is readily released into the atmosphere. The amount of radon available for release from the purge is dependent on the water volume purge rate, F_p, and on the radon concentration in the purge liquid, C_{Rn}. By conservatively assuming that all available radon in the purge water is released, the annual radon emission is

$$Rn_w = 3.65 \times 10^{-10} C_{Rn} F_p \quad (5)$$

where

3.65×10^{-10} = unit conversion factor (Ci/pCi)(d/yr), and
Rn_w = Rn-222 release rate from purge water (Ci/yr).

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

$$Rn_v = 3.65 \times 10^{-10} C_{Rn} V \quad (6)$$

where

Rn_v is the annual radon release from venting (Ci/yr).

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

$$Rn_x = 3.65 \times 10^{-10} C_{Rn} F_i \quad (7)$$

where

Rn_x is the annual radon release of the IX column contents (Ci/yr).

The total annual release of radon from the production wellfield is the sum of Rn_w, Rn_v and Rn_x. The parameters provided in **Table 7.3** and **Table 7.2.** Equations 3 through7 were used to estimate the source term for radon emissions for production in the MILDOS-Area model.

The occurrence of radon in water is controlled by the chemical concentration of radium in the host soil or rock and the emissivity of radon into water. Radon enters air-filled pores in the soil mainly because of the recoil of radon atoms on the decay of Ra-226. The fraction of radon formed in the soil which enters the pores is called the emanating power; reported values range from about 1% to 80%, with an average of 20%, depending on soil type, pore space, and water content (Mueller Associates, Inc., 1986). Varying environmental conditions have been found to affect the rate of radon emanation. In particular, moisture has been found to have significant effects on the radon emanation rate. For purposes of conservatively estimating the radon release from ISR wellfields, the emanating power is assumed to be 0.2.

Restoration Releases

The basic operating processes of the restoration wellfield are similar to those of the production wellfield. Groundwater affected by recovery processes in the production wellfields is restored to its pre-mining levels primarily by groundwater sweep and "pump and treat" (RO treatment and reinjection). Reductants may be utilized with the reinjection stream to reduce certain elements and remove them from the groundwater in the formation. Like the production wellfield, no particulate materials are expected to be released from the restoration operations. The primary source of radioactive release is the radon in the process water circulating within and discharged from the restoration operations. The annual radon releases from the restoration wellfield therefore can be calculated by equations 5 and 6.

New Well Field Releases

Conventional rotary rigs are commonly employed for all drilling activities at the Smith Ranch SUA-1548 license areas. Because all exploration drill holes are drill sealed with high-viscosity bentonitic mud to maintain aquifer isolation, no particulates are expected to be released during drilling operations. The only source of radioactive release is the radon release from radium-containing ore cuttings temporarily stored in the mud pit until they are buried. During the period when the ore cuttings are exposed in a mud pit, radioactive decay of Ra-226 is producing radon continuously. The amount of radon available for release, or the maximum release rate, in a year as a result of Ra-226 decay from ore cuttings in storage is assumed to be given by the following expression:

$$Rn_w = 10^{-12} EL[Ra]TMN \quad (7)$$

where

Rn_w = Rn-222 release rate from the new wellfield (Ci/yr),
10^{-12} = unit conversion factor (Ci/pCi),
[Ra] = concentration of Ra-226 in ore (pCi/g),
E = emanating factor (dimensionless),
L = decay constant of Rn-222 (0.181/d),
T = storage time in mud pit (d),
M = average mass of ore material in the mud pit (g), and
N = number of mud pits generated per year.

The following data were used to determine the radon doses from new wells at Smith Ranch and the North Butte Remote Satellite:

Storage time in the pits: 12 days
Ore material in the pits: 3.5E6 g/yr
Number of pits: 12

The quantity of radon (1.05E-02 Ci/yr) released from new wellfields is much less than 1% of the radon released during wellfield production.

Radon-222 Release Summary

A summary of the estimated radon releases (Ci/yr) from the Smith Ranch and North Butte Remote Satellite license areas is provided in tables included in **Appendix L** and **Appendix K**. The estimated radon release values are also found on page 5 of the MILDOS-Area output reports.

For the modeling efforts, it was assumed that all of the radon from the Smith Ranch and North Butte Remote Satellite would be released to the environment and proportioned at:

25% of the Rn-222 will be released from the wellfield header houses; and
75% of the Rn-222 will be released from the CPP and/or satellite ventilation stack(s).

This distribution has been historically in MILDOS-Area assessments. For comparisons dose rates were also calculated using:

10% of the Rn-222 will be released from the wellfield header houses; and
90% of the Rn-222 will be released from the CPP and/or satellite ventilation stack(s).

Results of the modeling showed that dose rates at the various receptors did not change significantly. That similarity suggests that with the range of values selected for the radon-222 distributions between releases at wellfield header house s and releases at the CPP and/or satellite plants was not significant in assessing the doses to receptors.

7.3.3.2 Potential Receptors

The potential receptors used in the MILDOS-Area simulations for Smith Ranch and the North Butte Remote Satellite are presented in **Appendix L** and **Appendix K** and include the license boundaries, nearby residences and towns and cities within 80 kilometers (50 miles).

7.3.3.3 Miscellaneous Parameters

The MILDOS-Area simulations used weather data from the Antelope Coal Company weather station which was the most representative weather data for the North Butte Remote Satellite at the time. The weather data from Antelope Coal Company was collected from 1997 to 2006. A meteorological station has been recently installed at North Butte, but the station has not collected enough data to be useful for the MILDOS-Area modeling. After a year's worth of data have been collected from the station, it will be evaluated to determine if the site-specific data is comparable to the regional data used in the modeling.

The MILDOS-Area simulations for Smith Ranch used weather data (1995-2009) from the Glenrock Coal Company. The Glenrock Coal Company ceased operations in circa 2000, but metrological data were collected at the site until December 2009. As with North Butte, a meteorological station has been recently installed at Smith Ranch, but again the station has not collected enough data to be useful for the MILDOS-Area modeling.

The population distribution used in the MILDOS-Area model to estimate population doses is from the demographic information presented in Sections 2.2.3 and 2.3.3 of this TR and Section 3.10 of the ER.

7.3.3.4 Total Effective Dose Equivalent to Individual Receptors

Smith Ranch – Reynolds Ranch Radon-222 Release Summary

The calculated TEDE at the license boundaries, nearest receptors and cities and towns within an 80 kilometers (50 mile) radius of Smith Ranch are summarized in **Table 7-4, Estimated Total Effective Dose Equivalent to Receptors within 80 kilometers of Smith Ranch.** The highest license boundary dose was 4.8 mrem/year at the north boundary. The dose rate at the nearest occupied residence (Sunquest Ranch) was 39.5 mrem/year. The highest dose rate at towns and cities within an 80 kilometers (50 mile) radius from Smith Ranch was 0.6 mrem/year at Glenrock and Douglas. **Table 7-4** also provides the TEDE at the various receptors for a different radon-222 distribution (10% mine/90% satellite).

Table 7-5, Estimated Total Effective Dose Equivalents to Receptors within 80 kilometers of Reynolds Ranch provides a summary of the dose rates for operations at the Reynolds Ranch Satellite with the different radon-222 distribution and an upper bound purge rate. The highest license boundary dose was 24.8 mrem/year at the east boundary. The dose rate at the nearest occupied residence (Duck Creek Ranch) was 3.9 mrem/year. The highest dose rate at towns and cities within a 80 kilometers (50 mile) radius from Reynolds Ranch was 0.8 mrem/year at Wright.

In all cases for the MILDOS-Area simulations, the annual dose limit (100 mrem/year) found in 10 CFR 20.1301 was not exceeded for individuals likely to receive the highest dose from operations at Smith Ranch and the Reynolds Ranch Satellite. The radiation dose rates were less than 5 mrem/year for IX resin shipments to Smith Ranch, radiation from Reynolds Ranch operations on Smith Ranch and radiation from Smith Ranch operations on Reynolds Ranch.

North Butte Remote Satellite Radon-222 Release Summary

The calculated TEDE at the license boundaries, nearest receptors and cities and towns within an 80 kilometers (50 mile) radius of the North Butte Remote Satellite are summarized in **Table 7-6, Estimated Total Effective Dose Equivalent to Receptors within 80 kilometers of the North Butte Remote Satellite**. The highest license boundary dose was 45.0 mrem/year at the east boundary. The dose rate at the nearest occupied residence (Pfister Ranch) was 10.0 mrem/year. The highest dose rate at towns and cities within an 80 kilometer (50 mile) radius from North Butte was 0.4 mrem/year at Wright. For comparison, natural occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mrem/year. **Table 7-6** also provides the TEDE at the various receptors for a different radon-222 distribution (10% mine/90% satellite) and for an upper bounds purge rate. In all cases, the annual dose limit (100 mrem/year) found in 10 CFR 20.1301 was not exceeded for individuals likely to receive the highest dose from operations at the North Butte Remote Satellite. The inclusion of the nearby Hank Unit, Moore Ranch, Nichols Ranch and the agricultural pathway each contributed less than 0.2 mrem/year to the calculated doses at the North Butte Remote Satellite.

