APPENDIX A-8

ENVIRONMENTAL EFFECTS OF SITE OPERATIONS INCLUDING DATA ON RADIOLOGICAL AND NON-RADIOLOGICAL EFFECTS, ACCIDENTS, AND THE ECONOMIC AND SOCIAL EFFECTS OF OPERATIONS

1.0 INTRODUCTION

This appendix (Appendix A-8) of the License Renewal submittal for Source Material License SUA-1548 has been prepared in conformance to NUREG-1569, "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*" (NRC, 2003c). The approach to preparation of license renewal submittals as presented in NUREG-1569 Appendix A is streamlined, requiring the licensee to present "*compliance history or record of site operations and changes*" to the NRC for review. Further, NUREG-1569 Appendix A states that:

> *"Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined".*

The information and data presented in the license renewal submittal can therefore be optimized, to present:

- By reference, any previously submitted documentation in areas that have not changed;
- The record of site operations demonstrating that health, safety and environment have been protected throughout the previous license period; and
- Any "new or significant" information, describing aspects of facility or operations that have changed during the previous license period.

This approach allows for the NRC review to be keenly focused on "*only those changes proposed by license renewal or amendment application*" (NRC, 2003c).

2.0 APPENDIX A-8 CONTENT

Appendix A-8 has been prepared to conform with NUREG-1569 Appendix A guidance, specifically:

> *"Environmental effects of site operations including data on radiological and non-radiological effects, accidents, and the economical and social effects of operations.*" (NRC, 2003c)

Appendix A-8 is specifically focused on the SR-HUP. Topics covered in Appendix A-8 include the following:

- A-8.1: Release and Accident History
  - A-8.1-1: Summary of Spills and Accidents
  - A-8.1-2: Environmental Impacts & Mitigative Action Review
- A-8.2: Surface and Groundwater Monitoring History
  - A-8.2-1: Historical Groundwater Monitoring Program
  - A-8.2-2: Historical Surface Water Monitoring Program

- A-8.3: Historic Radiation Assessments
  - A-8.3-1: Historical Radiation Monitoring Program Assessment
  - A-8.3-2: Historical Results of Radiation Dose Calculations
  - A-8.3-3: Historical Bioassay Program Assessment
  - A-8.3-4: Historical Occupational Exposure Rate Monitoring Assessment
- A-8.4: Historical Airborne Effluent and Environmental Monitoring Program Assessment
- A-8.5: Historical Quality Assurance Program Assessment
- A-8.6: Cumulative Effects of Operations

The topics discussed in Appendix A-8 are covered by reviewing and evaluating monitoring data collected since the last license renewal.

APPENDIX A-8.1
RELEASE AND ACCIDENT HISTORY

1.0 INTRODUCTION

This section provides a summary of releases under License SUA-1548 since the previous license submittal of November 15, 1999 (RAMC, 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 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. The releases reported to the NRC since the previous license submittal, the corrective actions taken, and an evaluation of potential impacts are discussed in Appendix A-8.1-1.

Appendix A-8.1-2 provides a description of the largest release occurring within the SR-HUP licensed (SUA-1548) area. Included in the description are summary discussions of the cause, reporting, regulatory response, actions taken by Cameco Resources, and the nature and extent of environmental impacts. The history of the largest release is reviewed to provide documentation of the methods by which Cameco Resources responded to the accidental release, from its initial detection and self-reporting to state regulatory agencies and the NRC, throughout the investigation of causes and impacts, and finally to document the remedial actions taken in protection of the environment.

APPENDIX A-8.1-1

SUMMARY OF SPILLS AND ACCIDENTS

1.0 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 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, etc. The releases reported to the NRC since the previous license submittal is summarized in Table A-8.1-1.

A total of 82 reportable releases have occurred at the SR-HUP site since the previous license renewal, totaling approximately 816,000 gallons. While any release is undesirable, the reported volume of released solution is a very small percentage of the total volume of solution being handled during mining. To put the released volume of solution into perspective, an estimated 63,000,000,000 gallons of solution has been circulated during the past 10 years of mining through approximately 2,000,000 feet of pipeline and 71,000 fittings in 202 header houses at the SR-HUP. The total volume of reported releases compared to the total volume of managed solution is approximately 1.3×10^{-5} gallons per gallon of solution managed. In comparison, for an average single family home, leaks account for approximately 13.7 percent of the total water use (Vickers 2001), which is a leak ratio that is over four orders of magnitude higher than the ratio of released solution to managed solution at the SR-HUP. Assuming a single family home has on average 100 feet of water pipeline and uses 350 gallons a day, approximately half a gallon leaks per day per foot of pipeline. In comparison, the SR-HUP averages approximately 0.0001 gallons released per day per foot of pipeline.

The volume released represents approximately 0.001 percent 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 percent of the spills involved production fluids, with uranium concentrations ranging from 2 mg/L 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 percent of spills resulted from mechanical and equipment failures, such as failed fittings, joints, flanges, and unions of pipelines, with 18 percent 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

Corrective actions resulting from Spill Committee reviews have included:

1. 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.
2. Daily inspection of all wellfields and headerhouses.
3. Unions will not be reused when repairs or maintenance is conducted on a wellhead or headerhouse.
4. 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.
5. When one component of a wellhead or headerhouse is found to be faulty, all like components are replaced to reduce the chance for releases.
6. All wetted fixtures at a wellhead are replaced every five years; this coincides with the ongoing required five year mechanical integrity test of all injection wells.
7. 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.
8. Pop-off valves failed to reset and were replaced with newer versions.
9. Installed an asbestos-free (green) gasket in all new PC/IC lines.
10. When moving into restoration phases, replace gaskets with either red-rubber or asbestos-free gaskets.
11. All hose connections on wells were replaced with a more robust version, which went through two stages until the best connection was found.
12. Gaskets have been changed from paper gaskets to neoprene.
13. Stainless steel fittings replaced all brass fitting 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 were recovered 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 RSO 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 Resources' 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 reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards are met. 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 SR-HUP operations.

On December 20, 1999, PRI forwarded an internal Environmental Audit Report to the Director of the WDEQ. This report, dated November 21, 1999, describes PRI's investigation and mitigative actions related to the unanticipated release of injection fluids into shallow sand units at the Highland Uranium Project. In correspondence dated August 11, 2000, PRI received four violations and an Administrative Order on Consent (docket No. 3211-00) were negotiated between PRI and LQD to address the findings of the audit report and assist with the orderly mitigation of the violations. Reports are sent to the WDEQ quarterly describing mitigative activities and status of the holes in question.

The goal of remediation is to recover all available fluids from previously dry sand units or return all affected ground waters to their original Class of Use, as determined by WDEQ, WQD Rules and Regulations, Chapter 8, Underground Water Use Suitability standards.

The audit report concluded inadequate well completion techniques and MIT procedures contributed to the leaking well casing. Presently Cameco Resources utilizes well casing connections with splines to secure the joints. The new well completion, leak detection and MIT procedures have eliminated the same well failures. As a result of the negotiations between WDEQ and PRI, 349 wells were suspected and the new and presently used MIT procedures were implemented to verify the wells competency. The wells failing the MIT test were either repaired or plugged and abandoned. To date 7 wells with elevated analytical results are awaiting plugging to close the Administrative Order.

2.0 EVALUATION OF POTENTIAL IMPACTS

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 A-8.1-1, 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 A-8.2-2. The results of this monitoring program show that measured concentrations of Natural Uranium (U^{Nat}) and Radium 226 (Ra^{226}) in stock ponds (some stock ponds

are filled by windmills and wells) along drainages near active mine units are all below the Effluent Concentration Limits 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 U^{Nat} and Ra^{226} below the Effluent Concentration Limits, with one exception. As discussed in Appendix A-8.2-1, Section 4.0, well GW-5 is located in an area with shallow natural uranium mineralization, resulting in naturally high uranium concentrations that exceed the Effluent Concentration Limit. 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 U^{Nat} and Ra^{226} concentrations since the last license renewal in November 1999 as subsequently discussed in Appendix A-8.2-2. An evaluation of environmental impacts resulting from the largest spill is provided in Appendix A-8.1-2. The largest spill occurred in June 2007 and involved a spill of 198,500 gallons of injection fluids resulting from human error. As documented in Appendix A-8.1-2, that spill had no immediate or long-term environmental impacts as indicated from post-release radiological survey results, soil and vegetable sampling results, and wells specifically drilled to confirm that there were no impacts to the shallow aquifer.

3.0 CONCLUSIONS

Spills and/or releases at SR-HUP 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. Best management practices and an active SR-HUP Spill Committee review of spills having occurred at SR-HUP have resulted in leak detection upgrades to existing systems as identified early in this section. These in conjunction with SR-UPH 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 Resources SR-HUP 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 they address 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 our 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 SRH have included securing the affected area with perimeter fencing and/or hurricane fencing and soil removal.