7.3.3.5 Population Dose

The annual population dose commitment to the population in the region within 80 kilometers (50 miles) of the North Butte Remote Satellite and Smith Ranch and the Reynolds Ranch Satellite is also predicted by the MILDOS-Area code. The population effective dose rate within 80 kilometer (50 mile) radius of the North Butte Remote Satellite was 1.3 person-rem/year and 0 person-rem/year beyond 80 kilometers (50 miles). The population effective dose rate within an 80 kilometer radius from Smith Ranch and Reynolds Ranch was 2.3 and 2.5 person-rem/year, respectively.

7.3.3.6 Potential Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions, and accidental spills of wellfield fluids (e.g., lixiviant).

Radon Releases

Radon emissions at satellite facilities that do not process yellowcake slurry or involve drying and packaging are considered the primary air contaminant during operations. Radon emissions during normal operations are considered the most important pathway for exposure to flora and fauna due to deposition of radon decay products on surface water, surface soils and vegetation. The MILDOS-Area model provides an estimate of surface deposition rate as a function of distance from the source for the radon decay products and calculates surface concentrations.

The potential exists for individual fauna (e.g., small mammals and birds) that are mobile to have contact with higher, but short-term, contact with concentrations of radon than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that individuals would receive an intermittent exposure, as opposed to a constant concentration for the entire year.

Fluid Discharges

There are currently no planned surface discharges from any SUA-1548 licensed facilities except for the Smith Ranch Satellite 2 Land Application facility. The primary disposal method for facility waste waters is via Class I deep disposal wells or evaporation ponds (Gas Hills). Therefore, any fluid discharges would be associated with spills, e.g., pipeline breaks or leaks. Spills of this type would be expected to occur within the restricted mine unit wellfield areas and between the wellfields and satellite process facility. Satellite processing buildings, fuel tanks, and chemical tanks are constructed on pads that are engineered to contain any spill from a pipe rupture, leaking vessel or inadvertent spill. Therefore, it is unlikely that any spills in the processing area would reach soils and vegetation. Cameco operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to any spill, which would result in cleanup of the spilled material and, if applicable, removal of any contaminated soil and vegetation.

Long-term experience at Smith Ranch has shown that single-event spills typically do not cause significant contamination of soil and vegetation. There is limited potential for wildlife or domestic animals to consume contaminated vegetation or seeds. Other than the potential for accidental spills discussed above which would be immediately assessed and cleaned up, the satellite facilities would not be expected to significantly impact food source such as vegetation and seeds that local animals depend upon.

7.4 Potential Non-radiological Effects

7.4.1 Potential Non-radioactive Airborne Effluents

An ISR facility by design is a self-contained circuit. Wastes generated by the facility are contained and eventually removed for disposal elsewhere. There has not been in the past nor is it anticipated that there will be a significant environmental impact from the non-radioactive airborne effluent releases in the future. Non-radioactive airborne effluents at the SUA-1548 license areas are limited to fugitive dust from access roads and mine unit activities and non-radioactive particulate emissions from the CPP yellowcake dryer and packaging room scrubber system. The emissions from the CPP are permitted under WDEQ AQD Permit No. OP-202.

Fugitive dust emissions will be minimal and dust suppressants will only be used if conditions warrant their use. When operational, WDEQ AQD Permit No. OP-202 requires particulate emission testing of the yellowcake dryer (which is fueled with natural gas) and yellowcake packaging room scrubber exhaust stacks annually. Currently (January 2012) the Highland CPF is not operational. However, two rotary vacuum dryers will be installed at the CPF once the facility is refurbished and emissions from the CPF will be similar to the Smith Ranch CPP. The monitoring programs discussed in Section 5.10 are designed to quickly identify any adverse conditions that may result during operations. No long-term irreversible effects have been identified and none are anticipated during the next renewal period.

7.4.2 Non-Radioactive Liquid Effluents

There have not been any non-radioactive liquid effluents discharged to the environment during the operation of the SUA-1548 license since the last renewal. Section 3.10 presents mitigation measures that have been implemented to reduce the potential for discharges during the next renewal period.

7.5 Potential Effects of Accidents

Accidents involving human safety associated with ISR facilities typically have far less severe consequences than accidents associated with underground and open pit mining methods. ISR provides a higher level of safety for employees and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be considered minor when compared to other industries. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the SUA-1548 licensed facilities and the low level of radioactivity associated with the process, combine to decrease the potential hazard of an accident that would jeopardize the general public.

NRC has previously evaluated the effects of accidents at conventional uranium milling facilities in NUREG 0706 and specifically at ISR uranium facilities in NUREG/CR-6733. These analyses demonstrate that, for most potential accidents, consequences are minor as long as effective emergency procedures and properly trained personnel are utilized. The SUA-1548 licensed facilities are consistent with the operating assumptions, site features, and designs examined in the NRC analyses in NUREG/CR-6733. Cameco has developed emergency management procedures to implement the recommendations contained in the NRC analyses. Training programs have been developed and implemented to ensure that Cameco personnel are adequately trained to respond to all potential emergencies. These training programs are discussed in Section 5.5.

NUREG 0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG 0706 are applicable to ISR facilities, such as transportation accidents. NUREG/CR-6733 specifically addressed risks at ISR facilities and identified the "risk insights" that are discussed in the following sections.

7.5.1 Potential Accidents Involving Radioactivity

7.5.1.1 Tank or Vessel Failure

A spill of materials contained in the process tanks at ISR facilities present a minimal radiological risk. Process fluids are contained in vessels and piping circuits within the processing buildings. Oxygen, hydrogen peroxide, carbon dioxide, propane and fuel are stored in outside storage tanks that are bermed or curbed to contain potential leaks. The satellite facilities are designed to control and confine liquid spills from tanks, should they occur. The facility building structures and concrete curbs are designed to contain the liquid spills from leakage or rupture of a process vessel and direct any spilled solution to a floor sump. The floor sump system directs any spilled solutions back into the facility process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for process vessels located outside the building. Consequently, any such accident would be of short duration and the remedial procedure is incorporated into the process plant design.

All tanks are constructed of fiberglass or steel. Instantaneous failure of a tank is highly unlikely. Tank failure would be more likely to occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

7.5.1.2 Potential Pipe Failure

Rupture of a pipe within the CPP or satellites can be easily detected by operating staff and can be quickly controlled and repaired. Spilled solution will be contained and managed in the same fashion as for a tank failure.

7.5.1.3 Potential Well Field Spill

The rupture of an injection or recovery line in a mine unit wellfield, or a trunkline between a wellfield and satellite or CPP, would result in a release of injection or production solution which would impact the ground in the area of the break. All piping from the CPP or satellite, to and within a wellfield is buried for frost protection. Pipelines are constructed of HDPE with butt welded joints. All pipelines are pressure tested with water at operating pressures prior to final burial and production flow, and following maintenance activities that may affect the integrity of the system.

Each mine unit wellfield has several header houses where injection and production wells are continuously monitored for pressure and flow. Individual wells have set high and low flow alarm limits. All monitored parameters and alarms are observed in the satellite control room via a computer system. In addition, each new header house has a "wet building" alarm to detect the presence of any liquids in the building basement. High and low flow alarms have been proven effective in the detection of significant piping failures (e.g., failed fusion weld). A discussion of the construction and leak detection features at new header houses is provided in Section 3.6.

Occasionally, small leaks at pipe joints and fittings in the header houses, bellholes or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. Cameco has implemented a program of continuous wellfield monitoring by roving wellfield operators and periodic inspections of each well that is in service. Small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in impacts. Following repair of a leak, Cameco requires that any affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Affected soil may be removed as appropriate.

7.5.1.4 Potential Lined Pond Failure

Smith Ranch utilizes two lined holding ponds. Additionally, two surge ponds are proposed for the North Butte Remote Satellite. Initially, two evaporation ponds will be installed at the Gas Hills Remote Satellite. Leakage from the ponds could potentially impact soil and groundwater. Existing ponds at Smith Ranch are routinely monitored for leakage. As stated earlier, the ponds to be built at the North Butte and Gas Hills Remote Satellites will be double lined and will have a leak detection system designed to detect any potential leaks before they impact the environment.

The ponds' leak detection system will consist of a network of perforated pipes in a permeable granular layer beneath the primary liner with the pipes draining to a collection sump. Should a leak in the liner occur, the water will flow through the permeable layer between the two liner systems, enter a perforated pipe and flow to a sump. The monitoring program for the lined ponds will include either a fluid level sensor in each pond sump with an alarm displayed at the satellite or a daily inspection of each sump by an operator. The ponds will also be inspected daily for visual indications of leaks, liner damage, or embankment deterioration due to erosion, slumps or other defects by an individual instructed in proper inspection procedures. The daily pond inspections will be recorded and initialed by the inspector. The environmental monitoring program associated with the leak detection system is discussed in Section 5.10.

7.5.1.5 Potential Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the mining zone of the orebody aquifer. A vertical excursion is a movement of solutions into overlying or underlying aquifers. In the event that an excursion does occur and is accidentally undetected, concentrations of metals such as uranium, selenium, arsenic, selenium and Ra-226 are likely to be low due to natural precipitation and adsorption onto clays. This phenomenon occurs because the metals, which are mobilized in the oxidized environment of the production area, are selectively removed from solution via precipitation and adsorption as they move into the reduced environment outside of the oxidized production area. Should an excursion occur, the excursion correction procedures outlined in Section 3.10.2 will be undertaken. Environmental monitoring to detect a lixiviant excursion is provided in Section 5.10.

Pre-ISR hydraulic testing of existing wellfield areas at the SUA-1548 license areas has defined the aquifer characteristics for the receiving strata or production zone at the site. The ore-bearing strata is physically and hydraulically separate from overlying and underlying aquifers. The well completion procedures used and the mechanical integrity testing for each injection well performed prior to leach solution injection ensure that injected solutions are contained within the wellfield. The monitoring program for overlying and underlying aquifers is a redundant check to ensure that the injection is controlled. Should an excursion occur, the excursion correction procedures outlined in Section 3.10.2 will be instituted immediately.

Cameco controls the lateral movement of lixiviant by maintaining wellfield production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution will either be recycled in the plant or sent to the liquid waste disposal system. When process bleed is properly distributed among the many patterns within the wellfield, the lixiviant is contained within the monitor well ring.

Cameco monitors for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. Monitor wells are installed as discussed in Section 3.5. Monitor wells are sampled twice each month for approved excursion indicators.

The historical experience at Smith Ranch and other ISR uranium operations indicates that the selected indicator parameters and UCL allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. Cameco prevents vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the LQD for review prior to initiating mine unit wellfield operations. Well construction and integrity testing is conducted in accordance with LQD regulations and methods approved by NRC, EPA and LQD. Construction and integrity testing methods have been discussed in detail in Section 3.5.2. Well abandonment is conducted in accordance with methods approved and monitored by the LQD and are discussed in detail in Section 3.3.2.

Cameco monitors for vertical excursions in the overlying aquifer using overlying and, where necessary, underlying aquifer monitor wells. These wells are located within the mine unit wellfield boundary at a density of one well per 16 hectares (4 acres). These monitor wells are sampled twice each month for approved excursion indicators.

Excursion parameter UCL for all aquifers are extremely close to baseline concentrations so that the slightest perturbation in water quality is detected and precautionary measures are taken. Because of the chemically conservative nature of the excursion parameters used, it would be extremely unlikely that at the time excursion correction procedures are instituted, any chemical parameter other than the excursion indicators will be different from baseline values. As such, no radiological groundwater degradation should result when a well is in excursion status.

In the event that an excursion does occur and is accidentally undetected, concentrations of metals such as uranium, arsenic, selenium and Ra-226 are likely to be low due to natural precipitation and adsorption onto clays. This phenomenon occurs because the metals, which are mobilized in the oxidized environment of the production zone, are selectively removed from solution via precipitation or adsorption as they move into the reduced environment outside of the production zone.

7.5.2 Potential Transportation Accidents

The potential transportation impacts associated with the transport of yellowcake, yellowcake slurry, and uranium-laden resins from ISR operations have previously been assessed by NRC. The NRC has assessed the transport of dried and packaged yellowcake from conventional uranium mills and has reviewed the proposed transportation of yellowcake and uranium-loaded IX resins from central processing facilities in a variety of license applications for new conventional or ISR uranium recovery facilities and license amendment applications for new satellite wellfields from existing licensees. Furthermore, during the review of PRI's license amendment request for the Gas Hills satellite facility, the NRC staff evaluated the impacts of shipping IX resin from the Gas Hills Remote Satellite to and from the Smith Ranch CPP (NRC, 2004). The EA identified that since the amount of traffic generated from shipping the IX resin to Smith Ranch would be minor compared to the overall traffic volume along the transportation route, it would not be expected to significantly contribute to congestion or accident rates along those roadways. These analyses have demonstrated that the transport of such materials does not pose a significant threat to public health and safety or the environment.

Because loaded IX resins, yellowcake slurry or yellowcake is transported off-site from a satellite or the CPP or CPF, transportation safety must be addressed. If the product is dried yellowcake, the drums are transferred to a truck trailer by a fork lift, and the shipment is sealed and treated as a dedicated shipment. If the product is yellowcake slurry or loaded IX resin, it is to be transferred into a designated tanker truck and transported from the satellite to either the CPP or CPF for further processing. At a hypothetical production rate of 40 metric tons (1 million pounds) per year, up to 50 shipments of yellowcake or up to 1,000 shipments of resin could be transported off site each year. In most cases, after leaving the satellite, CPP or CPF, transportation typically is on unpaved roads initially in remote locations and on paved roads later in the shipment. In some cases, unpaved roads may be used for transport from a satellite to the CPP or CPF. By-pass routes are used to the extent practicable so that these shipments do not pass through population centers. All transport conveyances carrying IX resin, yellowcake slurry or dried yellowcake are required to carry the appropriate certifications, and all drivers are required to hold appropriate licenses. DOT training requirements are provided in Section 5.6.

7.5.2.1 Potential Accidents Involving Resin or Yellowcake Slurry Shipments

Resin is transported from the existing Smith Ranch satellites to the CPP using specially designed sole use transport trailers on existing roads within the license area. Resin from the Reynolds Ranch satellite will be transported a short distance on County Road 31 (Ross Road). Resin will also be transported from the North Butte Remote Satellite, Gas Hills Remote Satellite, and Ruth Remote Satellite to the refurbished Highland CPF. Yellowcake slurry will also be transported from Gas Hills to the Highland CPF. Furthermore, Cameco has NRC approval to process third-party resin and yellowcake slurry at the Smith Ranch CPP and Highland CPF.

One of the potential additional risks associated with the operation of satellite facilities is the transfer of IX resin to and from the satellite facilities. Resin will be transported to and from the satellite facility in a 15,120 liter (4,000 gallon) capacity tanker trailer. It is currently anticipated that one load of uranium-loaded resin will be transported from the North Butte Remote Satellite to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility on a daily basis. Both IX resin and yellowcake slurry will be transported from the Gas Hills Remote Satellite to the CPF.

Cameco has developed comprehensive transportation plans for the Smith Ranch, North Butte Remote Satellite and Gas Hills Remote Satellite. A transportation plan will be developed for the Ruth Remote Satellite once the plans for the development of this satellite have further progressed. Within these traffic plans are the proposed transportation routes for resin and yellowcake slurry (Gas Hills) and estimated number of trips based on the anticipated production rates for each facility.

Resin shipments are treated similarly to yellowcake shipments with regards to DOT and NRC regulations. Materials will be handled as LSA-1 (Low Specific Activity) shipments for both uranium-loaded and barren eluted resin. Pertinent procedures include:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond placards.
- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified will be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index and the package identification number.
- Before each shipment of loaded or eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.
- Licensed and trained Cameco drivers will transport the resin between the satellite facilities and the CPP/CPF.
- Cameco's current emergency response plan for yellowcake and other transportation accidents to or from the yellowcake processing facilities is contained in the SHEQMS Volume VIII, *Emergency Manual*. This plan is being revised to include an emergency resin transfer accident procedure. Personnel at the satellite facilities and the CPP/CPF have received training for responding to a resin transfer transportation accident.

For transportation purposes, Cameco treats the eluted resin the same as the uranium loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC regulations will be the primary determining factor.

The worst case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium loaded resin where the entire tanker contents have been spilled. Because the uranium is ionically-bonded to the resin and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, Cameco will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each resin hauling truck is equipped with a radio or cell phone which can communicate with either the CPP, CPF or the satellite facilities. In the event of an accident and spill, the driver can use the radio or cell phone to summon help.
- A check-in and check-out procedure has been implemented where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system assures reasonably quick response time in the case that the driver is incapacitated in the accident.
- Each resin transport vehicle is equipped with an emergency spill kit which the driver can use to begin containment of any spilled material.
- Both the satellite and CPP/CPF facilities are equipped with emergency response packages to quickly respond to a transportation accident.