SR-HUP 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.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
11/23/99	HH-F-15	Approximately 900 gallons were released.	Fitting on bottom of tank broke.	Replaced fitting.
11/28/99 1:30am	Wellfield 3, production well 3-P-133	Approximately 1,500 gallons of production fluid were released with a natural uranium content of approx. 149.7 mg/l. The spill was contained in the wellfield and did not threaten any waters of the state.	Mechanical failure of a flexible rubber hose fitting joining the wellfield to the poly piping to the header house caused the leak.	The hose was replaced and approx. 100 gallons of the spill were recovered with a vacuum truck and disposed of.
12/4/99	Wellfield 1, Header House 2	Approximately 50,000 gallons were released.	Failure of an aluminum camlock fitting.	Replaced fitting and inspected all like fittings in wellfield.
12/9/99	CMP-5	Approximately 900 gallons were released.	Well not shut off after pumping.	Incident discussed with operator
12/11/99 3:00am	Wellfield 1, Header House 2	Approximately 25,000 gallons of injection fluid were released with a natural uranium content of approx. 5.6 mg/l. The spill left the fenced wellfield area, but did not leave the permit area and did not threaten any waters of the state.	Failure of an aluminum camlock fitting that was connected to the header house filtration system used to remove suspended particulates within the injection solutions.	Wellfield 1 production was shut-in to visually inspect and rectify the construction issue. Bleed solutions were continued in the wellfield to maintain hydrologic control of the wellfield mining solutions. The inspection indicated that no other operating wellfield utilized aluminum camlock fittings. Areas adversely affect by the spill will be reseeded as the seasons permit. Additional erosion control structures will be constructed and the affect soil graded.
12/31/99 4:30pm	Wellfield 1, Header House 5	Approximately 3,000 gallons of injection were released, with a natural uranium content of 4.5 mg/l. The spill did not leave the permit area, but did enter an ephemeral drainage adjacent to the header house.	Equipment Failure: Failed joint holding PVC pipe together.	Production was halted from Header Houses 4 and 5 until similar glue joints were visually inspected. Bleed solutions were continued in the wellfield to maintain hydrologic control of the wellfield mining solutions. The minor rills were graded and reseeded as the seasons allowed.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
1/17/00 2:30pm	Wellfield 4, well 4-P-2	Approximately 6,300 gallons of production fluid were released, with a natural uranium content of approx. 26 mg/L. The spill stayed within the fenced wellfield and did not leave the permit area or threaten any waters of the state.	Equipment Failure: failed manufacturer's crimp fitting connecting a flexible hose coming out of the wellhead to poly pipe which runs to the header house.	Similar crimp fittings were inspected and any that appear to have poor placement were replaced. Areas adversely affected by the spill will be reseeded as the seasons permit.
2/3/00	C-17	Approximately 1,800 gallons were released.	Clean-out line froze and broke, power down in wellfield.	Insured clean-out line was below ground to prevent freezing.
2/3/00	FP-156	Approximately 300 gallons were released.	Wellhead hose failed at well head.	Hose replaced and placed back into service.
2/15/00	FI-1128	Approximately 300 gallons were released.	Well head flange failed.	Replaced flange.
2/26/00 4:30am	Wellfield 4, well 4-P-13	Approximately 3,780 gallons of production fluid were released, with a natural uranium content of approx. 36 ppm.	Equipment failure: Failed manufacturer's crimp fitting connecting a flexible "red" hose coming out of the wellhead to poly pipe which runs to the header house.	All hoses of the type that failed were replaced with a higher-quality product. Areas adversely affected by the spill were reseeded as the seasons permit.
4/3/00	FI-1209	Approximately 1,000 gallons were released.	Well head flange failed.	Replaced flange.
8/7/00 8:00pm	Wellfield 4, well 4-P-30	Approximately 780 gallons of production fluid were released, with a U_3O_8 concentration of 24 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	Equipment Failure: Failed manufacturer's crimp fitting connecting a flexible "red" hose coming out of the wellhead to poly pipe which runs to the header house.	All hoses of the type that failed were replaced with a higher-quality product.
10/22/00 6:00pm	Wellfield 4, well 4-I-39	Approximately 1,100 gallons of injection fluid were released. The spill stayed within the permit area and did not threaten any waters of the state.	Human Error: Spill resulted from the failure of an employee to re-insert a plug in the gas trap after routine servicing.	Training program and protocols were reviewed to see if improvements can be made to prevent similar occurrences in the future. The minor surface erosion resulting from the spill were smoothed and seeded in the spring.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
11/22/00 12:00 noon	Wellfield 4, well 4-I-140	Approximately 1,870 gallons of injection fluid were released, with a U_3O_8 concentration of 2.3 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	Human Error: Spill resulted from the failure of an employee to re-insert a plug in the gas trap after routine servicing.	Training program and protocols were reviewed to see if improvements could be made to prevent similar occurrences in the future. All wells swabbed since September 1, 2000 were inspected to confirm the plugs were replaced. Minor surface erosion resulting from the spill were smoothed and seeded in the spring.
4/13/01	H-I-2	Approximately 1,500 gallons were released.	Glue joint on well head flange failed.	Repairs completed.
4/19/01	CI-186	Approximately 600 gallons were released.	Split 1.25-inch union to transition at well head.	Uncertain if fitting was faulty or over tightened. Repairs completed.
6/18/01 10:15pm	Deep Disposal Well #1	Approximately 1,100 gallons of water were released with a U_3O_8 concentration of 3 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	Equipment Failure: Failure of 3/8-inch diameter stainless steel tubing leading to the flow meter at the deep disposal well pump. The tubing sheared due to excessive vibration caused by failed bearings in the pump.	Upon discovering the leak, the well was immediately shut off. To prevent similar occurrences in the future, the pump was fitted with a device capable of shutting down the pump if excessive vibration is detected.
10/10/01	EPI-110	Approximately 100,800 gallons were released.	Meter run piped to wrong well.	Corrected and returned to service.
10/14/01 8:30am	Injection pipeline (SW¼, SE¼, Sec.26, T36N, R74W)	Approximately 3,600 gallons of water were released, with a U_3O_8 concentration of 0.9 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	Failure of an injection fluid pipeline connecting Wellfield 3 and the central processing plant; Water passed between a valve disc and the valve seat which were seated, but were not leak tight.	The valve was immediately tightened upon discovery of the leak. The minor erosion resulting from the spill was repaired.
10/22/01 10:30pm	Wellfield 3, Header house 3-2	Approximately 62,400 gallons of injection fluid were released with a U_3O_8 concentration of 2.7 ppm. The spill stayed within the permit area and did not threaten any waters of the state	Equipment Failure: Failed flange in the main PVC injection line feeding the header house.	The minor erosion resulting from the spill was repaired and the area was reseeded in the spring.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
12/5/01 3:30am	Wellfield 3, wells 3-I-44 and 3-I-53	Approximately 3,600 gallons of injection fluid were released, with a natural uranium concentration of approx. 0.8 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	Human Error: The spill resulted when an operator turned on two wells without realizing surface piping had been disconnected to carry out maintenance. The piping had been taped shut, but the tape was insufficient to prevent flow.	The minor erosion resulting from the spill was repaired and the area was reseeded in the spring.
1/4/02 7am	3-P-163	Approximately 1,800 gallons of production fluid were released containing 18 ppm U_3O_8. The spill stayed within the permit area and did not threaten any waters of the state.	Galvanized nipple at wellhead corroded through and allowed water to escape.	The corroded nipple was removed and replaced with a stainless steel nipple, which is resistant to corrosion. Galvanized nipples are no longer used for this license renewal submittal and previously used galvanized nipples are being replaced. The minor erosion resulting from the spill was repaired and the area was reseeded in the spring.
4/11/02	C-24	Approximately 1,000 gallons were released.	0.5-inch metal fitting corroded and failed.	Repaired and returned to service.
4/24/02 12:10pm	Header house 4-7 in the (NW ¼ , SW ¼, Sec.35, T36N, R74W)	Approximately 18,000 gallons of water were released, with a natural uranium concentration of approximately 1.2 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	A glue joint connecting a 6-inch PVC Schedule 40 pipe on the injection circuit to a 6-inch PVC Schedule 80 fitting failed. The cause of the spill is thought to be due to the use of bad glue or the license renewal submittal of glue to the joint after the primer had dried.	Failed line was replaced with new parts. The next day the same line failed at a different fitting. See description of spill below.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
4/25/02 12:10pm	Header house 4-7 (NW ¼, SW¼, Sec.35, T36N, R74W)	Approximately 3,500 gallons of water were released, with a natural uranium concentration of approximately 1.2 ppm. The spill stayed within the permit area and did not threaten any waters of the state.	PVC piping might have been damaged by UV radiation or from improper gluing techniques.	Additional destructive testing was conducted to assist in determining the possible cause of the failures. Employees will be retrained on the proper techniques of PVC gluing. The minor erosion resulting from the spills was repaired.
7/30/02	HH-4-8	Approximately 1,480 gallons were released.	Broken flange on main IC header.	Investigation was completed. The failure was caused by lack of support on the trunk line feeding the header. All header houses were inspected and similar issues corrected.
10/10/02		Approximately 750 gallons were released.	Threads bad on hose, resulting in failure.	Repaired and returned to service.
1/11/03 7:00am	Wellfield No. 3, Well 3P-97 (NE¼, SW¼, Sec.26, T36N, R74W)	Approximately 1,380 gallons of production fluid were released with a natural uranium concentration of approximately 20 mg/l, and affected approximately 0.1 acres. The released fluid flowed into a draw, but did not exit the fenced wellfield area.	A crimp ring on the end of a pre-manufactured hose at a production wellhead caused the spill.	The well was immediately shut-in and the well was repaired using a new hose and put back into service. All hoses with similar style crimp rings that are still in service will be replaced by hoses that have banded end connections.
2/9/03 6:00pm	Wellfield No. 3, Well 3P-113 (NE¼, SW¼, Sec.26, T36N, R74W)	Approximately 500 gallons of production fluid were released, with a natural uranium concentration of approximately 2 mg/l, and affected approximately 0.01 acres. The released fluid flowed into a dry draw, where it ponded and soaked into the ground. The fluid did not exit the fenced wellfield area.	The crimp ring on a pre-manufactured hose failed and allowed the release of production fluid.	The well was immediately shut-in. The well was repaired using a new hose with a different type of hose connection. All hoses in the area with similar style crimp rings were replaced on Feb. 10, 2003 with hoses that have banded end connections.
5/21/03	Trunk line station	Approximately 1,400 gallons were released.	Pinhole in steel tee inside the culvert (trunk line station).	Repairs completed and returned to service.
8/4/03	FI-106	Approximately 28,000 gallons were released.	Wrong well turned on by operator.	Review of procedures and revisions, as necessary.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
9/6/03 7:40am	Headerhouse 4-7 in Wellfield 4 (NW¼, Sec.35, T36N, R74W)	Approximately 20,800 gallons of injection fluid were released, with an approximate natural uranium concentration of 1.1 mg/l and affected approximately 0.25 acres. The entire affected area is contained within the fenced wellfield area.	The release was caused by the separation of a Schedule 80 PVC elbow along the injection pipeline due to apparent inferior glue joint. In addition, the low pressure and sump water detection devices used on this pipeline did not shut down the header house and activate the alarm, allowing the release to go undetected until the Operator discovered it.	The header house was immediately shut down. The safety circuit shunt trip and alarm system were redesigned to ensure that any future spill occurrences are detected in a timely manner. The area will be reevaluated during decommissioning of the wellfield to ensure that applicable decommissioning standards for soil are not exceeded.
9/29/03	CMP-13	Approximately 5,000 gallons of water with a U_3O_8 concentration of approximately 2 mg/l were released from CMP-13. Fluid did not enter waters of the state.	The fluid was released from a cracked pipe at the wellhead of CMP-13. During monitoring events the purge water is piped to the C-14 Headerhouse.	The situation was corrected and the well placed back into service.
10/15/03	2P-182	Approximately 5,000 gallons of production fluid with a U_3O_8 concentration of approximately 47 mg/l were released from well 2P-182. All the released fluid was retained in the fenced wellfield area.	The release resulted from the failure of a pressure relief valve on the wellhead.	The well was immediately shut off. A vacuum truck was used to recover approximately 4,000 gallons. All relief valves are being replaced.
10/20/03 2:30pm	C-Wellfield, Well CI-28 (SW¼, NE¼, Sec.14, T36N, R72W)	Approximately 2,800 gallons of injection fluid were released, with an approximate uranium concentration of 1.5mg/l, which affected approximately 0.5 acres. All released fluid remained within the fenced wellfield area and did not entire into any waters of the state.	The release was likely due to a break in the well casing just below the surface of injection well CI-28.	The well was immediately shut off and repaired. Mechanical Integrity tests continue to be conducted on a regular schedule to prevent this type of release. It was not possible to retrieve any of the released fluid, as the fluid immediately absorbed into the ground. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
12/20/03 10:30am	Headerhouse F-44 in the F-Wellfield; fluid leaking from Well FI-1286 meter run. (NW¼, SE¼, Sec.21, T36N, R73W)	Approximately 600 gallons of injection fluid were released, with an approximate uranium concentration of 1.5 mg/l. The released fluid remained within the fenced wellfield area and did not enter into any waters of the state.	A crack in a PVC end cap allowed the release of injection fluids.	Well FI-1286 was immediately shut off, the end cap was replaced, and fittings were repaired. It was not possible to retrieve any of the released fluid. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for the soils are met.
2/8/04 9:30pm	D Extension Wellfield, Well DI-204 (NE¼, SW¼, Sec.22, T36N, R73W)	Approximately 500 to 1000 gallons of injection fluid were released, with an approximate uranium concentration of 1.1 mg/l. The released fluid flowed into two small ponds of water in an ephemeral draw, contained within the fenced area of the wellfield.	The well was investigated with a downhole camera and was found that the well had leaked at the first casing joint, approximately 20 feet below the surface. A separation in the splined groove casing was observed at this joint. The last mechanical integrity test was conducted on June 28, 2001 and no problems were noted.	The well was immediately shut down and tagged out. The top joint of the well casing was repaired and the well was brought back into service. Approximately 1500 gallons of combined injection fluid, snowmelt, and purged monitor well water were recovered from the two small pools. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
2/11/04 3:15pm	Mine Unit 4, Well 4I-307 (NW¼, NE¼, Sec.22, T35N, R74W)	Approximately 400 to 600 gallons of injection fluid were released, with an approximate uranium concentration of 1.3 mg/l, and affected 0.01 acres.	The PVC flange assembly separated from the well casing at the top of well 4I-307. The separation appears to be due to improper application of the glue at the joint.	The well was tagged out of operation until the PVC flange assembly is installed back on the well casing. Proper glue application to the joint will be practiced to prevent future separation of the PVC flange assembly to this well. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
5/3/04 2:20pm	Mine Unit 4, near Headerhouse 4-9 (SE¼, SW¼, Sec.35, T36N, R74W)	Approximately 800 to 1000 gallons of production fluid overflowed onto the ground, with an approximate uranium concentration of 11.1 mg/l. The released fluid flowed approximately 200 feet where it then soaked into the ground. Approximately 0.01 acres were affected.	The release occurred when a steel fitting on the production line inside the valve station failed. Investigation showed that the cause of the failure was rusting of the fitting.	The main line was immediately shut down and repairs were completed. It was not possible to recover any of the fluid released to the ground; however, the fluid that remained in the culvert was recovered. Repairs were also made to other areas where this type of fitting was in place. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
7/22/04 10:00am	Mine Unit 4, near Headerhouse 4-9 (NW¼, SW¼, Sec.35, T36N, R74W)	Approximately 2700 to 5000 gallons of production fluid overflowed onto the ground, with an approximate uranium concentration of 11 mg/l. The release flowed approximately 500 feet where it soaked into the ground. Approximately 0.6 acres were affected.	The release occurred when a carbon steel fitting on the production pipeline located inside the valve station failed. Investigation showed that the cause of the failure was due to corrosion of the fitting.	Approximately 200 gallons were recovered from the small depression, and fluid from the culvert was also recovered. The fitting was replaced with stainless steel. All valve stations at Smith Ranch were inspected to assess if any similar equipment existed, and if found, were replaced. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
9/6/04	Mine Unit 2, Injection well 2I-122	Approximately 1,600 gallons of injection fluid were released. No fluid reached any waters of the state. All fluid soaked into the ground.	Investigation with a downhole camera showed the leak occurred at the first casing joint located about 15 feet below ground.	The well was turned off.
9/12/04 1:30pm	F-Wellfield, near Headerhouse F-42 (NE¼, SE¼, Sec.21, T36N, R73W)	Approximately 1000 gallons of production fluid overflowed onto the ground, with an approximate uranium concentration of 10.5 mg/l. The released fluid flowed approximately 600 feet where it then soaked into the ground. Approximately 0.03 acres were affected.	The release occurred when a steel reducer connecting the production line inside the valve station failed. Investigation showed that a hole had developed in the reducer as a result of rusting.	The main line was immediately shut down. The fluid that remained in the culvert was recovered. The reducer was replaced and the pipeline placed back into service.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
9/29/04 1:20pm	Near Mine Unit I, along the 14-inch injection trunk line that runs from Mine Unit I to Satellite No. 2 (SW¼, NW¼, Sec.24, T36N, R73W)	Approximately 2,000 gallons of injection fluid emerged from the point of failure and covered approximately 0.23 acres. The approximate uranium concentration of the injection fluid was 1.6 mg/l. None of the released fluid entered waters of the state.	The cause of the release was determined to be failure of a fusion joint.	The Injection Trunk Line was immediately shut down and repaired that evening. Approximately 1,200 gallons of the released fluid was recovered before it was absorbed. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for the soils are met.
10/9/04 4:00pm	Mine Unit C, at 6-inch pipeline in the C-19 Valve Station	Approximately 5,000 gallons of fluid with a uranium concentration of 7 mg/l were released. No fluid reached waters of the state.	Excavation of the valve station showed that the release was caused by a hole rusted in the steel tee.	Approximately 2,400 gallons were recovered with the vacuum truck.
1/10/05 10:00pm	Well FPI-45, located in the F-3 area of Mine Unit-F (SE¼, NE¼, Sec.21, T36N, R73W)	Approximately 300 gallons of injection fluid were released into a small, dry, ephemeral channel. All fluid soaked into the ground. The fluid had an approximate uranium concentration of 1 mg/l. The affected area was less than 0.01 acres.	The cause of the release was a pop-off valve that was stuck in a partially open position.	The well was shut off and the valve was serviced before the well was restarted. Before restarting, the valve was isolated and it was verified that the well was operating properly. All similar installations are being inspected to ensure the pop-off valves and all related equipment are functioning as intended.
2/26/05 10:30am	Wellfield F, Headerhouse F-5	Approximately 3,000 gallons of production fluid were released and flowed down an ephemeral draw for approximately 475 feet. The approximate uranium concentration of the production fluid was 11.5 mg/l, and the release affected approximately 0.1 acres.	Operator failed to open the production bypass valve at Satellite No. 3 prior to starting the wellfield after an unscheduled shutdown and opened another valve by mistake.	The header house was immediately shut down and repairs to the main PC header were completed on Feb. 27, 2005. The production bypass valve at Satellite No. 3 has been marked to distinguish it from the adjacent valve to avoid similar occurrences. Approximately 4,500 gallons of production fluid combined with runoff water was recovered.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
5/16/05 9:30am	H-Wellfield, Injection well HI-35 (SW¼, SE¼, Sec.12, T36N, R72W)	Approximately 20,700 gallons of injection fluid flowed from the hose onto the ground and into a small playa. The uranium concentration of the production fluid was approximately 1.1 mg/l and the release affected approximately 1.5 acres.	The release occurred when a brass nipple on the hose connection at the wellhead failed as a result of corrosion.	The well was immediately shut down and repairs were completed. A retaining trench was dug upstream of the playa to catch any remaining production fluid flowing toward the playa.
5/31/05 4:45am	Mine Unit I at a valve station manhole near Headerhouse I-3 (SE¼, SW¼, Sec.24, T35N, R73W)	Approximately 4,700 gallons of injection fluid flowed from the manhole onto the ground. The fluid flowed approximately 3,300 feet down an ephemeral draw where it then entered a small stockpond. The approximate uranium concentration of the released fluid was 1.1 mg/l. The release affected 0.22 acres.	The release occurred when a fused joint on a 6-inch poly feeder line failed. It is believed this failure was the result of settling of the 6-inch line and a weak fusion at the joint.	The joint was repaired and the line was placed back into service.
8/16/05 12:30pm	Mine Unit 15, a manhole near the staging area (SW¼, SE¼, Sec.10, T35N, R74W)	Approximately 1,050 gallons of production fluid flowed from the manhole onto the ground, with an approximate uranium concentration of 2.9 mg/l. The release affected 0.1 acres.	The release occurred when the flange between the 18-inch steel tee and the 18-inch poly trunk line began leaking.	The line was immediately shut down and repairs were completed. A small earthen dam was placed to prevent further migration of the released fluids. As a result, the spill did not enter any ephemeral drainage. Approximately 200 gallons of released fluid was recovered from ponded areas.
8/30/05 5:15am	Mine Unit F, Production well FP-435	Approximately 1,000 gallons of production fluid flowed from the well onto the ground. The approximate uranium concentration of the production fluid was 15.4 mg/l and the release affected approximately 0.04 acres.	The release occurred when a 1.5-inch Schedule 80 union on the wellhead failed.	The well was immediately shut down and repairs were completed. The union was replaced with a brass union instead of PVC. The entire area will be re-evaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
9/2/05 8:30pm	Mine Unit 2, Well 2P-182 (SW¼, SW¼, Sec.25, T36N, R74W)	Approximately 4,500 gallons of production fluid flowed from the wellhead onto the ground. The approximate uranium concentration of the production fluid was 8.6 mg/l and the release affected approximately 0.2 acres.	The release occurred when a 1.5-inch Schedule 80 union on the wellhead failed.	The well was immediately shut down and repairs were completed. The union was replaced with a brass union instead of PVC.
12/30/05 11:45am	Mine Unit C, Injection Well CI-140 (SW¼, NE¼, Sec.14, T36N, R73W)	Approximately 1,000 gallons of restoration injection fluid flowed from the wellhead and absorbed into the ground. The approximate uranium concentration of the restoration injection fluid was 0.7 mg/l and the release affected 0.15 acres.	The release occurred when the PVC wellhead casing failed at ground level due to degradation of the casing. The well was operating under normal operating pressures. The well passed the previous MIT in January 2005.	The well was immediately placed out of service until repairs could be made. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
1/9/06 12:30am	Mine Unit 3, Headerhouse 3-3 (SW¼, Sec.26, T36N, R74W)	Approximately 6,240 gallons of injection fluid flowed from the headerhouse. The approximate uranium concentration of the injection fluid was 1.7 mg/l and the release affected approximately 0.75 acres.	The release occurred when a full-faced rubber gasket failed at the tee for the main 6-inch IC line. The failure was caused from high pressure in the IC line and failure of the high/low pressure automatic shutdown device to function.	Upon discovery, the well was immediately placed out of service until repairs could be made. Flow from Mine Unit 3 was sent to the central processing plant instead of Satellite SR-1 until the corrective actions could be completed. A variety of corrective actions were conducted, including installing pressure reducing valves, wet alarms, and alarm lights.
2/10/06 9:30am	Mine Unit 2, Well 2P-182 (NE¼, SW¼, Sec.26, T36N, R74W)	Approximately 1,000 gallons of production fluid flowed from the wellhead onto the ground. The release had an approximate uranium concentration of 21.0 mg/l and affected approximately 2,000 square feet.	The release occurred when a 1.5-inch Schedule 80 union on the wellhead failed.	The well was immediately shut down and repairs were completed. The union was replaced with a brass union instead of PVC. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
10/21/06 6:00am	Deep Disposal Line from Bellhole 3-6-7 in Wellfield 3 (SE¼, SW¼, Sec.26, T36N, R74W)	Approximately 7,041 gallons of deep disposal well fluid filled the bellhole to the plant supply line level. The fluids then followed the supply line for 50 feet and surface to be absorbed into the ground. The uranium concentration of the released fluid was 1.8 mg/l and the release affected approximately 0.11 acres.	The release occurred when a welded joint in a carbon steel tee failed.	The plant was immediately shut down upon discovery of the release and until repairs could be completed. Approximately 3,100 gallons were recovered from two ponded areas.
11/22/06 9:30am	Wellfield 3 (SE¼, SW¼, Sec.26, T36N, R74W)	Approximately 2,100 gallons of mine waste fluid were released and absorbed into the ground. The uranium concentration of the mine waste fluid was 7.1 mg/l and the release affected approximately 0.15 acres.	The release occurred when a fused joint of a 6-inch buried polyline failed.	The line was immediately shut down until repairs could be completed. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
12/5/06 11:00am	Wellfield C, Headerhouse C-22	Approximately 10,000 gallons of mixed monitor well and restoration and mine waste fluid were absorbed into the ground. The released fluid had an approximate uranium concentration of 1.0 mg/l and affected approximately 0.26 acres.	The release occurred when a PVC line tied to the cleanout line failed as a result of freezing and subsequent breakage.	Upon discovery, the line was immediately shut down until repairs were completed. Approximately 9,000 gallons were recovered.
12/13/06 11:30am	Wellfield I, Well I-1-14	Approximately 560 gallons of injection fluid were absorbed into the ground. The released fluid had an approximate uranium concentration of 2.0 mg/l and affected approximately 0.04 acres.	The release occurred when a water trap failed as a result of corrosion preventing proper seating.	Upon discovery, the line was immediately shut down until repairs could be completed.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
1/13/07	Wellfield F, bellhole F-47	Approximately 5,000 gallons of injection fluid were released. The uranium concentration of the fluid was 2.0 mg/l and the release affected 0.03 acres.	The release occurred with the failure of a metal fitting.	Upon discovery, the line was immediately shut down until repairs could be completed. A total of 3,500 gallons were recovered with a vacuum truck. Mine Unit F and parts of Mine Unit D were taken out of service while an investigation was conducted to assess the cause.
2/19/07 8:15am	Wellfield 15, production well P-76	Approximately 6,000 gallons of production fluid were released. The uranium concentration of the fluid was 32.5 mg/l and the release affected approximately 0.09 acres.	The outer casing was checked and found to be good, the inter tubing had a hole and was replaced.	Upon discovery, the line was immediately shut down until repairs could be completed. A total of 5,500 gallons were recovered.
5/21/07	Wellfield I, Injection well I-19	Approximately 700 gallons of injection fluid were released and absorbed. The uranium concentration of the fluid was approximately 1.2 mg/l and the release affected 0.03 acres.	The cause was a petcock valve left in the open position.	Upon discovery, the valve was closed by the operator. The entire area will be reevaluated during the decommissioning of the wellfield to ensure that applicable decommissioning standards for soils are met.
6/19/07 12:30pm	Wellfield K, Injection well KI-156	Approximately 900 gallons of production fluid were released, with a uranium concentration of approximately 41.2 mg/l. The release affected approximately 0.03 acres.	An employee had finished swabbing well KI-156 and was backing the truck to attach the water trailer. The trailer was bumped when attempting to hook-up and the plastic water tank was breached, releasing the fluid.	The trailer was taken out of service. Approximately 60 gallons were recovered with a vacuum truck. The affected soils were removed from the spill area and disposed of at a licensed By-Product Facility.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
6/22/07	Wellfield H, injection well HI-744	Approximately 198,500 gallons were released from the injection well, with a uranium concentration of 3.3 mg/l.	HI-744 was not adequately isolated. A tee and valve were left in place on the meter run to HI-744 after HI-744 was removed from service. The valve isolating HI-744 was mistakenly opened and the valve to well HP-3911 was closed.	See Appendix A-8.1-2
6/25/07	Wellfield H, production well HP-397	Approximately 3747 gallons of production fluid were released with a uranium concentration of 21.0 mg/l, affecting 0.28 acres.	Corroded brass nipple at the wellhead.	See Appendix A-8.1-2
6/27/07	Wellfield 2, injection well 2-I-166	Approximately 900 gallons of injection fluid was released, with a uranium concentration of 1.1 mg/l. The release affected approximately 0.07 acres.	The release was caused by a broken flange.	Mine Units 2 and 3 were shut off until all wells could be inspected. The wells were inspected for potential problems as they were brought back on line.
8/23/07 10:55am	Deep disposal pipeline adjacent to Wellfield 2	Approximately 11,600 gallons of deep disposal fluid were released from the buried pipeline with approximately 7,500 gallons surfacing. The release affected approximately 0.34 acres.	The cause of the release was a failure of a cold fusion joint in the buried Deep Disposal polyline.	The line was shut off and repaired.
7/18/08 12:00pm	Booster station #5, located northeast of Wellfield 4	Approximately 2,887 gallons of production fluid were released from the booster pump station. The release affected approximately 0.18 acres.	Failure of a poly-can that encases a booster pump as a result of heat/pressure in the pump, and consequent melting of the polyethylene material of the can.	Upon discovery of the leak, the wellfield was immediately shut down. Corrective actions included setting booster pump drives to operate above a specific frequency, and an alarm if it falls below the frequency.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
8/17/08 1:00am	Mine Unit K injection trunk line to Headerhouse K-6	Approximately 7,965 gallons of injection fluid were released, with a uranium concentration of 1.4 ppm. The release affected approximately 1.55 acres.	The cause of the leak was a fuse joint failure on the trunk line.	Upon discovery, the pipeline was immediately isolated by shutting down the trunk line. A vacuum truck recovered 450 gallons of the spilled solution.
9/17/08 1:30am	Booster House #3, located northeast of Wellfield K	Approximately 3,932 gallons of production fluid were released from the booster station.	The cause of the release was a failure of a polyethylene can that encases a booster pump as a result of heat/pressure in the pump, and consequent melting of the polyethylene material of the can.	The wellfield was immediately shut down. Corrective actions include setting booster pump drives to operate above a specific frequency and to alarm if it falls below the frequency.
10/30/08 12:23am	Mine Unit K injection 8-inch trunk line to Headerhouse K-7	Approximately 5,500 gallons were released from the trunk line, with an approximate uranium concentration of 2.0 ppm. The release affected approximately 1 acre.	The cause of the leak was a failed electrically fused collar.	The pipeline was immediately isolated upon discovery of the leak by shutting down the trunk line. The use of the electric fusion below ground was discontinued in August 2008.
12/29/08 10:30am	Mine Unit 9, well 9I-44	Approximately 1,144 gallons of injection fluid were released, with an approximate uranium concentration of 0.2 ppm. The released fluid went beyond the fenced area and terminated approximately at the monitor well ring.	A 1-inch polyline from the well was punctured while attempting the removal of ice at the wellhead. The well was not operating at the time and the operator did not realize the puncture had occurred. The well was turned back on at the header house and the release occurred.	The well was immediately shut down until repairs could take place. The polyline was repaired.
1/9/09 3:00pm	Mine Unit 15, well 15P-122	Approximately 2,169 gallons of production solutions were released, with an estimated U_3O_8 concentration of 11 ppm.	A 1½ -inch transition at well 15P-122 was leaking due to rusted threads.	Approximately 2,000 gallons were recovered and disposed of via deep disposal well. Transitions of this type were inspected visually and replaced as needed.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
1/10/09 10:30pm	Satellite No. 2	Injection and production fluid leaked onto the floor of Satellite No. 2. The sump activated and transferred solutions to a storage tank within the satellite. Approximately 1,820 gallons exited the building.	An 8-inch Schedule 80 dump valve and associated piping broke free of IX-21 in Satellite No. 2, releasing fluid to the process area of the satellite.	The leak was isolated, clean up was completed, and radiation surveys confirmed the clean-up was successful. The satellite and affected area was cordoned off to reduce access until radiological surveys were completed. The dump valve and piping were repaired and the satellite placed back into service.
2/9/09 8:30am	Valve station in Wellfield 2 (SE¼, SE¼, Sec. 26, T36N, R74W)	Approximately 14,600 gallons of production solution were released with a U_3O_8 concentration of approximately 7 ppm.	A 16-inch steel tee on the main pipeline between Satellite SR-1 and the Central Processing Plant was leaking due to corrosion.	The valve station was repaired. Approximately 3,800 gallons were recovered and disposed of via deep disposal well. At the time of the leak, Cameco Resources already had a list of this type of valve station prioritized based on risk of a leak. The details from this spill were used to refine that list and implement repairs as necessary.
4/2/09 7:50pm	Mine Unit K, Well no. KI-218	Approximately 1,474 gallons of injection solution were released from the well, with a U_3O_8 concentration of approximately 2.0 ppm.	The release was caused by operator error.	Mine manager met with all wellfield operators to discuss incident.
5/11/09 11:45pm	Mine Unit J, Headerhouse J-3	Approximately 6,500 gallons of production solution were released, with a U_3O_8 concentration of approximately 19.8 ppm. Most of the released fluid was contained within the header house.	The release resulted from a failed gasket.	Approximately 5,600 gallons of the released fluid were recovered from the headerhouse.
5/26/09 1:00pm	Mine Unit H, well HI-43	Approximately 5,050 gallons of injection fluid were released from the well, with an approximate U_3O_8 concentration of 3.0 ppm.	The release was the result of the flange separating from the wellhead casing.	The H wellfield was turned off, awaiting replacement fittings for several wellheads in the H wellfield. Approximately 7,350 gallons were recovered, which included rainwater that had pooled in the area and co-mingled with the injection fluid.