NRC staff in 2009 evaluated the risk of transportation accidents related to shipments of third-party IX resin to the Smith Ranch CPP (NRC, 2009). Additionally, NRC staff previously evaluated IX resin transportation risks during their review of amendment requests to add Gas Hills, SR-2 and Reynolds Ranch satellite facilities to the SUA-1548 license (NRC, 2004, 2007a, 2007b). NRC staff concluded that if an accident causes the release of resin and entrained water, all IX resin, liquids and impacted soil would be removed from the spill site and processed through the elution circuit or disposed of at a NRC licensed disposal facility. All disturbed areas would then be reclaimed in accordance with applicable state and NRC regulations. NRC staff also determined that there would be no risk of airborne release of uranium as it remains ionically fixed to the resin (NRC, 2009).

Personnel at the satellites and CPP/CPF as well as the designated truck drivers have specialized training to handle an emergency response to a transportation accident.

7.5.2.2 Potential Accidents Involving Yellowcake Shipments

NUREG 0706 concluded that the probability of a truck accident involving shipments of yellowcake in any year is 11% for each uranium extraction facility. This calculation used average accident probabilities (4.0 x 10^{-7}/kilometer for rural interstate, 1.4 x 10^{-6}/kilometer for rural two-lane road, and 1.4 x 10^{-6}/kilometer for urban interstate) that NUREG/CR-6733 determined were conservative. The DOT reported that in 2007 only 8 out of 17,000 hazardous material transportation accidents involved radioactive material.

As with resin shipments, yellowcake slurry or dried product shipments are made in accordance with DOT and NRC regulations. Shipments are handled as LSA material and follow the same general shipping procedures as outlined for IX resin shipments in Section 7.5.2.1. The shipments meet the minimum packaging (Type IP-1 Industrial Packages) and labeling requirements for the transport of radioactive materials. Standard steel drums meet IP-1 requirements. Labeling requirements are as provided in NRC regulations at 10 CFR Part 71 which are compatible with the internationally accepted International Atomic Energy Agency TS-R-1 transport regulations.

The worst case accident scenario involving yellowcake transportation would be an accident involving the transport truck where the integrity of one or more drums containing yellowcake was breached, resulting in a release to the environment. Unlike IX resin shipments, ISR operators do not typically transport their own dried yellowcake to conversion facilities, but rather contract with transport companies that specialize in shipments of yellowcake. These companies have extensive emergency response programs including spill response equipment on board, drivers trained in radiological emergency response, constant monitoring of truck location and operating parameters, and standing contracts with environmental emergency response contractors for cleanup of spills. As with IX resin, the primary environmental impact associated with an accident involving the spill of yellowcake would be the salvage of soils impacted by the spill and the subsequent damage to the topsoil and vegetation structure.

NRC has approved the shipment of yellowcake slurry from the SUA-1548 satellites to the CPP. Currently, Cameco only plans to produce slurry from the Gas Hills Remote Satellite. The impacts of an accident involving yellowcake slurry would not be different from dried yellowcake, with the exception that the contained water in the slurry would prevent windblown contamination of nearby soils and vegetation. Response and cleanup would be the same as described above for resin or dried yellowcake. In their 25 years of operating experience, Cameco has never have experienced an accident involving a yellowcake shipment.

7.5.2.3 Potential Accidents Involving Shipments of Process Chemicals

Potential accidents involving truck shipments of process chemicals to the Smith Ranch SUA-1548 facilities could result in a local environmental impact. Any spills would be removed and the area would be cleaned and reclaimed. Shipments of the chemicals used in ISR processing in truck load quantities are common to many industries and present no abnormal risk. These chemicals include dry solid sodium carbonate, liquid carbon dioxide, liquid oxygen, concentrated sulfuric acid, hydrochloric acid liquid (50%), hydrogen peroxide, sodium hydroxide, and dry solid sodium chloride (salt). The production of yellowcake slurry at the Gas Hill Remote Satellite will increase the number of process chemical shipments to the facility, but will reduce the number of resin shipments to Smith Ranch. Since most of the spilled material would be recovered or removed, no significant long-term environmental impacts are anticipated from a shipping accident involving these materials.

7.5.2.4 Potential Accidents Involving Shipments of 11e.(2) Byproduct Material

Low level radioactive 11e.(2) byproduct material or unusable contaminated equipment generated during operations will be transported to an NRC-licensed disposal site as needed and at the time of decommissioning. Because of the low levels of radioactive concentrations involved, these infrequent shipments are considered to have minimal potential impact in the event of an accident. The effects of an accident involving the transportation of such wastes will be mitigated by the emergency response plan for transportation accidents.

7.5.3 Potential Natural Disaster Risk

NUREG/CR-6733 considered the potential risks to an ISL facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities, and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. Cameco is committed to following these standards.

The ISR project areas in the Powder River Basin are in seismic risk Zone 1. The Gas Hills Mining district is located in the south-central portion of the Wind River Basin. Historically, central Wyoming has had a moderate level of seismic activity compared to the rest of the state. The Gas Hills Remote Satellite is in seismic risk Zone 1. The Gas Hills area is the most seismically active of all of the Smith Ranch SUA-1548 license areas and earthquakes have been reported south, northwest and northeast of Jeffery City, (Reagor, et al, 1985). In 1975, a non-damaging magnitude 3.5 earthquake was reported approximately 40 kilometer(25 miles) north of Jeffery City, which places the earthquake within 16 kilometer(10 miles) of the Gas Hills Remote Satellite area. Three active exposed faults in the Wind River Basin and Gas Hills project area have been documented (NRC, 2004). Most of the central United States is within seismic risk

Zone 1 and only minor damage is expected from earthquakes that occur within this area. Seismology is discussed in detail in Sections 2.2.6, 2.3.6, 2.4.6, and 2.5.6, and Section 3.3.3 of the ER. When applicable, Cameco will utilize seismic building codes in the design of their ISR structures.

According to the Wyoming Climate Atlas, the State of Wyoming ranks 25th in the number of annual tornadoes (10), 33rd in fatalities (six deaths per million people), 37th in injuries, and 36th in property damage ($49,339,505) in the US from 1950 to 1994 (excerpted from the Wyoming Climate Atlas). The occurrence of severe weather for the SUA-1548 license areas is provided in Section 3.6.1.5 of the ER.

The NRC, in NUREG/CR-6733 concluded that the risk from tornadoes is very low at uranium ISR facilities, and that no design changes are necessary to mitigate the risk. One recommendation was to locate chemical storage tanks sufficiently far apart that potential leaks caused by tornado damage would not result in reactions between different chemicals mixing together. Cameco has procedures and provides instructions to operating personnel for response and mitigation of natural disasters and any associated spills of radioactive and chemical materials. Emergency response procedures will include:

- Notification of personnel of potential severe weather;
- Evacuation procedures;
- Damage inspection and reporting; and
- Cleanup and mitigation of chemical or radioactive material spills.

7.5.4 Potential Range Fire Risk

The following is Cameco's procedure for addressing a potential range fire at the Smith Ranch SUA-1548 license areas. This text is reflected in Cameco's Emergency Preparedness and Response Program – Volume III – Emergency Procedures Manual, Section 3; Fires and Explosions. This policy is the standard program for SUA-1548 operations, and will be extended to address the specifics of the remote satellites at North Butte, Gas Hills, and Ruth.

If a grass fire occurs in the immediate vicinity of the CPP, CPF or satellite buildings, management will be immediately notified. The Incident Commander will make a general announcement over the radio and telephone intercom warning employees of the location and nature of the range fire. The Incident Commander will then proceed to the area of the range fire and assess the situation.

A range fire near the CPP, CPF, satellites or the fuel storage area(s) may involve hazardous chemicals and/or radioactive materials. Before attempting to fight a fire, responding personnel must ascertain the location and size of the fire and determine the likelihood of involvement of chemicals or radioactive materials. If these materials may be involved, personnel MUST evacuate the area and consult the instructions for responding to fires in the Chemical Emergency Response Guide in Chapter 11.

Upon assessing the situation, the Incident Commander will determine the appropriate response (i.e., call 911, send employees to fight fire, provide the necessary firefighting equipment, possible site evacuation, etc.). During off-shift hours, the Lead Plant Operator will ensure that senior management is contacted and, if necessary, that 911 is called. During off-shift hours, the Lead Plant Operator is responsible for making all decisions until management arrives or the Lead Plant Operator is otherwise instructed by management.

The Incident Commander will maintain radio or visual contact with all employees fighting the fire and will keep the main office appraised of the situation. Range fires must be fought in teams of at least two and from the upwind side of the fire.

Equipment will only be operated by those individuals task trained in the operation of those particular pieces of equipment. The Incident Commander or his designee will make the determination as to which Smith Ranch personnel will remain on duty at the sites and who is available to assist the first responders (volunteer fire department) with firefighting activities, if requested.

7.5.5 Potential Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. The use of hazardous chemicals at Smith Ranch is regulated by OSHA.

Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none are used at the SUA-1548 facilities. The satellite facilities use oxygen, carbon dioxide, and sodium bicarbonate for addition to the injection solution. Sodium sulfide may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the CPP and/or the CPF.

The SUA-1548 license areas construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

7.5.5.1 Oxygen

Oxygen presents a substantial fire and explosion hazard. The design and installation of the oxygen storage facility is typically performed by the oxygen supplier and meets applicable industry standards. The oxygen is delivered to Smith Ranch SUA-1548 licensed facilities by truck and stored on site under pressure in a cryogenic tank in liquid form. The oxygen is added to the barren lixiviant upstream of the injection manifold. The design and installation of underground and above-ground gaseous oxygen piping, including material specifications, velocity restrictions, location and specifications for valves, and design specifications for metering stations and filters are in accordance with industry standards contained in Compressed Gas Association (CGA) G-4.4. Header houses will be equipped with an exhaust ventilation system.

Combustibles such as oil and grease will burn in oxygen if ignited. Cameco contractors and personnel ensure that all oxygen service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1. Cameco has developed and implemented emergency response procedures for a spill or fire involving oxygen systems.

7.5.5.2 Carbon Dioxide

The primary hazard associated with the use of carbon dioxide is concentration in confined spaces, presenting an asphyxiation hazard. Bulk carbon dioxide facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and carbon dioxide monitoring at low points is performed to protect workers from undetected leaks of carbon dioxide within the CPP.

7.5.5.3 Sodium Carbonate and Sodium Chloride

Sodium carbonate and sodium chloride are primarily inhalation hazards. Soda ash and carbon dioxide will be used to prepare sodium carbonate for injection in the mine unit wellfields. Sodium carbonate and sodium chloride are also used for regeneration of IX resin. Dry storage and handling systems will be designed to industry standards to control the discharge of dry material.

7.5.5.4 Sodium Sulfide

Sodium sulfide may be used as a reductant during groundwater restoration. Sodium sulfide is corrosive and will cause severe eye and skin bums. Routes of entry into the body include inhalation, ingestion, and contact with the skin. Under low pH conditions, sodium sulfide can react with water to liberate hydrogen sulfide gas. Sodium sulfide can be flammable and contact with heat, flame, or other sources of ignition is avoided. Sodium sulfide will be stored separately from hydrogen peroxide and sulfuric acid.

7.5.5.5 Sodium Hydroxide

Sodium hydroxide, also known as caustic soda or lye, is used to adjust the pH in the yellowcake precipitation circuit. Solid sodium hydroxide or solutions of sodium hydroxide may cause chemical burns, permanent injury or scarring if it contacts unprotected human skin. It may cause blindness if it contacts the eye. Protective equipment such as rubber gloves, safety clothing and eye protection are always used when handling the material or its solutions. Dissolution of sodium hydroxide is highly exothermic, and the resulting heat may cause heat burns or ignite flammables. It also produces heat when reacted with acids. Sodium hydroxide is corrosive to some metals, e.g. aluminum, which produces flammable hydrogen gas on contact. Sodium hydroxide is also mildly corrosive to glass, which can cause damage to glazing or freezing of ground glass joints. Sodium hydroxide is stored separately from hydrogen peroxide and sulfuric acid.

7.5.5.6 Hydrogen Peroxide

Hydrogen peroxide is one of the reagents used in the precipitation phase at SUA-1548 licensed facilities. Hydrogen peroxide has replaced anhydrous ammonia as a precipitant. A 50% solution of hydrogen peroxide is added to the acidified uranium-rich eluant to form an insoluble uranyl peroxide compound. Hydrogen peroxide is a strong oxidizer and is a reactive, easily decomposable compound. Its hazardous decomposition products include oxygen and hydrogen gas, heat, and steam. Decomposition can be caused by mechanical shock, incompatible materials including alkalies, light, ignition sources, excess heat, combustible materials, strong oxidants, rust, dust, and a pH above 4.0. When sealed in strong containers, the decomposition of hydrogen peroxide can cause excessive pressure to build up which may then cause the container to burst explosively.

As noted in NUREG/CR-6733, a hydrogen peroxide piping system leak in a process building has the potential to result in localized vapor concentrations in excess of the immediately dangerous to life or health value of 75 ppm within several minutes. A leak in a confined space has the potential to generate lethal concentrations of vapor at an even faster rate. Cameco has incorporated recommendations concerning materials of construction for tanks and piping systems and the use of local ventilation with explosion-proof fans to control vapors in the event of a leak of hydrogen peroxide.

The use of hydrogen peroxide at concentrations greater than 52% is subject to the following regulatory programs:

- Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119 for threshold quantities in excess of 3,400 kilograms (7,500 pounds); and
- Threshold Planning Quantities contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities in excess of 450 kilograms (1,000 pounds).

The SUA-1548 licensed operations include the use of hydrogen peroxide at a concentration of 50% contained in a hydrogen peroxide tank with a capacity of 23,000 liters (6,000 gallons). With the design hydrogen peroxide concentration and capacity, Cameco is not subject to the aforementioned regulatory programs.

7.5.5.7 Sulfuric Acid

Sulfuric acid is used to remove carbon dioxide gas from the rich eluate in preparation for precipitation with hydrogen peroxide or ammonia. The sulfuric acid is stored in a tank located outside the building and piped to the precipitation circuit. The concentration of sulfuric acid fumes that are immediately dangerous to life and health is 15 mg/m^3. In the risk analysis from NUREG/CR-6733, a spill of 93% sulfuric acid was not deemed a significant inhalation hazard to workers as long as normal air dilution is available from the facility ventilation system. NUREG/CR-6733 also noted that sulfuric acid reacts vigorously with ammonia, sodium carbonate, and water, all of which are present at the Smith Ranch CPP/CPF. To minimize the potential for chemical reactions in the unlikely event of simultaneous tank leaks, the sulfuric acid storage tank is located away from other process tanks.

The use of sulfuric acid is subject to threshold planning quantities contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities in excess of 450 kilograms (1,000 pounds). The Smith Ranch operations currently include a sulfuric acid tank with a capacity of 23,000 liters (6,000 gallons). Based on the design capacity, Cameco is subject to the Emergency Response Plan requirements.

7.5.6 Potential Accident Risks Associated with Coal Bed Methane Development

The presence of CBM development at the North Butte and Ruth Remote Satellite license areas presents potential accident risks not commonly associated with uranium ISR, including increased risks of methane seepage, explosions and/or fires.

7.5.6.1 Methane Migration and Seepage

Methane gas can reach the surface by naturally occurring seepage along fault lines, fractures, or sandstone layers in areas where coal beds are shallow. Gas migration could also be enhanced during CBM development in areas along a coal outcrop, which are not present on the North Butte or Ruth Remote Satellite license areas. Non-CBM wells that penetrate the coal seam may provide pathways for migration of methane if the casings or plugs are inadequate or faulty or lack isolation through the coal horizons.

The potential for migration of methane in CBM wells is minimized or prevented by the use of the current CBM industry standards for cementing and casing wells that isolate or protect all zones from gas or fluid migration.

Risks from methane associated with oil and gas wells, including CBM wells, are controlled through BLM-mandated conditions of approval for the Application for Permit to Drill that address well conditions, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans. In addition, CBM operators must have emergency plans and employee training programs that address fire prevention and control measures.

7.5.6.2 Potential CBM Pipeline Ruptures

CBM development involves the potential for leaks or ruptures of buried gas pipelines. Most ruptures occur when heavy equipment accidentally strikes the pipeline while operating in close proximity. These ruptures may result in a fire or explosion if a spark or open flame ignites the escaping gas.

The CBM operators monitor the pipeline flows by either remote sensors or daily inspections of flow meters. Routine monitoring reduces the probability of effects to health and safety from ruptures by facilitating the prompt detection of leaks. If pressure losses are detected, the wells are shut in until the problem is isolated and addressed.

Materials used in the pipelines are designed and selected in accordance with applicable standards to minimize the potential for a leak or rupture. Pipeline markers are posted at frequent intervals along the pipelines to warn excavators and to reduce the risk of accidental rupture from excavating equipment. Cameco will work with the CBM operator located on the license areas to ensure that all gas collection and transmission lines within proposed development areas are adequately marked to prevent accidental rupture by ISR activities.