TABLE A-8.1-1

SUMMARY OF SPILLS AND RELEASES

Date of Detection	Location	Description	Cause	Resolution
6/10/09 12:30pm	Mine Unit 9, Well no. 9I-142	Approximately 190 gallons of injection solutions were released from the well, with an approximate U_3O_8 concentration of 0.7 ppm.	A 1-inch diameter line was accidently damaged, causing the leak. The damage may have been from digging that occurred in a nearby drill pit.	The line was repaired.
8/26/09 4:30am	Mine Unit K, Well no. KI-10	Approximately 1,500 gallons of injection fluids were released from the well, with an estimated U_3O_8 concentration of 1.1 ppm.	The release was caused by the failure of a brass pipe nipple at the wellhead which had corroded from the inside.	During well repairs prior to the release, the decision was made to replace these brass nipple fittings with stainless steel fittings. As a result of the spill, a wellfield operator was been assigned to inspect all the wellheads in the wellfield to expedite and prioritize replacement of the fittings.
9/23/09 2:30pm	Bellhole No. 21E, near Headerhouse 1 in Mine Unit E	Approximately 90,600 gallons of treated process water were released from Bellhole No. 21E, with an approximate uranium concentration of 0.01 mg/l.	The release resulted from an open, unused 3-inch clean-out line connected to the Selenium Treatment Plant.	The source of the release was immediately turned off and two vacuum trucks were mobilized to the scene, recovering approximately 22,000 gallons of the released water.
11/19/09	Mine Unit 9, Well 9I-127A,(SE¼, SE¼, Sec.8, T35N, R74W)	Approximately 560 gallons of injection solution was released with a U_3O_8 concentration of 1.4 ppm.	Operator swabbed well onto ground rather than the water trailer.	Apparent cause investigation resulted in a revision to the SOP, and the changes were reviewed with all swabbing operators.
1/28/10	MU-J, JI-184, in HH-J-5	Approximately 224 gallons of injection solution was released with a U_3O_8 concentration of 1.3 ppm.	Pop off valve had PVC shavings back flushed into the valve seat, causing failure.	The well was shut off and the valve replaced.

FIGURES FOR APPENDIX A-8.1-2

1.0 BACKGROUND

This section provides a description of the largest release having occurred within the licensed area as of the submittal of the previous license renewal document (November 15, 1999) and an evaluation of the environmental impacts. The review period is in accordance with the requirements of NUREG-1569 "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*", which for a license renewal is ten years since the last license renewal submittal for the current license. Included in the description are summary discussions of the cause, reporting, regulatory response, actions taken by Cameco Resources in response to the regulatory response, and the nature and extent of environmental impacts.

The history of the largest release is reviewed to provide documentation of the methods by which Cameco Resources responded to the accidental release, from its initial detection and self-reporting to state regulatory agencies and the NRC throughout the investigation of causes and impacts, and finally to document the remedial actions taken in protection of the environment. It is important to note that the areal extent and depth of the release were confined to Cameco Resources' property and the licensed area, and did not impact adjacent landowners or nearby communities. The environmental impact of the release has been completely mitigated. Topsoil was the only affected medium, and all affected topsoil was removed and disposed as part of the mitigation.

2.0 LARGEST RELEASE

The largest release within the SR-HUP Licensed area occurring during the current licensing period occurred in the Highland MU"H" (refer to location map, Figure A-8.1-2.1). The release began on May 25, 2007 and continued for approximately 28 days. Both a production and an injection well were ultimately involved in the release. A total of 198,500 gallons was calculated to have been released from injection well HI-744 as a result of human error. During the field inspection and investigation, production well HP-397 was found to be leaking into the wetted area of HI-744, resulting in an additional 3,747 gallons. Figure A-8.1-2.2 illustrates MU"H", and shows the location of the affected wells. As described in greater detail below, the release originated from a valve which was incorrectly opened in headerhouse H-12 affecting HI-744, and a failed pipefitting at HP-397. The volume of the release, over the time period that the valve was opened, correlates to a flow rate of less than five gallons per minute (gpm), comparable to the flow from a normal household faucet.

Cameco Resources (operating as PRI. at the time) reported the release immediately upon detection to the WDEQ LQD and WQD on the 22nd of June 2007. LQD and WQD jointly issued a NOV, Docket No. 4122-07 on the 12th of September 2007, and a Settlement Agreement was documented on the 11th of December 2007.

Documentation reviewed for evaluation of environmental impacts of this release is listed in Section 4.0, below.

2.1 Description of Release

The root cause analysis report (PRI, 2007f) describes occurrence of the release as follows:

> *"On May 25, 2007, maintenance work was completed on the HI-744/HP-3911 meter run and returned to service. After this, a valve on the meter run connecting an out of service well field injection line was opened, causing an environmental release of injection fluid through an uncapped wellhead transition at wellhead HI-744. On June 22nd, a contractor's vehicle became stuck in the saturated zone near the release location, leading to the discovery of the release. On June 24, 2007 a second release was discovered originating from production well HP-397."*

The causes of the release included:

- HI-744 was not adequately isolated. A tee and valve were left in place on the meter run to HI-744 after HI-744 was removed from service.
- Sometime on or after May 25, 2007, the valve isolating HI-744 was mistakenly opened and the valve to well HP-3911 was closed. Because injection fluid piping to well HI-744 had been disconnected at the wellhead when it was removed from service, injection fluid discharged directly to the surface environment.
- The discharge of injection fluid at wellhead HI-744 went undetected until June 22, 2007.
- A corroded brass nipple caused a second release in MU"H" of production fluid from well HP-397. This release was detected while determining the extent of the affected area from the injection fluid release.

Environmental release of injection fluid was reported as 198,500 gallons. The injection fluid was sampled and analyzed. The uranium (U) concentration of released injection fluid was reported as 3.3 mg/L). Environmental release of production fluid was reported as 3,747 gallons. The production fluid was sampled and analyzed. The U concentration of released production fluid was reported as 21.1 mg/L.

A spill inspection was performed by WDEQ LQD on June 28, 2007 which concluded that there was potential surface damage due to contamination of topsoil with mining fluids. Based on the initial inspection, LQD pursued enforcement action in the form of a NOV.

The WDEQ LQD documented the results of water, vegetation and soil samples and provided recommendations for remediation in a memorandum to file (WDEQ, 2007b) dated the 5th of November 2007. Samples were analyzed for selenium (Se), arsenic (As), radium-226 (Ra^{226}) and uranium. Conclusions of the data analysis were:

- Concentrations of Se, U and Ra^{226} were highest in the shallowest depth of soils samples analyzed (i.e., topsoil, 0 to 2 inches). For this spill, WDEQ requested that samples be collected in the shallow depth (0 to 2 inches) rather than 0 to 6 inches.

- In vegetation samples, elevated Se and Ra^{226} concentrations were found at a distance of 784 feet from the production well. U activity was 0.005 to 0.02 microCuries per kilogram (µCi/kg), which is higher than baseline in the vegetation samples collected.

  - Background concentrations were established for soil, vegetation and the evaluation holes. DH-B6 is the drill hole background location, No. 2 is the vegetation background location and HH-12 is the soil background location.

  - Soil background values were: As 6.3 milligrams per kilogram (mg/kg), Se 0.4 mg/kg, U 1.4 mg/kg and Ra^{226} 8.9 pCi/g. Vegetation background concentrations were: As ND, Se 5.2 mg/kg, U 0.42 mg/kg, and Ra^{226} 8.9E-04 mCi/kg. Drill hole background values ranged from: As was 0.6mg/kg at 90' to 13.10mg/kg at 170', Se ND to 0.9 mg/kg, U 1.0 mg/kg at 20' to 6.3mg/kg at 60', Ra^{226} 0.4 pci/g at 30' to 2.0 pCi/g at 60'.

  - The acceptable concentration for Se in topsoil is 0.8 mg/kg. Analytical results for samples collected in three depth profiles (0 to 2 inches, 0 to 6 inches, and 6 to 12 inches) and at various distances from the spill origination point were elevated, primarily at the 0 to 2 inch depth, and ranged from approximately 1 mg/kg to 17 mg/kg. The furthest distance from the spill origination point showing elevated Se was 2,448 feet. Topsoil samples collected from 0 to 6 inches depth and from 6 to 12 inches depth showed a maximum Se concentration of approximately 2 mg/kg, and had no Se detections above the acceptable value when the sampling distance reached 410 feet.

  - The acceptable value for Ra^{226} in soil is 5 picoCuries per gram (pCi/g) from 0-6". Elevated activity within the 0-6" surfacial soil was detected relatively close to the injection spill origination point, with analytical results of 14 pCi/g and 27 pCI/g at distances of 207 feet and 410 feet, respectively. The soil standard for uranium is 10 pCi/g from 0-6". Elevated activity was detected in the shallowest topsoil profile (0 to 2 inches) at a distance of 2,448 feet from the production well. Uranium activity was at or below the acceptable level at deeper topsoil depths (i.e., 0 to 6 inches and 6 to 12 inches) in all sampling locations.

- Three holes were drilled with air to depths ranging from 120 feet to 200 feet to intercept the first aquifer from surface and assess the spill's effects. The purpose of drilling with air is to ensure that the first water bearing aquifer can easily be detected and potential impacts evaluated. One drill hole was located at the intersection of the two releases, approximately 450 feet to the south of production well HP-397. A second drill hole was located 50 feet beyond the full extent of the spill, approximately 2,900 feet to the south of production well HP-397. The third drill hole was drilled in a background area (unaffected by the spill) and was located approximately 1,000 feet to the southwest of production well HP-397. Drill cuttings were collected at 10 feet intervals to determine contaminant presence and lithology. The samples were analyzed by an outside accredited laboratory and the drill cutting lithology determined by a geologist. The drill cutting samples from the borehole in the affected area was compared to drill cuttings from a background borehole. The effected drill hole cutting constituent analysis was comparable to those obtained from the background drilling cutting samples. Analytical results of the drill cutting samples from the three drill holes and standards are presented in the tables below. It is important to note that the spill was found to have affected soils to a depth of

less than one foot. All analytical results at greater depths are representative of naturally occurring elements, and do not result from normal well field operations or from the spill.

TABLE A-8.1-2.1

ANALYTICAL RESULTS FOR DRILL HOLE H12-DH 004 LOCATED AT THE INTERSECTION OF THE TWO RELEASES (450 FEET SOUTH OF PRODUCTION WELL HP-397) WITH BACKGROUND

Soil Depth	Selenium[1]	Arsenic[1]	Ra^{226}[2]	Uranium[1]
0 to 10 feet	0.4	3.0	1.9	10.3
10 to 20 feet	0.6	2.2	1.6	5.4
20 to 30 feet	0.2	0.8	1.0	3.5
30 to 40 feet	0.5	2.3	1.8	11.7
40 to 50 feet	0.5	2.2	1.1	4.6
50 to 60 feet	1.4	31.1	2.5	6.8
60 to 70 feet	0.4	1.4	0.7	3.1
70 to 80 feet	ND	ND	1.0	3.3
80 to 90 feet	0.5	7.2	1.8	6.2
90 to 100 feet	0.2	8.9	0.8	2.9
100 to 110 feet	0.2	1.3	1.0	2.3
110 to 120 feet	0.4	2.4	0.9	2.9
120 to 130 feet	0.2	1.3	0.6	1.9
130 to 140 feet	0.2	1.7	1.0	1.8
140 to 150 feet	0.4	1.6	0.9	3.1
150 to 160 feet	0.6	4.8	1.8	5.4
160 to 170 feet	0.4	31.8	0.8	2.6
170 to 180 feet	0.6	66.5	1.2	6.5
180 to 190 feet	0.6	68.0	1.8	2.5
190 to 200 feet	1.8	6.9	2.3	4.3
First Aquifer	0.002 mg/l	0.006 mg/l	2.7 pCi/l	0.005 mg/l

[1] Results for Se, As and U in soil are mg/kg-dry.

[2] Results for Ra^{226} are in pCi/g-dry.

[3] ND = Not Detected

TABLE A-8.1-2.2

ANALYTICAL RESULTS FOR DRILL HOLE H12-DH-13 LOCATED 50 FEET BEYOND THE FURTHEST EXTENT OF RELEASE (2,900 FEET SOUTH OF PRODUCTION WELL HP-397) WITH BACKGROUND

Soil Depth	Selenium[1]	Arsenic[1]	Ra^{226}[2]	Uranium[1]
0 to 10 feet	ND	2.3	0.8	2.3
10 to 20 feet	ND	0.8	0.5	1.1
20 to 30 feet	ND	1.7	0.7	3.1
30 to 40 feet	0.9	2.8	2.6	8.1
40 to 50 feet	0.4	2.4	1.2	3.7
50 to 60 feet	0.2	3.0	1.0	3.1
60 to 70 feet	0.7	4.2	1.1	3.1
70 to 80 feet	0.3	1.4	0.9	3.1
80 to 90 feet	0.7	1.7	1.8	3.7
90 to 100 feet	1.8	3.7	4.1	10.2
100 to 110 feet	0.7	3.3	2.3	4.6
110 to 120 feet	0.2	2.4	1.3	2.3
First Aquifer	0.001 mg/l	0.007 mg/l	0.7 pCi/l	0.0033 mg/l

[1] Results for Se, As and U in soil are in mg/kg-dry.

[2] Results for Ra^{226} are in pCi/g-dry.

[3] ND = Not Detected

TABLE A-8.1-2.3

ANALYTICAL RESULTS FOR DRILL HOLE H12-DH-B6 LOCATED IN UNAFFECTED AREA - i.e., BACKGROUND (1,000 FEET SOUTHWEST OF PRODUCTION WELL HP-397)

Soil Depth	Selenium[1]	Arsenic[1]	Ra^{226}[2]	Uranium[1]
0 to 10 feet	0.9	1.7	1.1	3.9
10 to 20 feet	ND	1.5	0.6	1.2
20 to 30 feet	ND	1.5	0.4	1.0
30 to 40 feet	0.4	3.6	0.8	3.1
40 to 50 feet	0.6	2.2	1.7	4.5
50 to 60 feet	0.8	2.5	2.0	6.3
60 to 70 feet	ND	1.4	1.0	1.9
70 to 80 feet	ND	1.5	1.1	2.3
80 to 90 feet	0.4	0.6	1.7	2.5
90 to 100 feet	0.3	1.5	1.3	2.7
100 to 110 feet	0.3	2.1	0.9	2.7
110 to 120 feet	0.4	2.7	1.5	2.1
120 to 130 feet	0.3	1.4	1.0	1.9
130 to 140 feet	ND	1.2	0.7	1.8
140 to 150 feet	ND	1.5	0.8	1.6
150 to 160 feet	0.2	1.8	0.8	2.4
160 to 170 feet	0.4	13.1	0.4	1.4
170 to 180 feet	0.4	2.9	0.9	2.7
180 to 190 feet	0.8	2.9	1.2	3.4
190 to 200 feet	0.5	1.6	0.9	2.6
First Aquifer	0.002 mg/l	0.005 mg/l	1.2 pCi/l	0.0046 mg/l

[1] Results for Se, As and U in soil are in mg/kg-dry.

[2] Results for Ra^{226} are in pCi/g-dry.

[3] ND = Not Detected

TABLE A-8.1-2.4

STANDARD CRITERIA AND/OR RECOMMENDATIONS IN WATER VEGETATION AND SOIL FOR SE, AS, RA 226, AND U (WDEQ, 2007B)

Sample Type	Selenium (Se)	Arsenic (As)	Ra^{226}	Uranium (U)
Surface Water, Class 3	0.5 mg/L	7 µg/L	60 pCi/L	No standard
Ground Water, Class 3	0.05 mg/L	0.2 mg/L	5 pCi/L	5 mg/L
Vegetation	5 ppm	Baseline	Baseline	Baseline
Soil	0.8 mg/kg	Baseline	5 pCi/g	10 pCi/g
Soil water solution	0.05 ppm	No standard	No standard	No standard

Regulatory sources for these standards, as documented in the WDEQ memorandum (WDEQ, 2007b), are as follows:

Surface Water, Class 3 standards for Se, As, and Ra^{226}: Wyoming Department of Environmental Quality, Water Quality Rules and Regulations, Chapter 1.

Ground Water, Class 3 standards for Se, As, and U: Wyoming Department of Environmental Quality, Water Quality Rules and Regulations, Chapter 8.

Soil Recommendation for Se: Spackman *et.al.*, Interpretation of Selenium Research for Regulatory Application, Joint Subcommittee on Selenium in Soils, Vegetation, Overburden and Wildlife, 1996.

Soil standard for Ra^{226}: Office of Surface Mining, Overburden Sampling and Analytical QA/QC Requirements for Soils, Overburden and Regraded Spoil Characterization and Monitoring Programs for Federal Lands in the Southwest United States, 1999.