7.6 Potential Population, Social and Economic Effects

The potential population, social and economic impacts of operations is discussed in Sections 3.10 and 7.0 of the ER. The SUA-1548 license areas are located in rural remote areas and the potential population and social effects with the continued operation of Smith Ranch and the construction of Reynolds Ranch and the remote satellites will be minimal. In contrast, the potential economic effects of these activities will be positive and will benefit the state of Wyoming and surrounding communities.

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8.0 Alternatives

8.1 Introduction

As required by 10 CFR 51 and NUREG-1569, this section provides a listing of alternatives to the proposed action, including the proposed action, the no-action alternative, and reasonable alternatives considered but not carried forward for detailed analysis.

8.2 Proposed Action

As described in Section 1.0, and Sections 1.0 and 2.0 of the ER, the proposed action is to renew the Source Material License SUA-1548 for an additional 10-year period. Approval of this proposed action will allow Cameco to continue ISR operations at Smith Ranch and commence construction and operation of the North Butte, Gas Hills, and Ruth Remote Satellite facilities.

As presented in Section 3.0, the identified uranium ore bodies at Smith Ranch, and the North Butte, Gas Hills, and Ruth Remote Satellites have been shown to be amenable to the ISR process based upon R and D, laboratory testing, and operational experience. The ISR process involves the circulation of a recovery solution consisting of native groundwater infused with oxidizing and complexing agents, which is pumped into the ore zone through injection wells. Uranium dissolves into the recovery solution and is eventually pumped to the surface using recovery wells. The recovered solution is passed through pressurized, down-flow IX columns where the uranium attaches to synthetic IX resins. After the uranium attaches to these resins, it is removed from the resin using a strong brine solution. Uranium is then precipitated, washed, filtered, pressed, and dried into the final product-yellowcake.

Once uranium has been removed from the groundwater solution, this groundwater, less a small bleed rate which is treated and disposed, is re-infused with the oxidizing and complexing reagents and re-circulated through the recovery zone in a continuous process until the economically recoverable uranium resources in a given zone is removed. After uranium recovery is complete, groundwater in that area is restored to meet groundwater protection standards presented in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a parameter-by-parameter basis using BPT. If groundwater restoration activities are unable to achieve the background or maximum contaminant levels (whichever is greater) in Criterion 5(B)(5), a license amendment application request will be submitted to NRC for approval of ACL, but only after demonstrating that there are no specific hazards and the restored constituent concentrations are ALARA. After successful groundwater restoration has been achieved, all associated surface facilities will be subject to decontamination and decommissioning and final reclamation requirements such that, ultimately, there will be no visual evidence of site use and the entire disturbance area can be released for "unrestricted use."

Cameco has presented operational information to the NRC as well as new operating plans in accordance with license conditions and guidance within NUREG-1569 (June 2003) for the North Butte and Gas Hills Remote Satellites. As part of this application, Cameco is requesting the following:

- NRC approval of revised operational and reclamations plans, which include the option of producing yellowcake slurry at the Gas Hills Remote Satellite.
- NRC approval of the option for the use of deep disposal wells as an alternate or supplemental means of waste disposal at the Gas Hills Remote Satellite.
- NRC approval of the detailed designs and specifications for the evaporation ponds at the Gas Hills Remote Satellite as well as the surge ponds and redesigned satellite at the North Butte Remote Satellite as presented in this LRA supplement.

- SUA-1548 currently allows Cameco to receive and process up to 365 third party shipments of loaded IX resin at the CPP per calendar year. Cameco is requesting that the NRC approve a similar number of third party shipments of loaded IX resin from other licensees at the Highland CPF per year.
- NRC authorization of the refurbished Highland CPF to receive IX resins and slurried yellow cake from third party licensees (toll processing) for the purposes of processing, drying, packaging and transporting the source material to a uranium conversion facility on their behalf. This action was previously evaluated by the NRC and approved on March 15, 1993 as Amendment 46 to Source and Byproduct Materials License SUA-1511 for the Highland Uranium Project (NRC, 1993).
- NRC approval of an increase in flow rate at the following facilities:
    1. Reynolds Ranch Satellite from 4,500 gallons/minute to 6,000 gallons/minute
    2. North Butte Remote Satellite from 3,000 gallons/minute to 6,000 gallons/minute
    3. Gas Hills Remote Satellite from 12,000 to 13,500 gallons/minute

Furthermore, Cameco recognizes that information contained in the LRA regarding the Ruth Remote Satellite may not meet current NRC requirements. Cameco has not revised an operational plan nor adequately defined the mineral resource at the Ruth Remote Satellite (January 2012). Prior to initiation of ISR activities at the Ruth Remote Satellite, baseline environmental data, environmental impact analysis and the operating plan will be updated and provided to NRC Staff.

Cameco has presented operational information, affected environment baseline data, a summary of potential impacts from the proposed action, and an evaluation of alternatives to the proposed action in accordance with NRC guidance provided in NUREG-1748. An environmental evaluation has also been completed. Cameco is requesting that the NRC approve the operation plans and environmental information and analysis for renewal of License No. SUA-1548.

8.3 No-Action Alternative

10 CFR Part 51 as adopted by the NRC pursuant to NEPA and NUREG-1569 require that Cameco assess the no-action alternative. If the NRC chooses to deny the renewal of Source Material License SUA-1548, Cameco would be forced to cease recovery operations at Smith Ranch and complete groundwater restoration, decontamination and decommissioning, and reclamation in a timely manner, leaving a valuable mineral commodity unharvested. This denial would also affect the continued development of mineral resources at the North Butte, Gas Hills and Ruth Remote Satellites. Each of these remote satellites would go into immediate reclamation. Cameco currently has contracts for the sale of SUA-1548 uranium to be used as fuel in nuclear reactors. Denial of the license renewal application will impair Cameco's ability to deliver on these contracts and will have an impact on both national and international efforts to be independent (or partially independent) of fossil fuels as a power generation source. Finally, denial of this license renewal application would result in significant adverse financial and economic growth impacts to Converse, Campbell, Fremont, Johnson, and Natrona Counties, where the sites are located, due to loss of tax revenue and jobs.

Currently, the U.S. nuclear power generating industry is the world's largest producer of nuclear power, generating approximately 800 billion kWh of electricity in 2010, or over 20% of the total U.S. output and 30% of the worldwide electricity generation (WNA, 2011a). The U.S. imports approximately 90% of its uranium from foreign sources such as Canada, Australia, Russia, and Kazakhstan (WNA, 2011b). In 2010, domestic uranium recovery companies produced 2M kilograms (4.2M pounds) of yellowcake uranium

(EIA, 2011). By comparison, U.S. nuclear fuel reactors will require 23M kilograms (50.5M pounds) of yellowcake equivalent in 2011 (WNA, 2011b). Thus, domestic nuclear power generating companies were required to import or receive from government-based programs (i.e., down-blending of U.S. and Russian-based highly-enriched uranium) more than 90% of their required uranium. Denial of the requested license renewal by the NRC would cause the domestic nuclear power generating capacity to be deprived of enough uranium to supply approximately five nuclear power reactors per year, based on an estimated annual production from Smith Ranch and North Butte of 1.6M kilograms (3.5M pounds) and an average annual requirement of about 0.23M kilograms (0.55M pounds) of yellowcake equivalent for each of the 104 U.S. nuclear reactors operated in 2010 (WNA, 2011). Accordingly, these power reactors will be required to import sufficient uranium to fill this requirement, causing continued U.S. dependence on foreign sources of uranium for the foreseeable future.

8.4 Alternative Action

In contrast to the ISR process, alternative extraction methods would most likely follow a more conventional open pit or underground mining extraction system. Conventional mining practices have been historically employed within portions of the SUA-1548 license area specifically: Smith Ranch, Highland Uranium Project and in the Gas Hills. Conventional resource extraction would require creating an open pit that extends down to the ore stratum. At the base of the mine pit, uranium ore would be removed, loaded and transported to processing facilities. Historically an open pit was used to develop a highwall face and underground techniques were employed to remove additional ore. Overburden is generally removed by heavy equipment through the processes of ripping, loading and hauling. Furthermore, drilling and blasting techniques may also be used to further expose the ore body. Removed material, such as topsoil and overburden would be stockpiled adjacent to the mine pit and by so doing, enlarge the disturbance footprint. Potential groundwater infiltration to the open pit will require this water be pumped from the pit area to maintain access to the desired ore stratum.

Conventional open pit extraction at new sites where no recovery has occurred often requires conventional processing facilities to upgrade the raw ore into a concentrated form. A conventional mill will require operations to accomplish this concentration process including crushers, solution tanks, and concentration facilities. Sulfuric acid is the typical dissolution agent utilized within the milling process. Mill waste is delivered to a tailings pond located near the conventional mill.