Soil standard for U: NRC, Draft Standard Review Plan for In Situ Leach Uranium Extraction License Application, NUREG-1569.

Soil/water solution recommendation for Se: Colorado State University Extension-Natural Resources, No. 6.109. Diagnosing Selenium Toxicity.

Remediation recommendations provided by LQD included removing soil to a depth of 8 to 12 inches in the impacted areas, as delineated by LQD on Figure A-8.1-2.2, re-seeding the stripped area, and stabilizing to prevent erosion until the vegetative cover is established. Monitoring was recommended to be conducted in the fall of 2008 for Se, U, and Ra^{226} in soil and vegetation samples in the area of the spill that was not to be stripped. Cameco Resources also contracted Worley Parsons Komex for an environmental assessment of the release. Cameco Resources provided sampling and analytical data for the analysis performed by Worley Parsons Komex, which included soil, water, and vegetation sampling as well as a gamma survey and maps of the area impacted by the release. A letter report (Worley Parsons Komex, 2007) described the nature and extent of the release, and provided recommendations for remediation based on review of applicable environmental regulations and precedents. Recommendations made by Worley Parsons Komex included

excavation and disposal of soils impacted by radium at a level of 5 pCi/g or greater within a defined area (near Pool 6) to a depth of 12 inches. Remediation for the uranium concentration associated with the released fluids was considered to be driven by health risk based exposure (dose) modeling, and the existing data and models supported a conclusion that "*it (was) highly unlikely that observed concentrations present an unacceptable risk to human health or the environment*".

2.2 Enforcement Action

WDEQ LQD and WQD jointly issued the NOV Settlement Agreement on December 11, 2007 (WDEQ, 2007a). Corrective action required by the terms of the Settlement Agreement included removing topsoil in the impacted area to a depth of 8 to 12 inches. The Settlement Agreement also recommended that the removed topsoil be replaced with a suitable soil material if the stripped depth represented a significant percentage of the total pre-existing depth of topsoil. Other recommendations were made for seed mix selection and temporary protection of the re-seeded area from grazing.

The Settlement Agreement also required changes to Cameco Resources' facility operations and maintenance as follows:

- Installation of a leak detection system with an alarm on new well fields (beginning with MU "K") within one year of the Settlement Agreement date;
- Daily inspections (and documentation thereof) of all operating well fields and header houses beginning immediately within the signed Settlement Agreement;
- Designation of an individual to provide consistent and periodic training of standard operating procedures (SOPs), to be implemented within one year of the signed Settlement Agreement;
- Abandon the practice of reusing unions after maintenance on fittings;
- Installation of early detection systems for all Bell Holes;
- Continue to systematically test and replace as needed materials/parts in well fields, including all flanges of the type that failed in MU "2", with a goal to have all replacements complete within one year of the signed Settlement Agreement; and
- Replacement of wetted wellhead fixtures on all operational wells to be completed at least every five years from initial startup for active wells. If the combination of standby and operational life is five years or more, then the wellhead fixtures must be replaced before the well is placed back in service.

Cameco Resources was also required to provide a revision to WDEQ Mining Permit 603 including a discussion of spill maintenance, prevention and reporting. A materials management plan was also required with the permit revision. The permit revision was due and completed within 90 days of the signed Settlement Agreement. Cameco Resources was also issued a fine by the WDEQ, with an initial payment of approximately two-thirds and stipulation to waive the remaining approximately one-third if all other Settlement Agreement conditions were met.

2.3 Remedial Action

A Cameco Resources internal memorandum (Cameco Resources, 2008a) documented agreements reached with WDEQ for mitigation efforts. Each item in the NOV was addressed, including soil removal depth and areal extent, re-seeding, continuation of monitoring in the non-stripped spill area, and sediment control measures. Operational requirements were also addressed, including installation of leak detection systems, daily inspection and documentation of well field and header houses, designation of an individual for oversight of re-training, ending the practice of re-using unions after repair or maintenance, installation of early detection systems for pipeline Bell Holes, systematic testing and replacement of materials and parts in the well fields, replacement of wetted wellhead fixtures on operational wells every five years, and maintenance of on-site documentation for verification of compliance with the operational requirements.

A sediment control plan for a collection sump (prepared by Hydro-Engineering, L.L.C.) was presented by Cameco Resources to WDEQ LQD in a letter dated May 15, 2008 (Cameco Resources, 2008c).

WDEQ conducted a field inspection on June 25 and 26, 2008 (WDEQ, 2008). Findings of the field inspection included an observation that: "*Clay soils near the surface may prevent migration of contaminant below 4-6 inches.*" Following this observation, WDEQ noted that: "*PRI may not need to remove 12 inches.*" It was subsequently determined that only the immediate area around production well HP-397 would require additional soil removal, and soil removal in all other areas was complete. All removed soils were disposed at a licensed 11e2 byproduct facility.

A technical report issued by Cameco Resources (2008f) titled "*H-Field Spill Technical Report, Mitigate Contamination of Soils, Partial Compliance for Notice of Violation Docket No. 4122-07 Permit 603, Cameco Resources, Inc.*" documents that the original agreement describing mitigation of contamination of soils was "*overly conservative and potentially damaging to the environment*". Changes to the mitigation plan (as agreed upon September 11, 2008) included a risk-based approach to mitigation of contaminated topsoil. In summary, the risk-based approach allowed for: "*1) pathway risk assessment for topsoil samples taken July 1, 2008; 2) clean-up of one area that was higher than the other results in the area; 3) additional sampling to further assess the site; and 4) final assessment of the additional samples*". Details of the risk-based approach for As, Se, Ra^{226} and U were presented. Background topsoil samples were collected at four locations outside the spill area and within 500 feet. These samples were analyzed for As, Se, total U and Ra^{226}. Results are summarized as follows:

- As concentration in the background samples was found to range from 0.9 to 7.3 mg/kg, while As results from 22 previous samples within the spill area ranged from 0.9 to 6.5 mg/kg. As results from the spill area were documented (Cameco Resources, 2008f) as "*indistinguishable from background and further assessment is not necessary*".
- Total Se concentration in background samples was found to range from 0.2 to 0.5 mg/kg, while Se results from 22 previous samples within the spill area ranged from 0.5 to 16.7

mg/kg. Extractable Se concentrations from background and from the spill area were also measured. The extractable Se in background was found to be less than 0.001 mg/L while the spill area results ranged from 0.001 mg/L to 0.623 mg/L. *"Guideline No.1 Topsoil and Overburden"* (WDEQ LQD, 1994) states that extractable Se concentrations of 0.3 mg/L to 0.8 mg/L will be considered marginally unsuitable in the upper four feet of soil. Only one sample in the spill area exceeded the "marginally unsuitable" criterion of 0.3 mg/L. This sample was collected at a depth profile of 0 to 2 inches, so it is unlikely that a sample representative of the upper four feet would exceed the "marginally unsuitable" criterion.

- Se concentration in vegetation can also be measured per Guideline No. 1 (WDEQ LQD, 1994) for bond release where there is a possibility of 40 contiguous acres of affected area. Vegetation samples collected in the spill area and in background areas showed that the affected acreage was localized, and less than 40 acres.

- Total U concentration in background samples ranged from 1.4 mg/kg to 3.1 mg/kg, in samples taken at depths of 0 to 6 inches. Total U results from previous sampling within the spill area ranged from 1.5 to 8.2 mg/kg. The spill area results are elevated above background. However, the trigger level for MOU between the EPA and the NRC; EPA & NRC, 2002) is 47 mg/kg. Sampling results for total U within the spill area and in background samples were well below the trigger level, and further assessment of total uranium contamination in the spill area was not necessary.

- Ra^{226} activity in background samples ranged from 1.4 to 3.1 pCi/g, while radium-226 results from 12 sampling points within the spill area taken at depths of 0 to 6 inches ranged from 1.5 to 13.6 pCi/g. The trigger level for radium-226 in residential soil (per the MOU, EPA & NRC, 2002) is 5 pCi/g necessitating further analysis by risk assessment. The *RESRAD* computer code was used to calculate site-specific radiation dose and excessive lifetime cancer risk to a chronically exposed on-site resident. The risk assessment was based on operational and public scenarios. The operational exposure was modeled as two hours of labor per month at an affected wellhead location. The public exposure was modeled as a hunter being in the area for a few hours per year. The highest analyzed value for Ra^{226} in the spill area (i.e., 26 pCi/g) was used in the model. This is conservative since the sampled locations exhibited lower concentrations, and the topsoil in the vicinity of the highest analyzed reading was removed in September 2008. A recent Ra^{226} result for that location is 0.9 pCi/g. The worker and public exposure doses were projected by *RESRAD* modeling to be less than 0.2 mrem. The allowable annual limits for workers and the public are 5,000 mrem and 100 mrem, respectively. The *RESRAD* modeled dose is far below both annual limits, and shows that radium activity in the spill area does not present a health risk to either workers or members of the general public.

WDEQ decided to close those sections of the Settlement Agreement that required removal and disposal of contaminated topsoil at a licensed 11e2 byproduct facility (WDEQ, 2007a; Settlement Agreement paragraphs 4A and 4B), based on soil mitigation and calculated low risk at this site, and to proceed with drill seeding during the 2009 spring growing season.

2.4 Current Status

The *"Permit to Mine 603 Highland Uranium Project, 2009 Annual Report"* (Cameco Resources, 2009g) provides the most current record of remediation activities in the MU "H" spill area. Seeding an area of 2,983 square feet (0.07 acres) was reported to have occurred on October 8, 2008. The type of seed,

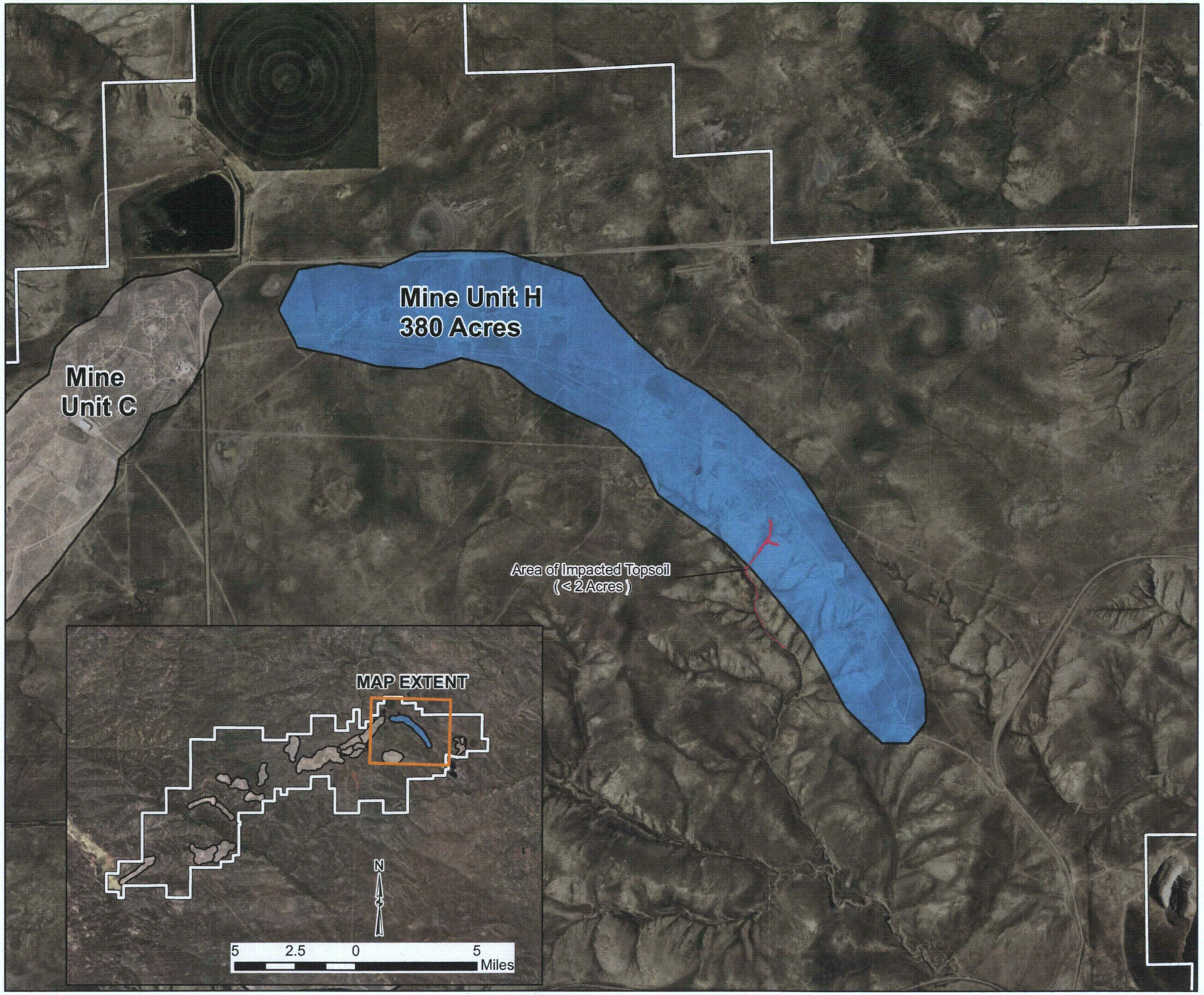
seeding procedure, rate of application, type and rate of fertilizer, and type and rate of mulch is documented in Table 4-1 of the 2009 Annual Report (Cameco Resources, 2009e). Table 4-2 of the 2009 Annual Report (Cameco Resources, 2009e) presents summary activities of the Proposed Reclamation Plan, which include: seeding and fertilization of the exposed area, implementation of surface erosion controls, and importing additional soil if necessary. The affected acreage was documented as less than one acre in the MU "H" spill area.

3.0 CONCLUSIONS

Environmental impacts of the MU "H" spill were mitigated through corrective actions by Cameco Resources, in full cooperation with WDEQ LQD and WQD. Immediately upon detection, the cause of the release (open valve and failed pipe fitting) was corrected and the release was reported. Cameco Resources investigated the cause and cooperated with WDEQ in the investigation of the nature and extent of the release within weeks of initial detection. When it was determined that the extent of contamination was limited to topsoil, Cameco Resources removed and disposed the affected soil, reseeded and stabilized the area. Cameco Resources also contracted Worley Parsons Komex for a "third-party" environmental assessment of the release and review of applicable regulation and precedents to ensure that Cameco Resources' mitigation efforts would adequately address potential regulatory issues.

As shown on Figure A-8.1-2.2, the release was limited to a total area of less than two acres, completely on Cameco Resources' property and within the permitted area. The contamination was limited to topsoil and the affected topsoil was removed and properly disposed. The release had no immediate or long-term environmental impacts on neighboring properties. The environmental impacts in the release area have been mitigated by re-establishment of vegetative cover. The area has been reseeded, fertilized and stabilized with erosion controls. All terms of the Settlement Agreement have been met.

FIGURES FOR APPENDIX A-8.1-2



LEGEND

- Smith Ranch-Highland Uranium Project Boundary
- Mine Unit H
- Extent Of Largest Spill
- Mine Unit C

REFERENCES

Project and Mine Unit Boundaries: Base map provided by Cameco Resources to Golder Associates Inc. on August 28, 2009.
Projection: UTM, Zone 13 North, NAD83, Meters.

1,500 750 0 1,500 FEET

SCALE 1:18,000 1 INCH = 1,500 FEET
WHEN PRODUCED AT SIZE 11X17IN

N

PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

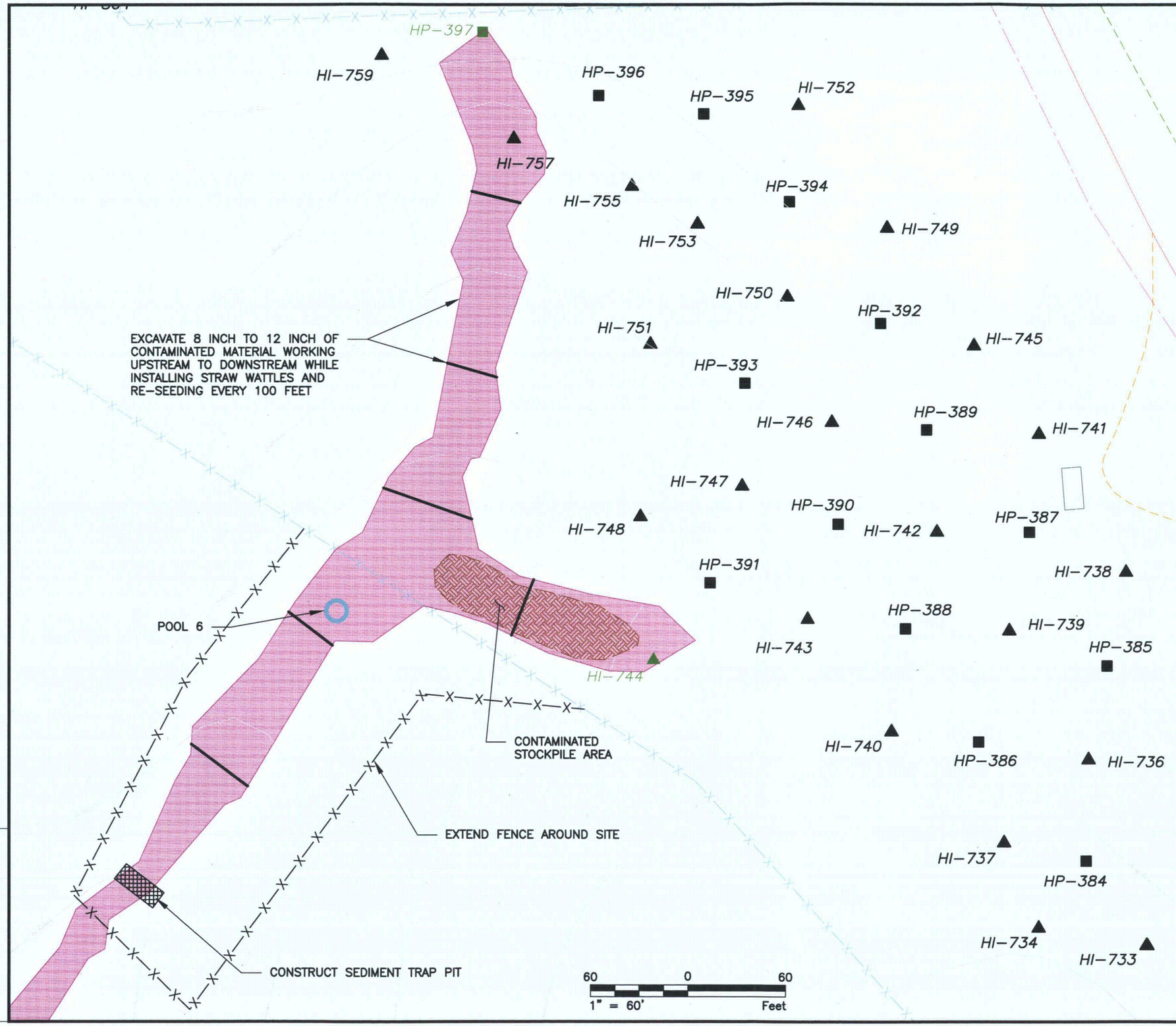
TITLE

LOCATION OF MINE UNIT H AND LARGEST SPILL

Golder Associates
Denver, Colorado

PROJECT No.		093-81703	FILE No. 11x17_RA_MineUnitH.mxd	
DESIGN	AR	12/01/2009	SCALE AS SHOWN	REV 0
GIS	AR	12/01/2009		
CHECK	MEM	05/11/2010	FIGURE A-8.1-2.1	
REVIEW	KFM	05/11/2010		

Map Document: M:\Cameco\ArcMap\RenewalApp\11x17_RA_MineUnitH.mxd / Modified 7/29/2010 10:44:09 AM / Plotted 7/29/2010 10:44:09 AM by aratke



LEGEND

HP-390 ■	PRODUCTION WELL
HI-740 ▲	INJECTION WELL
HI-744 ▲ HP-397 ■	LEAKING WELLS
	IMPACTED TOPSOIL
	CONTAMINATED STOCKPILE (TOPSOIL REMOVED)
5450	EXISTING GRADE TOPOGRAPHY
—X—X—X—X—	FENCE (EXISTING)
—X—X—X—X—	FENCE (INSTALLED FOR MITIGATION)
	POWER LINE
	PIPELINE
	GRAVEL ROAD
	DIRT ROAD
	REMEDIATION AREA
	STRAW WATTLE
	SEDIMENT TRAP

REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
MINE UNIT H
SPILL CLEANUP

Golder Associates
DENVER, COLORADO

PROJECT No.		093-81703	FILE No.	09381703A011
DESIGN	SD	12/16/09	SCALE AS SHOWN	REV. 0
CADD	MTM	12/16/09		
CHECK	PL	12/17/09	**FIGURE A-8.1-2.2**	
REVIEW	KFM	12/18/09		

Plot Time: 08/02/10 15:24

Dwg Name: N:\09\093-81703\A011\...\E RENEWAL\09381703A011.dwg
Layout Name: 11x17 Landscape Machine: DEN1-L-NROSENTH
Last Update: Jul 30, 2010 15:16 By: MTMarks
Last Plot: Aug 02, 2010 15:24 By: nrosenthal

APPENDIX A-8.2

SURFACE AND GROUNDWATER MONITORING HISTORY

Appendix A-8.2 Surface and Groundwater Monitoring History

1.0 INTRODUCTION

This section provides a summary and review of data from the Surface Water and Groundwater Monitoring Programs, as presented most recently in the License Amendment Application (Amendment No. 11) to add RR (PRI, 2007c) and conducted under License SUA-1548. The Groundwater Monitoring and Surface Monitoring programs have not changed or been updated since RR application was submitted, and it is therefore incorporated by reference here.