The heap leach process is a technology that is considered to be part of the conventional mining and milling industry (NRC, 2009). Heap leaching includes placing ore in a heap and spraying the heap with an acid solution that separates the uranium from the ore. The uranium rich solution is then collected and transported to an IX facility. Heap leaching requires some crushing and grading to build up the ore pile. Uranium recovery from heap leaching is expected to range from 50 to 80%, resulting in a final tailings material of around 0.01% U_3O_8 content. Once heap leaching is completed, the depleted materials are 11e.(2) byproduct material that must be placed in a tailings impoundment unless NRC grants an exemption for disposal in place. Heap leaching was used mostly on an experimental basis in the 1970s and 1980s, but has not been commonly used in the United States since then. While impacts from heap leaching may be less than those from conventional milling, impacts from heap leaching are still greater than those associated with ISR processing. This type of alternative would increase potential environmental impacts and would increase the required effort needed to extract the ore content.

If uranium deposits exist at depths too far below the surface for open pit extraction, underground mining techniques might be employed. These techniques typically include a deep vertical shaft, cross cuts and tunnels to provide access to remove the uranium ore. Typically a ventilation shaft or multiple ventilation shafts, manways and haulage ways would be required. The nature of the process and depth of mining would require dewatering and surface discharge of the dewatered groundwater. Although this process would produce less waste material compared to open pit, worker safety, cost and the environmental effects of dewatering must always be addressed.

From an environmental perspective, open pit and underground production, and the associated milling generate higher risks to employees, the public, and the environment. Radiological exposure to personnel in these processes is increased not only from the extraction process, but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is traditionally much higher in open pit and underground extraction processes than has been the experience at ISR operations. Mill tailings ponds and heap leaches are highly regulated by the NRC and necessitate very rigorous closure standards.

In a comparison of the overall impacts of ISR with conventional mining, an NRC evaluation (NUREG-0925 [1983] Para. 2.3.51) concluded that environmental and socioeconomic advantages of ISR include the following:

1. Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much less.
2. No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISR is generally less than 1% of that produced by conventional milling methods (more than 950 kilograms (2,090 pounds) of tailings usually result from processing each metric ton (2,200 pounds) of ore.
3. Because no ore and overburden stockpiles, or tailings piles, are created and the crushing and grinding ore-processing operations are not needed, corresponding air pollution problems caused by windblown dusts from these sources are eliminated.
4. Tailings produced by conventional mills contain essentially all of the Ra-226 originally present in the ore. By comparison, less than 5% of the Ra-226 in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings, and the potential for radiation exposure is significantly less than that associated with conventional mining and milling.
5. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire site can be returned to unrestricted use within a relatively short time.
6. ISR results in significantly less water consumption than conventional mining and milling.

In the April 2001 EA for the last SUA-1548 license renewal, NRC concluded that the environmental impacts associated with the renewal did not warrant limiting future operations or denial of the license renewal. Cameco considers that the impact analysis contained in this SUA-1548 license renewal is similar to what NRC Staff evaluated in 2001 and that the Staff's conclusions should be the same as in 2001.

8.5 Reasonable Alternatives Considered but not Carried Forward for Detailed Analysis

8.5.1 Lixiviant Alternatives

At Smith Ranch and associated remote satellite locations, 24 years of operational experience and familiarity with several pilot programs prior to the commercial phase have shown that sodium carbonate/carbon dioxide lixiviant is very efficient at removing the uranium from the sandstone host rock with very little adverse environmental impact. At the North Butte Remote Satellite the geology and mineralogy is similar to what is found at Smith Ranch. Initial laboratory testing at the Cameco Research Center in Port Hope, Ontario suggests that the cores tested can achieve recovery rates as high as 80% with a standard 1.0 grams/Liter sodium carbonate lixiviant utilizing gaseous oxygen or liquid hydrogen peroxide as an oxidant. Alternatively, native groundwater can be fortified with a carbonate complexing agent of sodium bicarbonate and/or gaseous carbon dioxide to which the oxidant is added. Specific ratios of carbonate and oxidant concentrations are determined and modified as necessary during production.

Alternate recovery solutions include ammonium carbonate solutions and strong acidic solutions. Both of these solutions have been used in the past in ISR operations, but are now rarely used because of the difficulties in restoring and stabilizing the affected ore zone aquifers. As discussed in the final Supplemental EIS for the Moore Ranch ISR Project (NRC, 2010a), acid-based lixiviants such as sulfuric acid dissolve heavy metals and other solids associated with uranium in the host rock creating chemical compounds that require additional remediation effort and have greater adverse environmental impacts. Strong acid-based lixiviants are now not considered to be viable options.

Ammonia-based lixiviants have been used in the past at ISR projects in Wyoming and other states. Operational experience has, however, shown that ammonia adsorbs onto clay minerals associated with the uranium host rock and then slowly desorbs from the clay fractions during aquifer restoration (NRC, 2010a). At the Irigaray ISR Project in Johnson County, Wyoming and ISR projects in other states traces of the ammonium bicarbonate lixiviant have been shown to remain in the aquifer even after extensive aquifer restoration attempts. Because of this and the great consumptive use of groundwater needed to restore an ammoniated mine unit, an ammonia-based lixiviant is now not considered to be a viable option.

8.5.2 Waste Management Alternatives

The primary liquid waste management methodology for Smith Ranch and the North Butte, Gas Hills, and Ruth Remote Satellites is deep well disposal in conjunction with storage/surge pods and/or tanks to dispose of high TDS liquid wastes that primarily result from uranium processing activities. Zones receiving these types of wastes are approximately 2,700 to 3,000 meters (9,000 to 10,000 feet) below the ground surface and are authorized by the State of Wyoming UIC Program and the EPA. An additional waste water disposal method at Smith Ranch consists of land application. Treated mine unit purge water is stored in a surface reservoir and land applied during the non-freezing months of the year. Deep well disposal is the only waste water disposal method proposed for the North Butte and Ruth Remote Satellites. Evaporation ponds employing both conventional and enhanced evaporation are also proposed at the Gas Hills Remote Satellite. No other waste water disposal alternatives appear to be technically feasible or economically viable at this time.

All 11e.(2) solid wastes are transported off site and disposed at an NRC licensed disposal facility. Cameco currently has a contract with Denison Mines (USA), White Mesa Facility near Blanding, Utah for 11e.(2) byproduct waste disposal.

The ER compares the potential environmental impacts of the no-action alternative, the proposed action and the alternative action as described above for all resource groups: land use, transportation, geology, soils, water resources, ecological resources, air quality, noise, historic and cultural resources, visual resources, socioeconomics, public and occupational health, and waste management.

8.5.3 Cumulative Impacts

Cumulative impacts to the environment occur when several ongoing developments occur within the same area at the same time. Section 2.4 of the ER addresses energy development nearby or adjacent to the SUA-1548 license area. Section 4.0 of the ER presents the cumulative impacts analysis in greater detail and addresses those resources where a cumulative impact analysis is meaningful. Meaningful cumulative impacts are discussed in Section 4.0.

8.6 References

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9.0 Cost Benefit Analysis

9.1 General

The general need for uranium is in the operation of nuclear power reactors. For reactor licensing evaluations, the benefits of the energy produced are weighed against related environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. Incremental impacts in the fuel cycle are justified in terms of the benefits of energy generation. However, it is appropriate to review the specific site-related benefits and costs of an individual fuel-cycle facility such as SUA-1548. The monetary benefits to the state and local communities from Smith Ranch and the North Butte, Gas Hills and Ruth Remote Satellites are discussed in Section 7.0 of the ER.

Nuclear generation began more than 50 years ago. Today, this energy source generates as much global electricity as was produced then by all sources. Some two-thirds of the world population inhabits nations where nuclear power plants are an integral part of electricity production and industrial infrastructure. Half the world's people live in countries where new nuclear power reactors are in the planning process or under construction. Even in light of the recent Fukushima Daiichi nuclear disaster in Japan, nuclear energy continues to be an attractive option for the development of clean energy.

9.2 Quantifiable Benefits and Costs

9.2.1 Current Quantifiable Benefits and Costs

SUA-1548 operations will accrue monetary benefits to the surrounding communities from local expenditures, and state and local taxes paid by the project. To further identify project benefits to adjacent communities, a study of the economic impacts associated with SUA-1548 was completed by the University of Wyoming, Department of Agriculture and Applied Economics (University of Wyoming, 2010). Developed at the request of Cameco, the document satisfies guidance established in NUREG-1569 and NUREG-1748. The study measured the impact of jobs, employee income, government revenues, purchases of goods and services, contractor payments, production royalties, and other economic contributions from SUA-1548 on the Wyoming economy. Costs and benefits associated with SUA-1548 were evaluated. Costs and benefits associated with the Ruth Remote Satellite were not quantifiable at the time of the study. An operation plan has yet to be developed by Cameco for the Ruth Remote Satellite. Information relevant to the operational plan will be provided at a later date.