The Groundwater Monitoring Program at SR-HUP ensures that wellfields are being safely operated and that groundwater excursions are detected in a timely fashion to prevent degradation of groundwater quality outside of the wellfields. The Groundwater Monitoring Program consists of pre-operational monitoring at wellfields, operational monitoring at wellfields, and monitoring at domestic and stock wells near operating wellfields. These monitoring programs, results of the monitoring, and evaluation of the results are described in more detail in Appendix A-8.2-1.

The Surface Water Monitoring Program involves quarterly sampling and analysis of stock ponds located near operating mine units. Sampling and analysis of the ponds ensures that any potential impacts to surface water are detected in a timely manner. The details of the Surface Water Monitoring Program, results of this monitoring, and an evaluation of the monitoring results are provided in Appendix A-8.2-2.

APPENDIX A-8.2-1

HISTORICAL GROUNDWATER MONITORING PROGRAM

1.0 INTRODUCTION

This section provides a summary and review of data from the Groundwater Monitoring Program, as presented in the NRC RR Application of December 2006, Volume I, Chapter 5, Sections 5.1 through 5.3 (PRI, 2006c) and conducted under License SUA-1548. 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 Groundwater Monitoring Program at the SR-HUP provides additional assurance that wellfields are being safely operated and that groundwater excursions are detected in a timely fashion to prevent degradation of groundwater quality outside of the wellfields. The Groundwater Monitoring Program consists of pre-operational monitoring at wellfields (as described in Section 5.1 of the NRC Application of December 2004), operational monitoring at wellfields (Section 5.2), and monitoring at domestic and stock wells near operating wellfields (Section 5.3).

Since the previous license renewal submittal as submitted on November 15, 1999, groundwater monitoring has been conducted at wells used to monitor active MUs at the SR-HUP site and at domestic and stock wells located near the active MUs. The network of wells has been revised over time to adjust to the addition of the HUP by Amendment No. 5, August 18, 2003 and the addition of other MUs. MUs at the SR-HUP site are shown on Figure 8.2-1-1. MUs "A", "B", "C", "D", "D extension", "E", "F", "H", "I" and "J" are part of the HUP, and MUs "1", "2", "3", "4", "4A", "9", "15", "15A", and "K" are part of the SR. Groundwater monitoring at RU, NB, GH, and RR (see Figure A-8.2-1-2) has not been conducted since the previous license submittal as these sites are not in production as of the time of this License Renewal submittal. However, as a result of a review of Ground and Surface Water Rights for the licensed area, an update of SR-HUP Application Addendum D6-8 for Surface and Ground Water Rights for T35_R74, T36_R72, T36_R73, T36_R74, T37_R73 and T37_R74 has been prepared and included in this submittal on an accompanying CD under a separate PDF file due to the extensive nature of the information contained in the tables.

Additional MUs are added through the SERP process. Section 2.0 summarizes the circumstances under which Cameco Resources must obtain a License Amendment and/or NRC approval, and the regulatory basis for adding MUs through the SERP process. Section 3.0 provides a summary of groundwater monitoring program at each MU, and Section 4.0 provides a summary of groundwater monitoring at domestic and livestock wells near active MUs. Excursions are discussed in Appendix A-4.1.

2.0 REGULATORY PROCESS

Source Materials License SUA-1548 issued to Cameco Resources is a Performance-Based License, and under that license Cameco Resources 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 submittal (as updated);

- Make changes in the procedures presented in the license submittal (as updated); and/or
- Conduct tests or experiments not presented in the license submittal (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:

- Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license submittal (as updated);
- Result in any appreciable increase in the likelihood of occurrence of a malfunction of a SSC important to safety previously evaluated in the license submittal (as updated);
- Result in any appreciable increase in the consequences of an accident previously evaluated in the license submittal (as updated);
- Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license submittal (as updated);
- Create a possibility for an accident of a different type than any previously evaluated in the license submittal (as updated);
- Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license submittal (as updated);
- Result in a departure from the method of evaluation described in the license renewal submittal (as updated) used in establishing the FSER or the EA or TERs or other analysis and evaluations for license amendments; and
- For purposes of this paragraph as applied to this license, SSC means any SSC which has been referenced in a staff SER, TER, EA, or EIS and supplements and amendments thereof.

Additionally, Cameco Resources must obtain a license amendment unless 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 facility SER, TER, and EIS or EA. This would include all supplements and amendments, and TERs, EAs, EISs issued with amendments to this license.

Determination of compliance concerning the above listed conditions will be made by a SERP." The SERP will consist 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 process allows Cameco Resources to evaluate and approve pre-mining aquifer pump tests and with approval of the WDEQ, start up of a new wellfield.

3.0 MONITORING AT MINE UNITS

Groundwater monitoring is conducted at MUs that are in operation to provide early detection of any migration of extraction fluids from the portion of the aquifer where uranium recovery occurs, which is referred to as the "production zone". Also, groundwater monitoring is performed on MUs undergoing restoration to evaluate the effectiveness of the restoration program. The monitoring program provides a means of detecting production fluids that may migrate outside the production zone into other portions of the MU, or into overlying or underlying aquifers. Therefore groundwater monitoring at MUs consists of sampling monitoring wells completed in the production zone aquifer, overlying aquifer, and underlying aquifer.

3.1 Monitoring Well Network

Monitoring wells completed in the production zone aquifer consist of two types: wells completed in the mineralized production pattern area (designated as "MP" wells); and wells configured in a "ring" approximately 500 feet outside the mineralized production pattern (designated as "M" wells). MP-wells are not sampled during the production phase of the mining operation and are used for obtaining pre-mining baseline data and post-mining restoration monitoring.

Wells completed in the overlying aquifer are designated as "MS" or "MO", depending on the MU, and wells completed in the underlying aquifer are designated as "MD" or "MU". For MUs identified with a letter, the letter precedes the monitoring well type (such as monitoring well JMO-004, which is completed in the overlying aquifer at MU "J"). For MUs identified with a number, the letter follows the monitoring well type (such as well MD-410, which is completed in the underlying aquifer at MU "4"). Some monitor wells are designated for water-level monitoring only because they pump dry during the evacuation of the required one casing volume prior to sampling. In some cases wells are designated Trend Wells and are located between the outer injection wells and the monitor ring to detect potential migration of fluids prior to impacting the monitor ring. The trend wells are not utilized as excursion indicators for compliance purposes.

3.2 Baseline, Production, and Restoration Monitoring

Baseline samples are collected prior to the mining operation in any given wellfield to characterize the aquifer and establish UCLs for excursion indicators and restoration targets. Baseline samples are sent to an accredited outside laboratory with an accompanying Chain of Custody to be analyzed for WDEQ, LQD Guideline 8 parameters. After four rounds of sampling are completed the UCLs are established and approved by the WDEQ for the parameters of interest.

Wells outside the mineralized production pattern of the production aquifer (i.e., M-wells) and wells in the overlying and underlying aquifers are monitored for water levels and excursion parameters (i.e., chloride, alkalinity, and conductivity) twice a month with at least 10 days between sampling events during production operations and every 60 days during restoration. Production pattern monitoring wells (MP-wells) are also monitored every 60 days during restoration operations to evaluate the restoration

progress. The collected samples are analyzed in the on-site Chemical Laboratory and once a month split samples are sent to an outside accredited lab for quality assurance. Monitoring results for the excursion parameters are compared to the UCLs determined from baseline data to determine if an excursion of production fluids has occurred. If concentrations of any two of the three excursion parameters exceed the UCLs, then the results indicate that an excursion has possibly occurred. Excursions at each MU are summarized in Appendix A-4. Each month, approximately 1,700 samples are collected from monitoring wells to monitor for excursions. Excursion events do not necessarily result in environmental impacts, but can be indicative of the unintended movement of production fluids (Miller, 2009).

When an excursion is first indicated by monitoring results, sampling is repeated within 24 hours of receiving the analytical data to confirm the excursion. If the excursion is confirmed, the 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. Weekly monitoring is continued until the excursion is no longer detected in the monitoring sample results. Twelve (12) confirmed excursion events have occurred since the previous license renewal submittal. These events and the follow-up are summarized in the following sections. Operational monitoring at each MU is summarized in the sections below for the "update" period, which extends from the previous license renewal submittal on November 15, 1999, through the first quarter of 2010. During the update period, nine (9) MUs have begun production: MU "2", MU "4", MU "4A", MU "9", MU "15", MU "15A", MU "D extension", MU "I", MU "J", and MU "K". For these MUs, pre-operational hydrologic test data and baseline water quality data were submitted to the WDEQ LQD for approval prior to injection of lixiviate in the well field to begin production. Hydrologic test results, UCLs, and baseline water quality data were reviewed by a SERP prior to wellfield start-up. Copies of the SERP reviews are submitted to the NRC in the Semi-Annual Effluent and Environmental Monitoring Report. For each new MU, a SERP ensured that the pre-operational test documents met the requirements stated in the most recent approved License Renewal Submittal (December 2004, Chapter 5, 5.1.3 "Mine Unit Hydrological Test Document"). Additionally, a SERP determined that there is no increased environmental or safety risk from start-up of each MU. The specific SERP reviews that apply to each new MU are provided in Appendix A.2-2 and are incorporated by reference into this document. Hydrological Test Reports associated with the start-up of the MUs are also referenced with the corresponding SERP in Appendix A.2-2.

During restoration, the groundwater monitoring program continues, but with changes to the monitoring network and frequency of monitoring. At the start of restoration, the MP-Wells designated as restoration stability monitoring wells are sampled and analyzed for the baseline suite of water quality parameters. Following the initial sampling, the restoration stability monitoring MP-wells are sampled approximately every 60 days during active restoration, with samples analyzed for at least conductivity, chloride, and U. During the groundwater sweep stage of restoration, the monitoring frequency for monitoring wells in the production aquifer (M-wells), overlying aquifer (MO or MS-wells), and underlying aquifer (MU or MD-wells)

is reduced to once every 60 days. Regulatory agencies are contacted if the wells cannot be monitored within 65 days of the last sampling event. Samples from the monitoring wells continue to be analyzed for the excursion parameters, as they were during production. Following concurrence from WDEQ that restoration has been achieved in the MU, a six month stability period is assessed, during which monitoring continues at the restoration stability monitoring MP-wells and the monitoring wells. During this period, the wells are sampled once every two months, with restoration stability monitoring MP-wells sampled for excursion parameters, U, TDS, and other parameters, if necessary, and monitoring wells sampled for excursion parameters.

Sections 3.3 through 3.17 summarize the monitoring program at each MU. A summary of any excursions for each MU is provided in Appendix A-4.

3.3 Mine Unit 1

Production activities at MU "1" ended during the third quarter 2006 and the MU is currently undergoing restoration. The monitoring network at MU "1" consists of 27 monitoring wells completed in the production zone aquifer, outside the mineralized zone (25 wells designated as "M" and two designated as "T"), 11 monitoring wells in the underlying aquifer, and 11 monitoring wells in the overlying aquifer. During the update period, monitoring wells at MU "1" have been sampled twice a month for excursion parameters, with at least 10 days between sampling events.

Restoration activities in the wellfield began in September 2006 with groundwater sweep and recirculation. The RO unit began operation on May 24, 2007. Bioremediation began in the third quarter of 2009.

3.4 Mine Unit 2

MU "2" began production in February 6, 2003 and is currently in production. The monitoring network at MU "1" consists of 24 monitoring wells completed outside the mineralized zone of the production zone aquifer, 13 monitoring wells in the underlying aquifer, and 13 monitoring wells in the overlying aquifer. During the update period, monitoring wells at MU "2" have been sampled twice a month for excursion parameters, with at least 10 days between sampling events.

3.5 Mine Unit 3

MU "3" began production in August 1998 and is currently in production. The monitoring network at MU "3" consists of 17 monitoring wells completed outside the mineralized zone of the production zone aquifer, 10 monitoring wells completed in the underlying aquifer, and 13 monitoring wells in the overlying aquifer. Monitoring at MU "3" has been conducted twice a month for excursion parameters, with at least 10 days between sampling events.

3.6 MU "4" and 4A

MU "4" and "4A" are currently in stand-by status. Production at MU "4" and MU "4A" began in September 9, 1999 and first quarter 2001, respectively. The monitoring network at MU "4" and MU "4A" consists of 57 monitoring wells completed in the production zone aquifer, 17 monitoring wells completed in the underlying aquifer, and 16 monitoring wells in the overlying aquifer. During the update period, monitoring wells at MU "4" and MU "4A" have been monitored twice a month for excursion parameters, with at least 10 days between sampling events.

3.7 Mine Unit 9

MU "9" began production in December 2008 and is currently in production. At the time of this license renewal, MU "9" is in the initial stages of development and 49 wells are being monitored: perimeter wells M-904 through M-920, M-939 through M-945, M-950, M951, and 9MP-012; overlying wells 9MO-002 through 9MO-012; and underlying wells 9MU-002 through 9MU-012. Once MU "9" is fully operational, the monitoring network will consist of 50 monitoring wells completed in the production zone aquifer, 14 monitoring wells completed in the underlying aquifer, and 15 wells in the overlying aquifer. Since operation began, monitoring wells at MU "9" have been monitored twice a month with at least 10 days between sampling events for the excursion parameters.

3.8 Mine Unit 15 and 15A

MU "15" and MU "15A" began production in March 21, 2005 and October 22, 2007, respectively, and are currently in production. The monitoring network at MU "15" and MU "15A" consisted of 64 monitoring wells with 57 monitor wells completed in the production zone aquifer currently being sampled. MU "15A" extended MU "15" and the overlapping monitor wells were discontinued, resulting in a common monitor ring around both MU "15" and MU "15A". Vertical monitoring consists of 34 monitoring wells completed in the underlying aquifer, and 34 monitoring wells completed in the overlying aquifer. During the update period, monitoring wells at MU "15" and MU "15A" have been monitored twice a month with at least 10 days between sampling events for excursion parameters.

3.9 Mine Unit A

Restoration at MU "A" was approved by WDEQ on November 23, 2003 and by NRC on June 19, 2005. From January 1988 until July 1991, the MU was in production. Restoration of groundwater at MU "A" was conducted from July 1991 to October 1998, using groundwater sweep, RO treatment and the addition of chemical reductant. Restoration of this MU was deemed complete and in accordance with the approved reclamation plan and the MU "A" monitoring wells were plugged from March 2005 through May 2005. No groundwater monitoring was conducted at this MU during the update period.

3.10 Mine Unit B

Restoration at MU "B" was approved by WDEQ on March 31, 2008 and is undergoing the approval process with the NRC. Uranium mineralization in the 30-Sand aquifer was mined at MU "B" from January 1988 until July 1991. Restoration of groundwater at MU "B" was conducted from July 1991 to June 2005 using groundwater seep, RO treatment, and the addition of chemical and biological reductants. As discussed in "MU "B" Groundwater Submittal" to the NRC (Cameco Resources, 2009d), restoration has been successful at returning groundwater to its previous Class of Use, as defined by WDEQ Water Quality Rules and Regulations, Chapter 8, Section 4(d).

During the update period, monitoring was conducted at 79 monitoring wells within MU "B": 42 wells completed outside the mineralized zone of the production aquifer; 20 wells completed within the mineralized zone of the production zone aquifer; seven completed in the overlying aquifer; and 10 completed in the underlying aquifer. Monitoring wells were sampled for excursion parameters at an approximate frequency of every 60 days. Monitoring of the wells was discontinued in January 2005, except at well BM-42, which continues to be monitored due to elevated analytical parameters. Details of the excursion are provided in Appendix A-4.

3.11 Mine Unit C

MU "C" is currently undergoing restoration. Uranium mineralization in the 50-Sand aquifer was mined from MU "C" from July 1989 to May 1999. Restoration activities began in August 1997 in the northern portion and have consisted of groundwater sweep, recirculation and degassing, RO, and bioremediation.

During the update period, monitoring was conducted at 111 monitoring wells: 40 wells completed outside the mineralized zone of the production aquifer; 32 wells completed in the mineralized zone of the production zone aquifer; 17 completed in the overlying aquifer; and 22 completed in the underlying aquifer. Because the MU has been in restoration during the update period, monitoring for excursion parameters was conducted approximately every 60 days.

On September 24, 2009, a request was made to WDEQ to move production monitoring well CMP-027 from MU "C" to MU "E" on the basis that this well is located within the production zone wellfield pattern of header house E-1 in MU "E. The WDEQ indicated this was acceptable in a response letter dated December 18, 2009 provided specified conditions were met. A Change Control Form was subsequently issued to WDEQ on January 12, 2010 and final approval of the change request is pending.

3.12 Mine Unit D and D Extension

MU "D" and MU "D-extension" began production in June 11, 1991 and May 1, 2001, respectively, and are in the beginning phases of restoration. The monitoring network at MU "D" and MU "D-extension" consists of 27 monitoring wells completed in the production zone aquifer, eight monitoring wells completed in the underlying aquifer, and one monitoring well in the overlying aquifer. During the update period, monitoring wells at MU "D"

and MU "D-extension" have been monitored twice a month with at least 10 days between sampling events for excursion parameters.

3.13 Mine Unit E

MU "E" began production in November 22, 1991, and is currently in production. The monitoring network at MU-E consists of 26 monitoring wells completed in the production zone aquifer, 12 monitoring wells completed in the underlying aquifer, and 13 wells completed in the overlying aquifer. During the update period, monitoring wells at MU "E" have been monitored twice a month with at least 10 days between sampling events for excursion parameters.

3.14 Mine Unit F

MU "F" began production in May 27, 1994, and is currently in production. The monitoring network at MU-F consists of 46 wells completed outside the mineralized zone of the production zone aquifer, 18 "trend" wells also completed outside the mineralized zone of the production zone aquifer, 21 monitoring wells completed in the underlying aquifer, and 21 wells completed in the overlying aquifer. The 18 trend wells are not used for compliance monitoring. During the update period, monitoring wells at MU"F" have been monitored twice a month with at least 10 days between sampling events for the excursion parameters.

3.15 Mine Unit H

MU "H" began production in November 11, 1998, and is currently in production. The monitoring network at MU "H" consists of 45 wells completed in the production zone aquifer, 12 wells completed in the underlying aquifer, and 15 wells completed in the overlying aquifer. During the update period, monitoring wells at MU "H" have been monitored semi-monthly twice a month with at least 10 days between sampling events for excursion parameters.

3.16 Mine Unit I

MU "I" began production in April 23, 2004, and is currently in production. The monitoring network at MU "I" currently consists of 29 wells: 19 wells completed outside the mineralized zone of the production zone aquifer; one well completed in the mineralized zone of the production zone aquifer; four wells in the overlying aquifer; and five wells in underlying aquifer. During the update period, monitoring wells at MU "I" have been monitored semi-monthly twice a month with at least 10 days between sampling events for excursion parameters.

3.17 MU "J"

MU "J" began production in May 23, 2006 and is currently in production. The monitoring network at MU "J" consists of 30 wells completed outside the mineralized zone of the production zone aquifer, two "trend" wells also completed outside the mineralized zone of the production zone aquifer, and 12 wells completed in the overlying aquifer. The two trend wells are not used for compliance monitoring. Monitoring at MU "J" has been conducted semi-monthly twice a month with at least 10 days between sampling events for excursion

parameters, except at wells JMO-009, JMO-013, and JMO-015, which are sampled weekly for excursion parameters.

3.18 Mine Unit K

MU "K" began production in February 2007, and is currently in production. The monitoring network at MU "K" consists of 29 wells completed in the production zone aquifer outside the mineralized zone, 12 monitoring wells in the underlying aquifer, and 11 monitoring wells completed in the overlying aquifer. Two of the monitoring wells in the underlying aquifer (KMU-003D and KMU-013A) do not contain enough water to sample and are currently being monitored for water levels only. Following approval from WDEQ (WDEQ 2009), sampling at production zone wells KM-029, KM-030, KM-031, KM-032, KM-033, and KM-034 commenced May 6, 2009, and wells KM-001, KM-002, KM-003, KM-005, and KM-028 were dropped from the sampling schedule. Since production began, monitoring wells at MU "K" have been monitored semi-monthly twice a month with at least 10 days between sampling events for the excursion parameters.

4.0 MONITORING OF DOMESTIC AND LIVESTOCK WELLS

Operating livestock and domestic wells within one kilometer of operating MUs have been sampled quarterly for natural U and Ra^{226}. Since the previous license, an additional nine MUs started operating resulting in an increase in the number of livestock and domestic wells that are sampled quarterly. Table A-8.2-1-A summarizes the location and use of each well in the groundwater monitoring program at the time of this license renewal request. The wells are indentified as: GW-1 through GW-6, GW-8 through GW-18, and GW-20. The locations of these wells are shown on Figure A-8.2-1-8.

TABLE A-8.2-1-A

DOMESTIC AND LIVESTOCK WELLS IN GROUNDWATER MONITORING PROGRAM

Site	Location	Source	Use	Analyses
GW-1	Sec. 1, T35N, R 74W	Windmill	Livestock	U, Ra^{226}
GW-2	Sec. 35, T36N, R74W	Water Well	Livestock	U, Ra^{226}
GW-3	Sec. 27, T36N, R74W	Windmill	Livestock	U, Ra^{226}
GW-4	Sec. 23, T36N, R74W	Windmill	Livestock	U, Ra^{226}
GW-5	Sec. 30, T36N, R73W	Windmill	Livestock	U, Ra^{226}
GW-6	Sec. 21, T36N, R73W	Windmill	Livestock	U, Ra^{226}
GW-7*	Sec. 27, T36N, R73W	Water Well	Domestic	U, Rad^{226}
GW-8	Sec. 23, T36N, R73W	Windmill	Livestock	U, Rad^{226}
GW-9	Sec. 14, T36N, R73W	Windmill	Livestock	U, Ra^{226}
GW-10	Sec. 14, T36N, R73W	Water Well	Livestock	U, Ra^{226}

TABLE A-8.2-1-A

DOMESTIC AND LIVESTOCK WELLS IN GROUNDWATER MONITORING PROGRAM

Site	Location	Source	Use	Analyses
GW-11	Sec. 11, T36N, R73W	Water Well	Livestock	U, Ra^{226}
GW-12	Sec. 7, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-13	Sec. 9, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-14	Sec. 10, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-15	Sec. 15, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-16	Sec. 11, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-17	Sec. 8, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-18	Sec. 2, T36N, R72W	Water Well	Livestock	U, Ra^{226}
GW-20	Sec. 27, R36N, R73W	Water Well	Livestock	U, Ra^{226}

* GW-7 was dismantled in 2007 and replaced with well GW-20.

Concentrations of U^{Nat} and Ra^{226} from the livestock and domestic wells are compared to the Effluent Concentrations (EC) 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 ECs are 6×10^{-8} μCi/ml for Ra^{226} and 3×10^{-7} μCi/ml for U^{Nat}. Concentrations of U have exceeded the ECs three times at one well, GW-5, which is located between MUs J and K. These exceedances are summarized in Table A-8.2-1-B. No other results have exceeded the EC Limits.

TABLE A-8.2-1-B

URANIUM RESULTS FOR GW-5 WHICH EXCEED THE EFFLUENT CONCENTRATION LIMIT

Site	Quarter and Year	U^{Nat} Concentration (μCi/ml)	Effluent Concentration Limit (μCi/ml)	% Effluent Concentration Limit
GW-5	3rd Q / 2003	5.9×10^{-7}	3.0×10^{-7}	197.7
GW-5	4th Q / 2004	6.0×10^{-7}	3.0×10^{-7}	199.0
GW-5	2nd Q / 2005	8.4×10^{-7}	3.0×10^{-7}	279.8

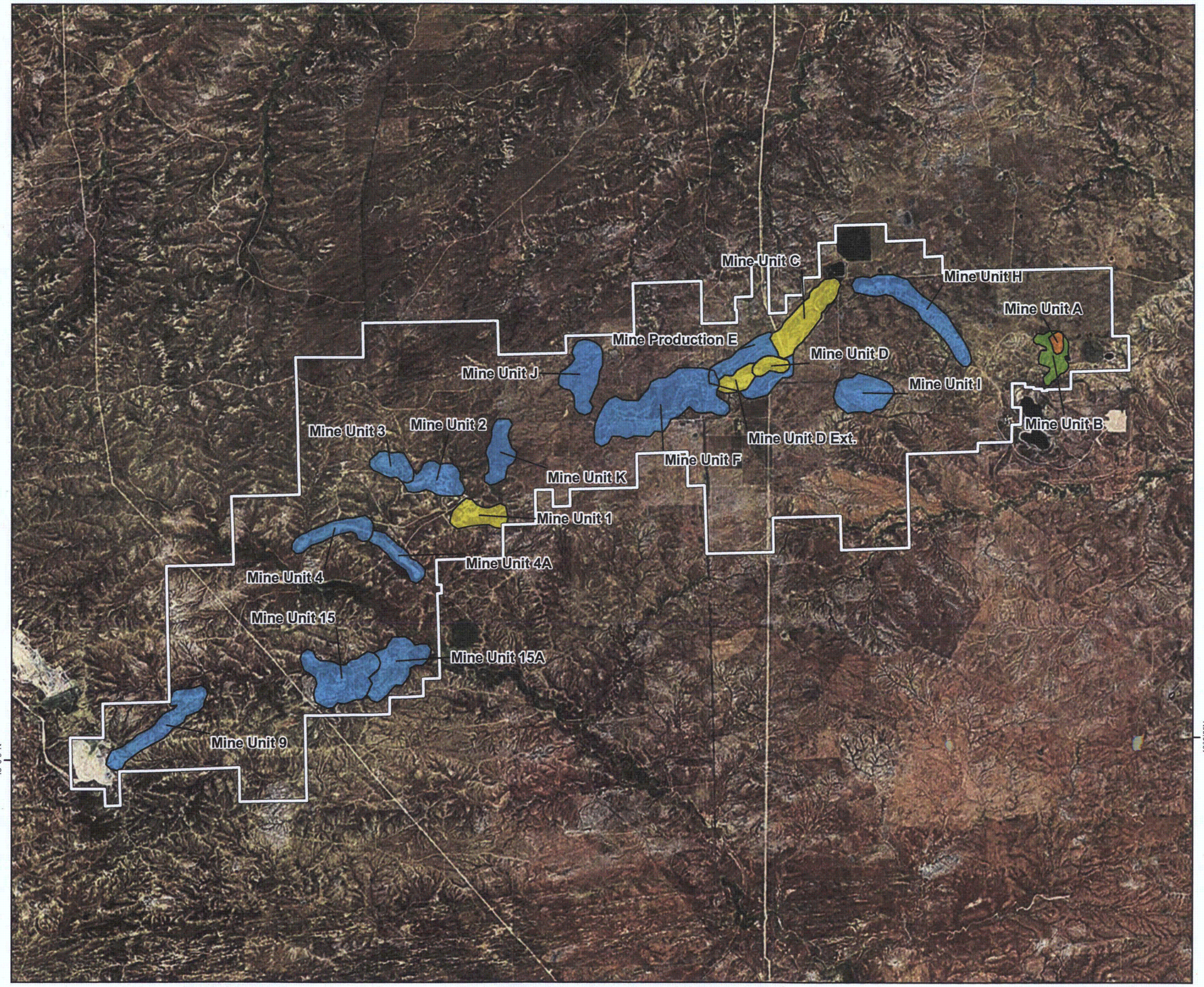
As documented in the July 1 through December 31, 2004 Semi-Annual Effluent and Environmental Monitoring Report for License SUA-1548 (PRI, 2005c), water well GW-5 is located in an area with

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 50 to 120 feet (this was verified on the downhole geophyisical logs from drilling deeper zones that intersected the "E" sandstone from surface down to 120 feet in this area). Well GW-5 has a depth of approximately 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 concentrations in this well are naturally occurring due to the uranium mineralization in the shallow aquifer in which GW-5 is completed. The higher uranium levels at this well are not likely from mining operations due to the large distance to the nearest wellfield operating at the time (approximately 0.5 miles from MU-F), and the known occurrence of these shallow ore bodies.

4.1 Summary

Operating livestock and domestic wells within one kilometer of operating MUs have been sampled quarterly for U^{Nat} and Ra^{226}. Only one well, GW-5, has reported a concentration that exceeds the Effluent Concentrations presented in 10 CFR Part 20, Appendix B. As described in Section 4.0, the high U concentrations at this well are due to natural uranium mineralization in the area in which the well was completed. The results of the groundwater monitoring program indicate that SR-HUP operations have not impacted aquifers encountered at the depths of the wells, which range from approximately 150 feet to 700 feet.

FIGURES FOR APPENDIX A-8.2-1



LEGEND

- Smith Ranch-Highland Uranium Project Boundary
- Undergoing Restoration
- Currently in Production
- Approved Restoration (WDEQ and NRC)
- Approved Restoration (WDEQ)

REFERENCES

Project and Mine Unit Boundaries: Base map provided by Cameco Resources to Golder Associates Inc. on August 28, 2009.
Projection: UTM, Zone 13 North, NAD83, Meters.

8,000 4,000 0 8,000 FEET

SCALE 1:96,000 1 INCH = 8,000 FEET
WHEN PRODUCED AT SIZE 11X17IN

N

PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE

MINE UNITS AT SMITH RANCH-HIGHLAND URANIUM PROJECT

Golder Associates
Denver, Colorado

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GIS	AR	12/01/2009	FIGURE A-8.2-1-1
CHECK	MEM	05/11/2010	
REVIEW	KFM	05/11/2010	

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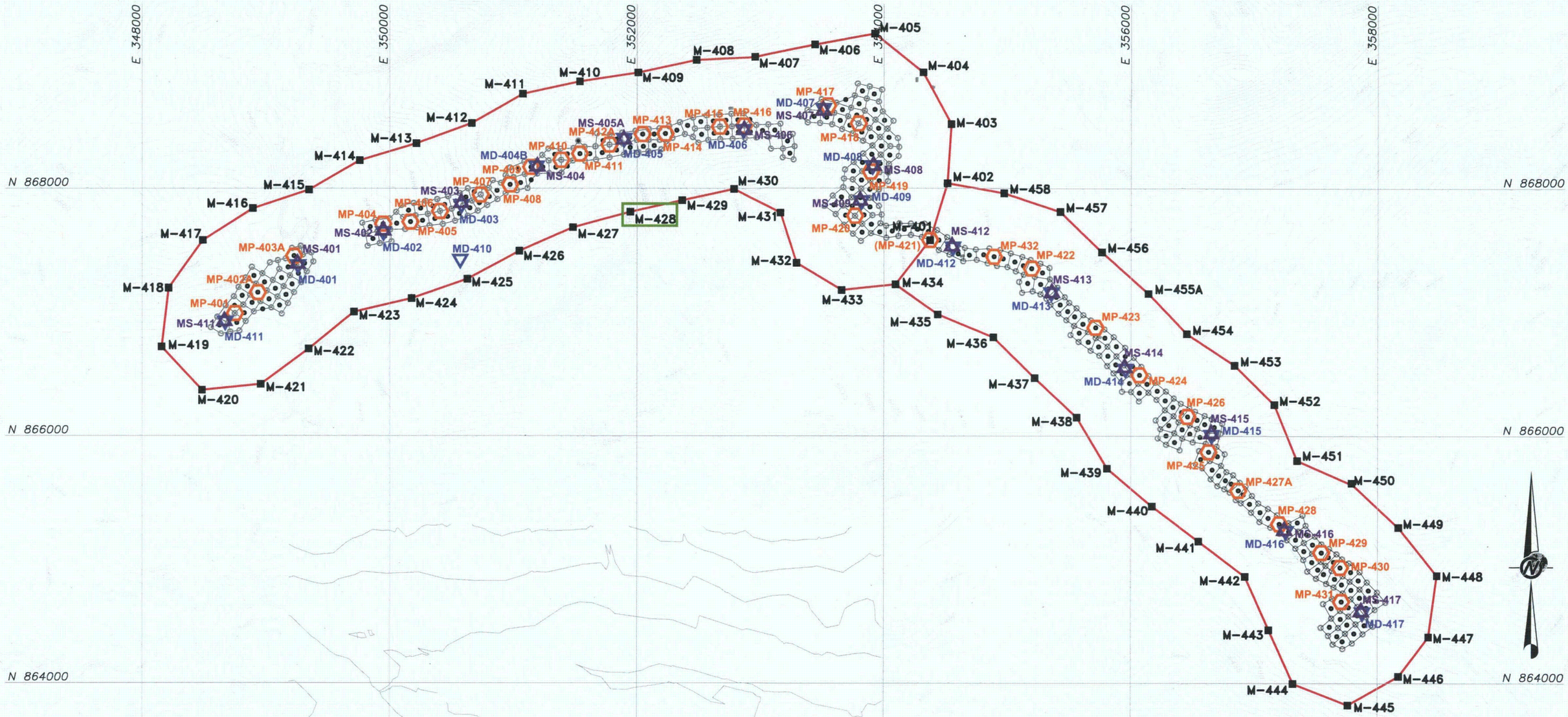

LEGEND

5400	EXISTING GROUND TOPOGRAPHY (SEE REFERENCE)
	MONITORING WELL RING
M-428 ■	LOCATION OF EXCURSION
MS-405A △	OVERLYING AQUIFER MONITORING WELL
MD-405 ▽	UNDERLYING AQUIFER MONITORING WELL
M-429 ■	PRODUCTION ZONE AQUIFER MONITORING WELL
MP-412A ⬡	MINERALIZED PRODUCTION ZONE MONITORING WELL
○	INJECTION WELL
•	PRODUCTION WELL

REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
MINE UNIT 4 AND 4A

Golder Associates
DENVER, COLORADO

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REVIEW	KFM	12/07/09		

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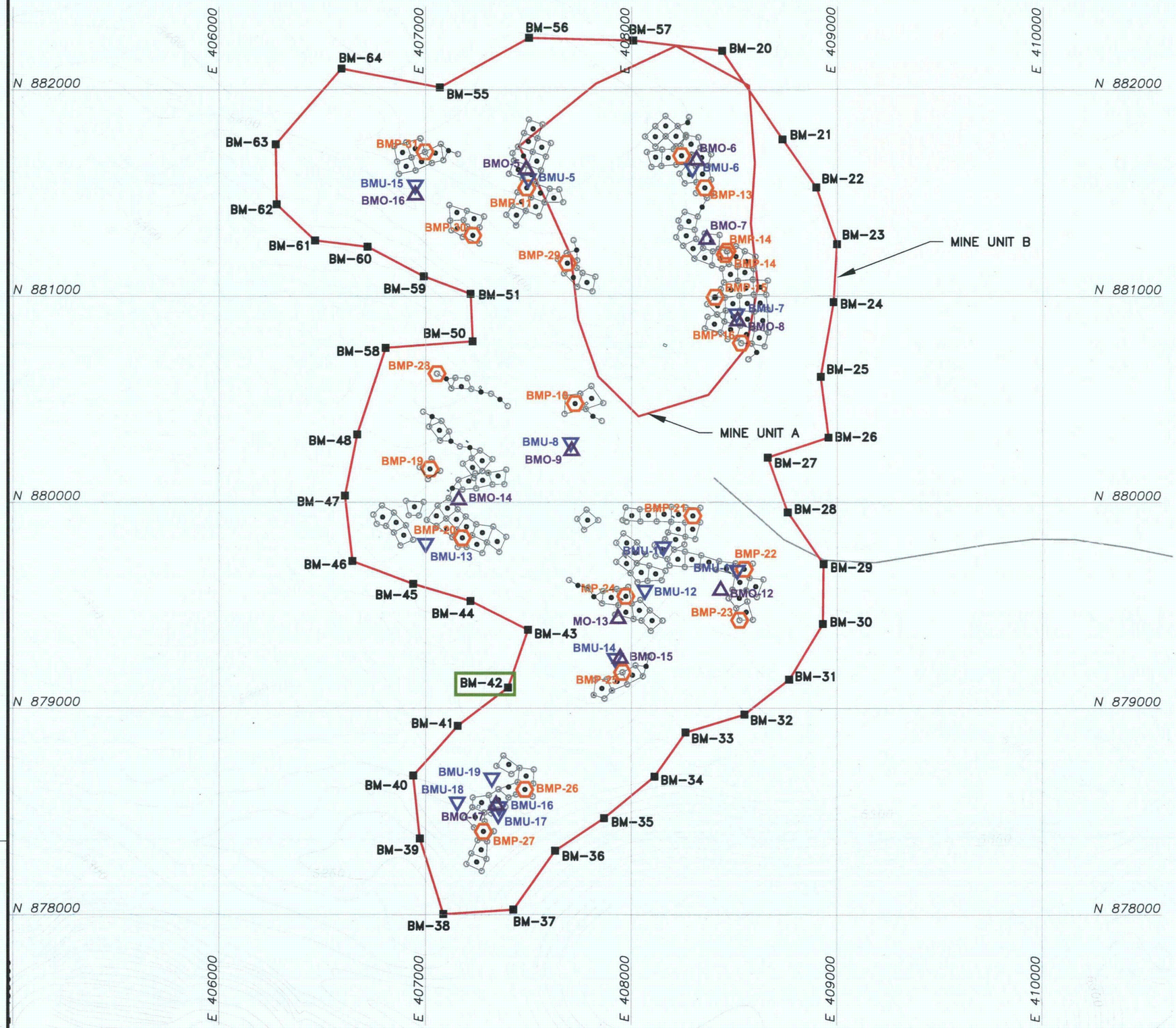
Layout Name: FIG A-8.2-1-2 (ORIGINAL)
Last Update: Jul 29, 2010 By: mtm
Last Plot: Aug 02, 2010 15:12 By: rosenthal