Cameco's presence in Wyoming has proven beneficial to the Wyoming economy as a whole and to local communities in particular. For example, Cameco's Wyoming expenditures from 2005 to 2009 increased from $16M to $40.3M. Approximately two-thirds of this increase went to purchasing products from Wyoming vendors, while payroll comprised roughly 25% of this increase. An estimated 10% was allotted to Wyoming taxes and royalty payments. Total expenditures in Wyoming by Cameco for this period are estimated to be $139.6M.

The recent relocation of Cameco's U.S. Headquarters from Denver, Colorado to Cheyenne, Wyoming in 2010 is estimated to have increased the total annual operating expenditures in Wyoming to $42.8M. Utilizing this annual expenditure sum, the Cameco/University of Wyoming Study developed the following economic correlations resulting from uranium operations in the state. See Section 7.0 of the ER for a more detailed discussion of the economic benefits associated with Cameco uranium production.

- Cameco payroll in Wyoming is estimated to be $12.5M (approximately 169 employees).

- Secondary employment (Cameco employees spending with other Wyoming businesses) is estimated to have added an additional 69 jobs to the Wyoming economy for a total employment positive impact of 238 jobs.
- Labor income generated from the 69 secondary jobs is estimated to have added $2.2M. Combined with the $12.5M in Cameco income, the total income is estimated to be $14.7M.
- Cameco payroll also generated an estimated $7.8M in secondary output due to spending by Cameco employees with other businesses in Wyoming. Combined with the $12.5M in Cameco earnings output, the total economic output is estimated to be $20.3M.
- Wyoming taxes and royalty payments paid by Cameco are estimated to be $3.7M. Approximately 26 tax revenue related jobs are created from this revenue.
- Secondary employment, resulting from spending of royalty payments by households and by spending of tax revenue by state and local governments in Wyoming, is estimated to have added an additional 19 jobs to the Wyoming economy (income of approximately $613,000).
- Cameco purchases an estimated $26.1M from Wyoming vendors annually. Recipients of these purchases include payments to drilling contractors and purchases from over 300 businesses located within Wyoming. Purchases to Wyoming vendors in support of SUA-1548 operations supports an estimated 105 jobs in the Wyoming economy. Secondary employment in Wyoming, resulting from spending by these vendors and their employees supports an additional 56 jobs in the Wyoming economy for a total positive employment impact of 162 jobs.
- The largest vendor purchases are from construction ($12M), trade ($9.7M), and transportation/information/public utilities ($4M). Additionally, these direct expenditures also generate an estimated $6.9M in secondary output in the Wyoming economy due to spending by the vendors and their employees. The combined total output effect is estimated to be $32.9M.

9.2.2 Future Quantifiable Benefits and Costs

Giving additional support to the Wyoming economy, jobs created by SUA-1548 are deemed to be well paying jobs. For the 169 jobs directly with Cameco, the average salary per job is approximately $74,000. Jobs (301 direct jobs) associated with Cameco's expenditures in Wyoming have an average salary per job of approximately $67,000. Because secondary employment tends to be more service oriented, the average earnings for these jobs are somewhat lower at slightly less than $35,000. Still, the overall average for all jobs associated with Cameco's operations in Wyoming is more than $56,000. This is 25% higher than the Wyoming average ($45,106) and 12% above the U.S. average ($50,259) in 2008.

Results from this analysis indicate that for every direct uranium job created in the mining sector, there are 1.6 other jobs created elsewhere in the Wyoming economy. The study also indicates that for every $1.00 of uranium employment income, there is $1.20 of income in other sectors of the Wyoming economy.

The above summary reflects the economics for current Cameco production. Expanded Cameco operations, as requested in this LRA, would provide greater economic benefits to the Wyoming economy. Approval of this LRA would allow further development of Cameco's uranium operations in Wyoming to include the North Butte and Gas Hills Remote Satellites. Operational plans for the Ruth Remote Satellite are not yet developed, but plans are to begin design of this facility late in the next renewal period. Further development of Cameco's uranium operations in Wyoming will positively impact the following sectors:

1. Construction expenditures associated with the expansions.
2. Increased production from facilities once the expansion is completed.

Cameco is planning to spend a total of $82M to expand its uranium production facilities in Wyoming over the next three years. Anticipated spending includes $17M in 2011, $30M in 2012, and $35M in 2013 (University of Wyoming, 2010). Proposed investment from Cameco on further developing their uranium production facilities could support up to 656 job-years (1 job for one year = 1 job year) of total employment in Wyoming over the 3-year period. Estimated total labor income resulting from this employment could be up to $34.3M resulting in the total economic activity potentially reaching up to $52.3M. The average salary per job is estimated to be more than $52,000 annually. Projected economic impacts would continue for the duration of the 3-year construction period.

With the expansion of production facilities, Cameco is planning to eventually increase uranium production from the current level of 0.9M kilograms (1.9M pounds) per year to 1.6M kilograms (3.6M pounds) per year. Proposed expanded levels of production would increase Cameco expenditures in Wyoming to approximately $80.2M per year including: $23.7M in payroll, $7.1M in Wyoming taxes and production royalties, and $49.4M in vendor purchases. Increased expenditures in Wyoming are estimated to support a total employment of 843 jobs. Estimated labor/household income at this level of expenditure would be $51.5M and the total economic activity in the state's economy with the expansion would be approximately $112.1M.

The proposed SUA-1548 expansion will add employment to the local communities in close proximity to the operation. Environmental impacts of the project are and will continue to be minimal as demonstrated by 25 years of operations at Smith Ranch with minimal resulting environmental impacts. Groundwater impacts, radiological impacts and the disturbance of the land are the three potential uncompensated environmental costs associated with SUA-1548. Groundwater will be restored to as near pre-ISR quality as possible, as has been demonstrated by Cameco at Smith Ranch and groundwater restoration efforts completed to date by other operators. Radiological impacts of the project have been and will continue to be small as the amount of solid 11e.(2) byproduct materials produced is small and such materials are transported off site for disposal at a NRC-licensed disposal facility. Disturbance of the land has been and will continue to be a very small impact, which is mitigated by the approved surface reclamation techniques to bring the land back to its pre-ISR uses. Interim reclamation efforts at Smith Ranch and other ISR projects have demonstrated that this goal is achievable. The benefits associated with the production of uranium and the power generated as a result is considered to offset the relatively small risks associated with the above noted environmental impacts.

9.2.3 Alternatives Benefits and Costs

Denial by the NRC of this LRA (the no-action alternative) would force Cameco to cease uranium recovery operations at Smith Ranch. Groundwater restoration, decontamination and decommissioning/ reclamation in a timely manner would begin, leaving a valuable mineral commodity undeveloped. This action would also result in no further development at the North Butte, Gas Hills, and Ruth Remote satellites. Denial would also result in the loss of all uranium production and the sale of uranium as fuel. Finally, non-license renewal would result in significant adverse financial and economic growth impacts to the State of Wyoming and adjacent communities to the project due to loss of tax revenue and jobs. Financial impacts to Wyoming would likely exceed $42M per year once restoration is completed.

If Cameco was required to employ a conventional mining alternative (alternative action), uranium recovery operations would continue. However, the environmental and socioeconomic impacts of this alternative action would be far greater than the proposed action. Specifically, the physical land disturbance would be greater and the number of workers required to accomplish the proposed action would be significant. Although there would be greater payrolls, tax revenues and jobs, the sale of nuclear fuel would not likely increase and mineral royalty payments to the state would remain the same or might be lower.

In considering the energy value of the uranium produced by ISR methods, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the project is favorable, and that renewing SUA-1548 for an additional 10 years is the appropriate regulatory action.

Section 7.0 of the ER provides more detail related to the project's economic parameters.

9.3 References

Taylor, David T. and Thomas Foulke, "The Economic Impact of Cameco on Wyoming: Existing Uranium Operations and Planned Expansion", University of Wyoming, 2010 (Confidential).

10.0 Environmental Approvals and Consultations

As discussed in Section 1.0, this is a renewal application of NRC License SUA-1548 originally issued in 1992, and renewed in 2001. A summary of all relevant permits for SUA-1548 and their current status is provided in **Table 10-1, Smith Ranch Required Permits, Table 10-2, North Butte Required Permits, Table 10-3, Gas Hills Required Permits, and Table 10-4, Ruth Required Permits.**

There have been numerous official consultations held with state and federal agencies during the course of obtaining approval to operate SUA-1548. A record of these consultations is provided in **Table 10-5, Agency Consultations**.