Plot Time: 08/02/10 15:12



LEGEND

- EXISTING GROUND TOPOGRAPHY (SEE REFERENCE)
- MONITORING WELL RING
- BM-42 ■ LOCATION OF EXCURSION
- BM0-15 △ OVERLYING AQUIFER MONITORING WELL
- BMU-17 ▽ UNDERLYING AQUIFER MONITORING WELL
- BM-50 ■ PRODUCTION ZONE AQUIFER MONITORING WELL
- BMP-16 ⬡ MINERALIZED PRODUCTION ZONE MONITORING WELL
- ○ INJECTION WELL
- • PRODUCTION WELL

REFERENCE

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

500 0 500

1" = 500' Feet

PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE

MINE UNIT B

Golder Associates
DENVER, COLORADO

PROJECT No.		093-81703	FILE No.	09381703A018
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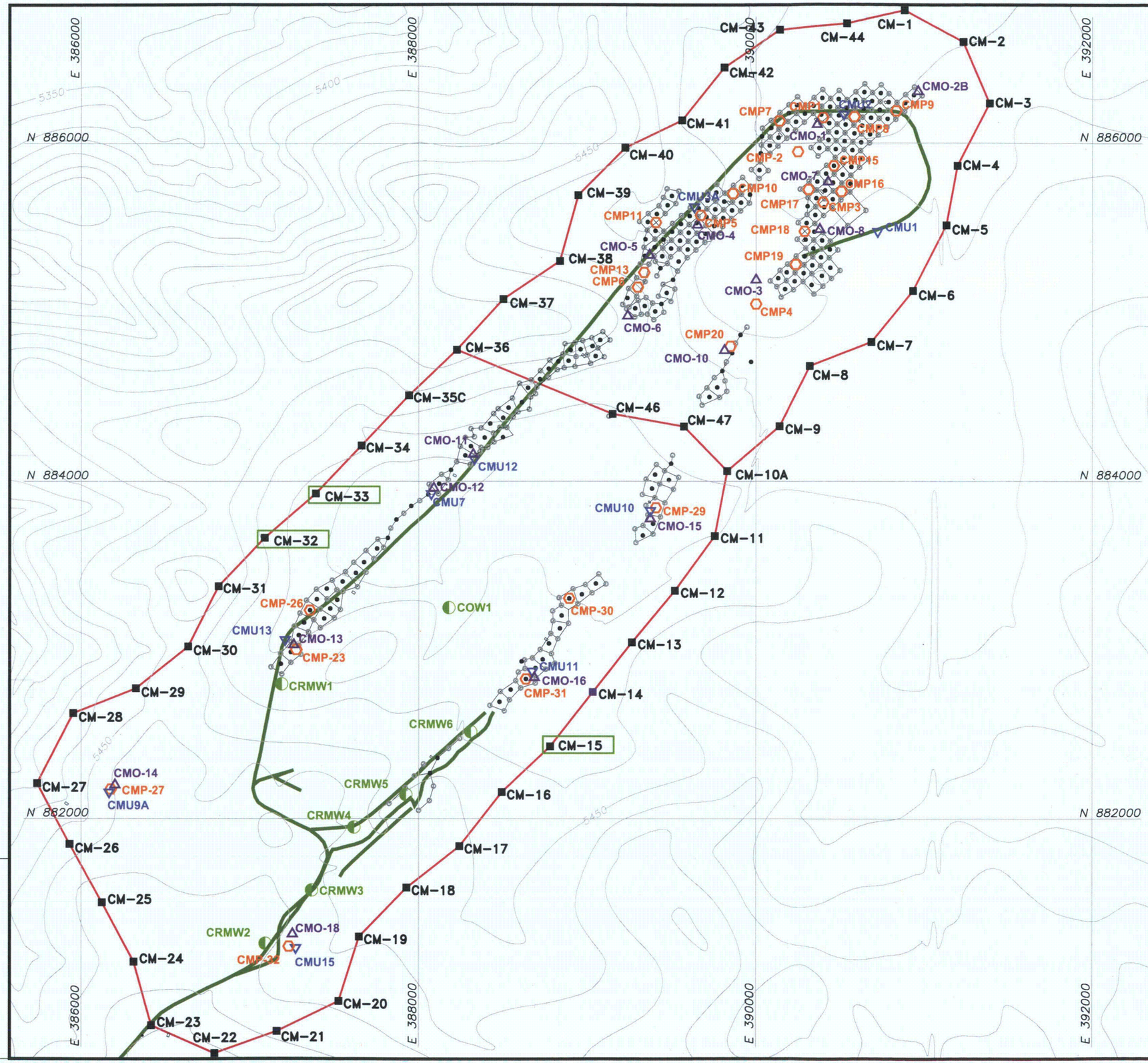

LEGEND

- EXISTING GROUND TOPOGRAPHY (SEE REFERENCE)
- MONITORING WELL RING
- ABANDONED EXXON UNDERGROUND MINE WORKINGS
- CM-15 ■ LOCATION OF EXCURSION
- CMO-10 △ OVERLYING AQUIFER MONITORING WELL
- CMU-1 ▽ UNDERLYING AQUIFER MONITORING WELL
- CM-9 ■ PRODUCTION ZONE AQUIFER MONITORING WELL
- CMP-4 ⬡ MINERALIZED PRODUCTION ZONE MONITORING WELL
- CRMW1 ◐ RESTORATION MONITORING WELL
- ○ INJECTION WELL
- • PRODUCTION WELL

REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

600 0 600

1" = 600' Feet

PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE

MINE UNIT C

Golder Associates
DENVER, COLORADO

PROJECT No.		093-81703	FILE No.	09381703A015
DESIGN	SD	11/18/09	SCALE AS SHOWN	REV. 0
CADD	MTM	11/18/09		
CHECK	SD	12/03/09	FIGURE A-8.2-1-4	
REVIEW	KFM	12/07/09		

Plot Time: 08/02/10 15:14

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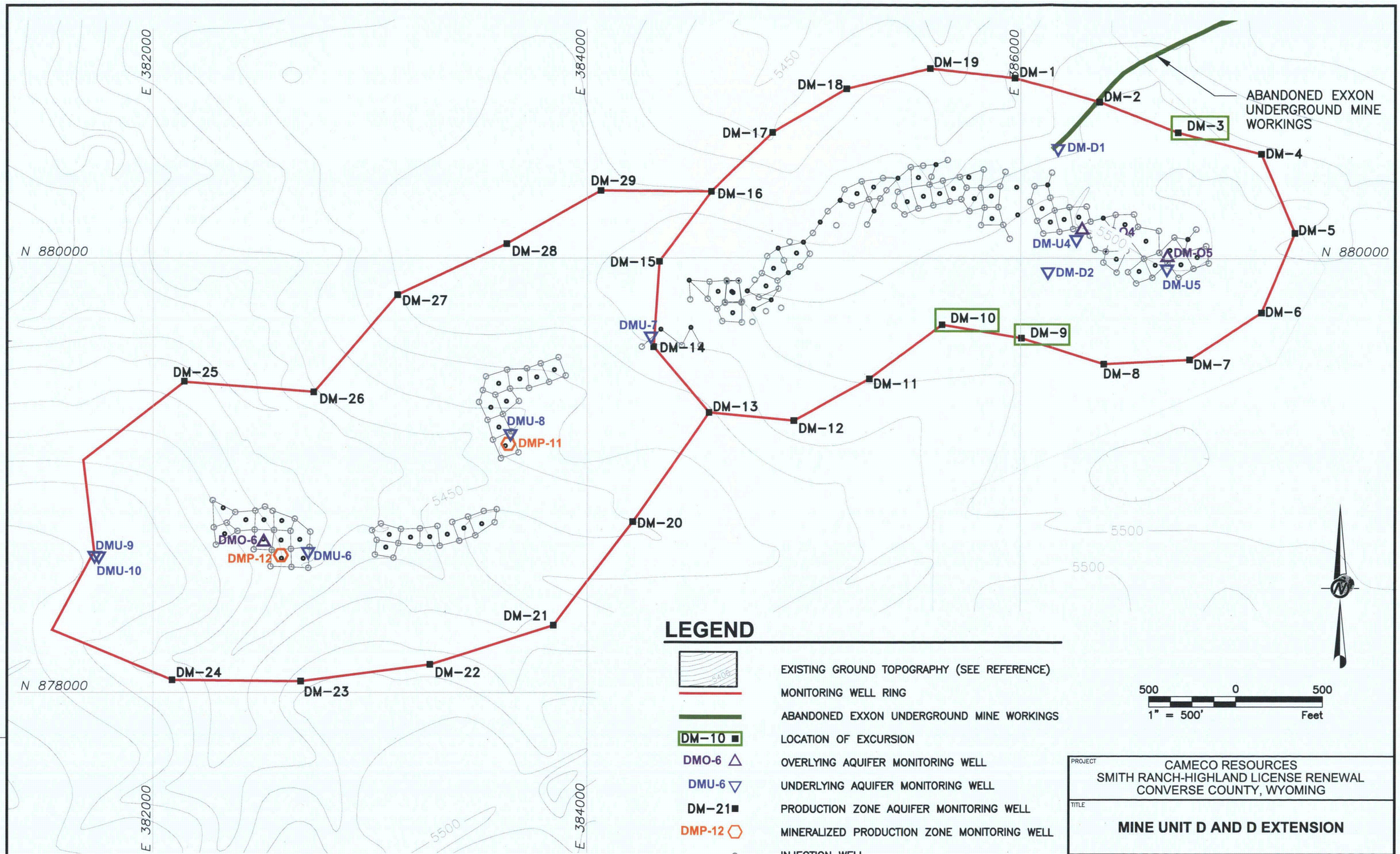
Last Plot: Aug 02, 2010 15:14 By: nrosenthal



LEGEND

	EXISTING GROUND TOPOGRAPHY (SEE REFERENCE)
	MONITORING WELL RING
	ABANDONED EXXON UNDERGROUND MINE WORKINGS
DM-10 ■	LOCATION OF EXCURSION
DMO-6 △	OVERLYING AQUIFER MONITORING WELL
DMU-6 ▽	UNDERLYING AQUIFER MONITORING WELL
DM-21 ■	PRODUCTION ZONE AQUIFER MONITORING WELL
DMP-12 ⬡	MINERALIZED PRODUCTION ZONE MONITORING WELL
○	INJECTION WELL
•	PRODUCTION WELL

REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
MINE UNIT D AND D EXTENSION

Golder Associates
DENVER, COLORADO

PROJECT No.		093-81703	FILE No.	09381703A014
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CADD	MTM	11/18/09		
CHECK	SD	12/03/09	FIGURE A-8.2-1-5	
REVIEW	KFM	12/07/09		

Plot Time: 08/02/10 15:16

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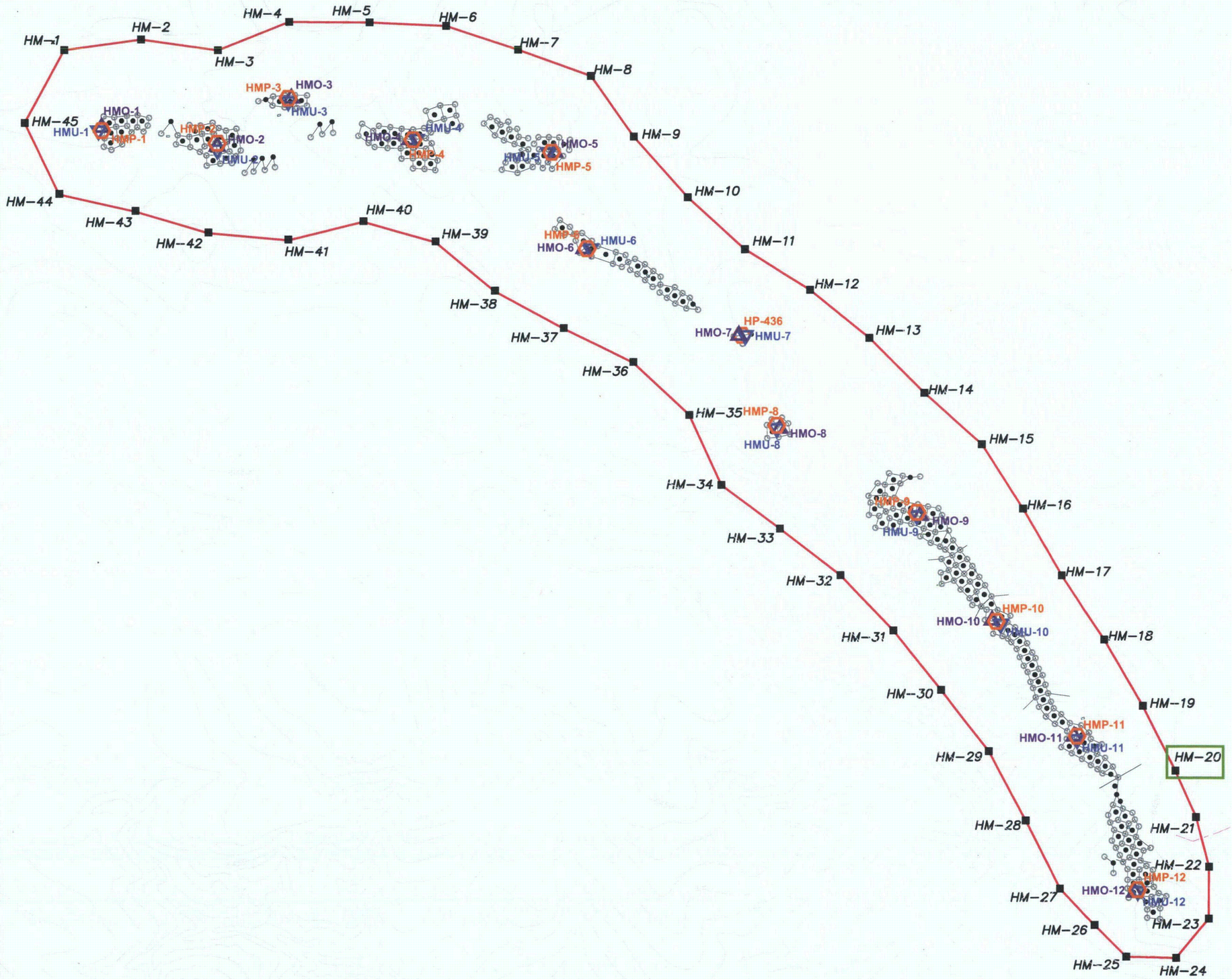
Last Plot: Aug 02, 2010 15:[illegible] By: nrosenthal



LEGEND

	EXISTING GROUND TOPOGRAPHY (SEE REFERENCE)
	MONITORING WELL RING
HM-20 ■	LOCATION OF EXCURSION
HMO-8 △	OVERLYING AQUIFER MONITORING WELL
HMU-5 ▽	UNDERLYING AQUIFER MONITORING WELL
M-429■	PRODUCTION ZONE AQUIFER MONITORING WELL
HMP-7 ⬡	MINERALIZED PRODUCTION ZONE MONITORING WELL
○	INJECTION WELL
•	PRODUCTION WELL

REFERENCE

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

800 0 800
1" = 800' Feet

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
MINE UNIT H

Golder Associates
DENVER, COLORADO

PROJECT No.	093-81703		FILE No.	09381703A013
DESIGN	SD	02/05/10	SCALE AS SHOWN	REV. A
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CHECK	PL	02/08/10	**FIGURE A-8.2-1-6**	
REVIEW	KFM	02/08/10		

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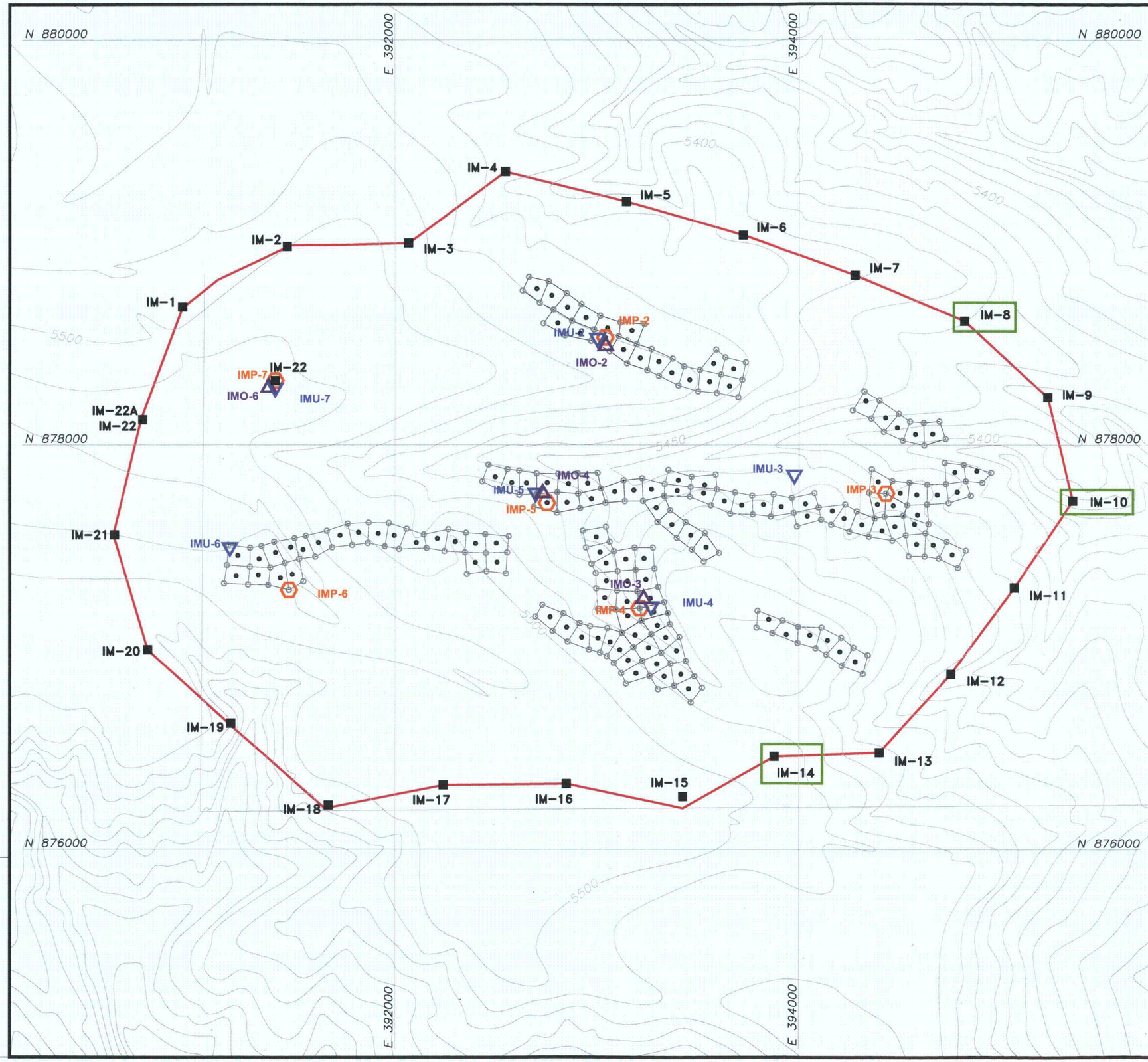
Last Plot: Aug 02, 2010 15[redacted] By: rrosenthal

Plot Time: 08/02/10 15:20



LEGEND

- EXISTING GROUND TOPOGRAPHY (REFERENCE)
- MONITORING WELL RING
- IM-8 — LOCATION OF EXCURSION
- IMO-3 — OVERLYING AQUIFER MONITORING WELL
- IMU-4 — UNDERLYING AQUIFER MONITORING WELL
- IM-9 — PRODUCTION ZONE AQUIFER MONITORING WELL
- IMP-3 — MINERALIZED PRODUCTION ZONE MONITORING WELL
- INJECTION WELL
- PRODUCTION WELL

REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

500 0 500

1" = 500' Feet

PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE

MINE UNIT I

Golder Associates
DENVER, COLORADO

PROJECT No.		093-81703	FILE No.	09381703A017
DESIGN	SD	11/18/09	SCALE AS SHOWN	REV. 0
CADD	MTM	11/18/09		
CHECK	SD	12/03/09	FIGURE A-8.2-1-7	
REVIEW	KFM	12/07/09		

Plot Time: 08/02/10 15:17

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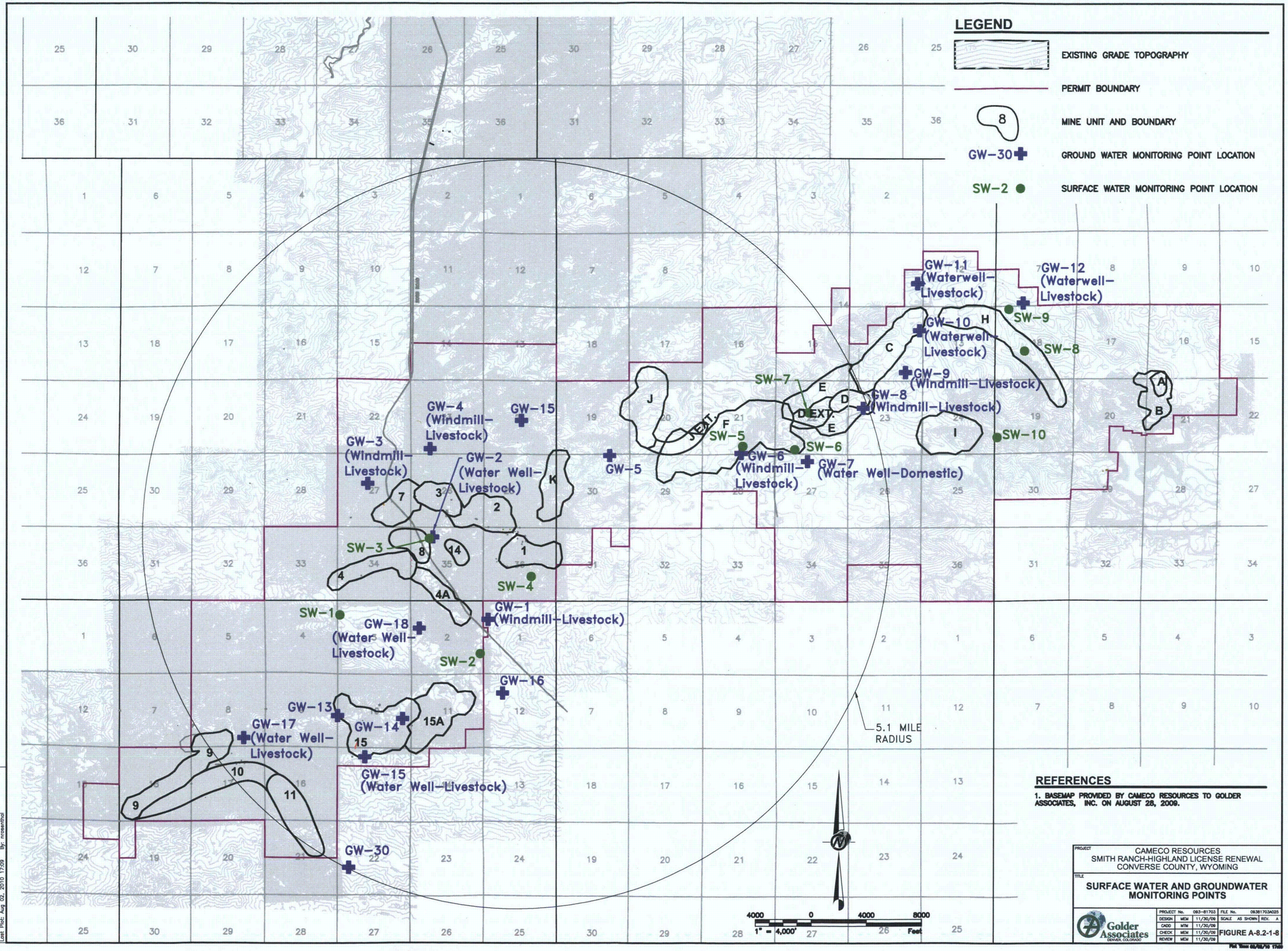
Last Plot: Aug 02, 2010 15[illegible] By: nrosenthal



REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
SURFACE WATER AND GROUNDWATER MONITORING POINTS

Golder Associates
DENVER, COLORADO

PROJECT No.	093-81703	FILE No.	093817034025	
DESIGN	MEM	11/30/09	SCALE AS SHOWN	REV. A
CADD	MTM	11/30/09		
CHECK	MEM	11/30/09	FIGURE A-8.2-1-8	
REVIEW	MEM	11/30/09		

Dwg Name: N:\09\093-81703_A_ E RENEWAL\093817034025.dwg
Layout Name: FIG A-8.2-2-1 Machine: DENT-L-NROSENTH
Last Update: Aug 02, 2010 15:28 By: nrosenthal
Last Plot: Aug 02, 2010 17:09 By: nrosenthal

Plot Time: 08/02/10 17:09

APPENDIX A-8.2-2

HISTORICAL SURFACE WATER MONITORING PROGRAM

1.0 HISTORICAL SURFACE WATER MONITORING PROGRAM

This section provides a brief background of the characteristics of surface water in the SR-HUP license area, a description of information reviewed and existing plans and procedures in-place to prevent surface water impacts, a description of the surface water monitoring program, the results of the monitoring program, and an evaluation of the monitoring data to assess potential impacts to surface water. Surface water monitoring data for the project, covered under License SUA-1548, was reviewed and is documented in this appendix since the previous license submittal of November 15, 1999. The review period is in accordance with the requirements of NUREG-1569 "*Standard Review Plan for In Situ Leach Uranium Extraction License Applications*", which for a license renewal is the period since submittal of the renewal submittal for the current license. The approved surface water monitoring program was reviewed to validate that the SR-HUP ISR facility is being operated in a manner so as to protect health, safety and the environment.

2.0 BACKGROUND

The purpose of a surface water monitoring program is to detect any potential migration of contaminants from the site into nearby surface water bodies (NRC, 2003c). In general, the risk of contamination to surface water bodies from ISR operations is low when proper operational procedures are followed (NRC, 2003c). Surface water occurrence in drainages within the SR-HUP license area is ephemeral and often drainages can remain dry for several years. This is due primarily to the overall low precipitation in the license area (Culler, 1961). Most of the high flow rates in the drainages in the license area result from high-intensity storms (e.g. storms that produce a lot precipitation in a short time frame) that are most likely to occur during May and June (Lowers, 1960). Portions of, an intermittent drainage referred to as Sage Creek, which runs from northwest to southeast, are present within the licensed area. Other drainages within SR license area also run from the northwest to the southeast, while portions of the HUP site drain from southeast to northwest.

In evaluating potential impacts to surface water at the SR-HUP, the following aspects of construction and operations were reviewed and evaluated:

- Relevant maps identifying surface water bodies, streams and Cameco Resource's assessment of likely consequences of surface water contamination to verify that their previous characterization is still relevant regarding impacts from site activities.
- Historical and renewal period records of precipitation, the presence of water in surface water features and analytical data from surface water sampling.
- Water use during the renewal period and anticipated future water uses.

- On-going construction activity such as road construction, erosion, run-off, construction equipment related spills/leaks impacts to surface waters and related habitats. These are covered under General Permit WYR-10-0000, General Permit to Discharge Storm Water Associated with Large Construction Activity Under the Wyoming Pollutant Discharge Elimination System. A Storm Water Pollution Prevention Plan (SWPPP) has been prepared for implementation under this permit (Tetra Tech, 2010b). It should be noted that the vast majority of construction activity at these facilities is temporary in nature. Surface water impacts from such activities have been eliminated, reduced and/or mitigated through thorough planning, design and best management construction methods as outlined in the SWPPP.

- Plant and Wellfield Operations. Plant process water and the discharge of stormwater is regulated under specific NPDES Permit Authorization Number-WYR000648 and facility implementation program/plans such as the SWPPP (Cameco Resources, 2010b) and Spill Prevention, Countermeasures Control Plan (SPCC). Storm water controls at the SR CPP and at the HUP CP Facility (this facility is currently on standby and not operational) include multiple catchment basins that are of sufficient size to contain runoff from these areas. The catchment basins are inspected frequently and have never overfilled or discharged stormwater outside the berms.

A review of the NUREG-1910 Generic Environmental Impact Statement (GEIS) for ISR facilities in Eastern Wyoming (NRC, 2009) also indicates that the NRC has determined that "*compliance with permit conditions during operations, aquifer restoration and decommissioning would reduce impacts to surface water from storm water runoff and discharges of treated water. For these reasons, potential impacts to surface waters from operations would be small.*"

3.0 DESCRIPTION OF MONITORING PROGRAM

A network of ten (10) surface water monitoring points at stock ponds within the SR-HUP is sampled by Cameco Resources. Quarterly sampling of Sage Creek and the stock ponds for analysis of uranium and radium-226 (Ra^{226})is conducted when adequate water exists to permit sampling. Surface water monitoring is not conducted at RR, RU, NB and GH since mining operations have not been initiated at these sites as discussed in Appendices B, C and D, respectively. The dewatering of the underground mine during the 1970s was discharged 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 contaminant, but these discharges are no longer occurring and dry conditions have limited sampling since that time.

The ten stock pond monitoring points were added August 18, 2003 as a part of Amendment No. 5 (NRC, 2003d) that combined the SR and HUP operations (at this time, RU and NB also added as satellite facilities). Also, sampling of the effluent from the HUP Treatment Plant was discontinued in the Third Quarter of 2003 since the HUP 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 A-8.2-2-1. The surface water

samples are analyzed for natural uranium [U^{nat}] and radium-226 [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) at SR and samples are collected when water is available;
- SW-2 (Stock Pond): This location is closest to Mine Unit 4 (MU-4) at SR and samples are collected when water is available;.
- SW-3 (Stock Pond): This location is closest to Mine Unit 2 (MU-2) at SR and samples are collected when water is available;
- SW-4 (Stock Pond): This location is closest to Mine Unit 1 (MU-1) at SR and samples are collected when water is available.;
- SW-5 (Stock Pond): This location is closest to Mine Unit J (MU-J) at HUP and samples are collected when water is available;
- SW-6(Stock Pond): This location is closest to Mine Unit F (MU-F) at HUP and samples are collected when water is available;
- SW-7 (Stock Pond): This location is closest to Mine Unit D (MU-D) at HUP and samples are collected when water is available;
- SW-8 (Stock Pond): This location is closest to Mine Unit H (MU-H) at HUP and samples are collected when water is available;
- SW-9 (Stock Pond): This location is closest to Mine Unit H (MU-H) at H and samples are collected when water is available; and
- SW-10 (Stock Pond): This location is closest to Mine Unit I (MU-I) at H and samples are collected when water is available.

4.0 RESULTS OF SURFACE WATER MONITORING

Surface water monitoring results collected since the last license renewal (RAMC,1999) are provided in Table A-8.2-2-1, which summarizes the quarterly monitoring data that have been provided in the Semi-Annual Effluent Environmental Monitoring Reports that are provided to the NRC. 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 in gaseous effluents during the preceding six month period. The results in Table A-8.2-2-1 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 licensed area. Also, 25 percent of samples collected (60 out of 240 through the second quarter of 2009) were not detectable for Ra^{226} and 12 percent of samples collected (28 out of 240 through the second quarter of 2009) were not detectable for U^{nat}. The analytical detection limit for U^{nat} is 2.0×10^{-10} µCi/ml (or 3.0×10^{-4} mg/l), and 2.0×10^{-11} µCi/ml for Ra^{226}. A review of the monitoring data show that concentrations of U^{nat} 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 A-8.2-2-1)

5.0 EVALUATION OF SURFACE MONITORING PROGRAM

In all cases, measured concentrations of U^{nat} and Ra^{226} (as tabulated in Table A-8.2-2-1) were less than the 10 CFR 20, Appendix B, Effluent Concentration Limits of 3.0×10^{-7} µCi/ml and 6.0×10^{-8} µCi/ml, respectively, during the monitoring periods. These Effluent Limits 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). Three monitoring locations (SW-1, SW-6 and SW-8) were selected for preparation of scatter plots because these sampling locations were analyzed the most often (i.e., were dry less than other monitoring points) and had measured concentrations at least as high as other monitoring locations. Figure A-8.2-2-2 (SW-1), Figure A-8.2-2-3 (SW-6) and Figure A-8.2-2-4 (SW-8) show plots of U^{nat} concentrations versus time since the last license renewal in 1999. These plots show that U^{nat} concentrations vary, but are all below the 10 CFR 20, Appendix B, Effluent Concentration Limit of 3.0×10^{-7} µCi/ml. Likewise, Figure A-8.2-2-5 (SW-6) and Figure A-8.2-2-6 (SW-8) show plots of Ra^{226} with time. Data for Ra^{226} at SW-1 was not plotted because there were only four detections, all less than Effluent Concentration Limits, during the monitoring period. These plots show that concentrations vary, but also are all below the 10 CFR 20, Appendix B, Effluent Concentration Limit of 6.0×10^{-8} µCi/ml. While any trends would be difficult to ascertain given the intermittent nature of the data, the average concentrations of U^{nat} over the last decade are typically more than an order of magnitude less than the Effluent Concentration Limit. Likewise, average concentrations of Ra^{226} over the last decade are typically two orders of magnitude less than the Effluent Concentration Limit.

These data are consistent with NUREG-1910, "*Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities-Final Report,*" (also termed GEIS), which is focused on operations such as the SR-HUP in Eastern Wyoming. The GEIS indicates the impacts to surface water from ISR operations or construction of new well fields or roads are expected to be small because of the following factors:

- Groundwater from ore-bearing aquifers is not expected to have any significant connection to surface water features.
- The ephemeral nature of surface water flow at most ISR sites in Eastern Wyoming.
- The site's standard operating procedures (Cameco Resources, 2010b; Tetra Tech, 2010a) describe the potential sources of storm water contamination (i.e. spills) from the site, and best management practices to prevent storm water impact (see discussion of spills below).

- Erosion into drainages as a result of construction of well fields and roads is expected to be small because these activities are temporary and since disturbed surfaces are resurfaced (roads) or contoured and vegetated to limit erosion (Tetra Tech, 2010b). Also, existing roads are used when possible so that the overall area impacted by roads is kept small in proportion to the overall area of drainages.

Based on license reviews, SPCC and SWPPPs requirements and spill reports, the facilities have been and continue to be operated within the terms of their license and permit(s) requirements and have followed their SWPPPs and SPCC. Cameco Resources has documented each spill since the license was issued and the spills for the license renewal period are summarized in Appendix A-8.1 (Summary of Spills and Accidents). The spills constitute a relatively small volume compared to the large quantities of water circulated at the site, totaling approximately 615,000 gallons. The volume spilled and released represents approximately 0.01 percent of the total volume of production fluid circulated since the previous license submittal. Follow-up for each spill has provided documentation that the environmental impacts were insignificant. This documentation, in concert with the surface water monitoring program, provide assurances that the current operational and construction practices are not adversely impacting surface water at the site.

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2000-2001

Sample Location	Radionuclide	2000				2001			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-1	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-2	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-3	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-4	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-5	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-6	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-7	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-8	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-9	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SW-10	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sage Creek Upstream	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Sage Creek Downstream	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Treatment Plant Outfall	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

N/A-Were not monitored until operations commenced in 2004 upstream of this drainage
All units in µCi/ml unless otherwise stated

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2002-2003

Sample Location	Radionuclide	2002				2003			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-1	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	1.5E-08	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	2.2E-02	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	<	Dry
SW-2	U^{nat}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
SW-3	U^{nat}	N/A	N/A	N/A	N/A	N/A	N/A	3.0E-09	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	4.4E-03	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	<	Dry
SW-4	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
SW-5	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
SW-6	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	1.4E-09	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	2.0E-03	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	<	Dry
SW-7	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
SW-8	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	8.8E-09	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	1.3E-02	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	<	Dry
SW-9	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	Dry	Dry

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2002-2003

Sample Location	Radionuclide	2002				2003			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-10	U^{Nat}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	U^{Nat} (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry
	Ra^{226}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sage Creek Upstream	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry		
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry		
Sage Creek Downstream	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry		
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry		
Treatment Plant Outfall	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry		
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry		

N/A-Were not monitored until operations commenced in 2004 in this drainage
All units in µCi/ml unless otherwise stated

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2004-2005

Sample Location	Radionuclide	2004				2005			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-1	U^{Nat}	3.1E-08	2.4E-08	1.2E-09	Dry	2.1E-08	1.3E-08	Dry	Dry
	U^{Nat} (mg/L)	4.5E-02	3.5E-02	1.7E-03	Dry	3.0E-02	1.9E-02	Dry	Dry
	Ra^{226}	3.0E-10	<	<	Dry	4.0E-10	<	Dry	Dry
SW-2	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
SW-3	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
SW-4	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
SW-5	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
SW-6	U^{Nat}	1.4E-09	1.0E-09	<	8.8E-10	1.1E-09	1.0E-09	1.6E-09	Dry
	U^{Nat} (mg/L)	2.0E-03	1.5E-03	<	1.3E-03	1.6E-03	1.5E-03	2.3E-03	Dry
	Ra^{226}	4.0E-10	<	<	1.1E-08	<	7.0E-10	3.0E-10	Dry
SW-7	U^{Nat}	<	<	<	1.2E-09	<	1.9E-08	1.4E-09	Dry
	U^{Nat} (mg/L)	<	<	<	1.7E-03	<	2.8E-02	2.0E-03	Dry
	Ra^{226}	<	<	<	1.7E-09	<	<	1.2E-09	Dry
SW-8	U^{Nat}	3.4E-09	3.5E-09	1.1E-09	3.2E-09	8.1E-10	6.0E-08	1.6E-08	3.1E-08
	U^{Nat} (mg/L)	4.9E-03	5.1E-03	1.6E-03	4.6E-03	1.2E-03	8.7E-02	2.3E-02	4.5E-02
	Ra^{226}	4.0E-10	4.0E-10	<	9.0E-10	4.0E-10	8.0E-10	1.3E-09	8.0E+10
SW-9	U^{Nat}	2.7E-09	1.4E-09	Dry	Dry	Dry	1.2E-08	Dry	Dry
	U^{Nat} (mg/L)	3.9E-03	2.0E-03	Dry	Dry	Dry	1.7E-02	Dry	Dry
	Ra^{226}	<	<	Dry	Dry	Dry	1.3E-09	Dry	Dry
SW-10	U^{Nat}	6.8E-10	4.0E-09	1.8E-09	Dry	1.5E-09	2.2E-07	Dry	4.4E-08
	U^{Nat} (mg/L)	9.9E-04	5.8E-03	2.6E-03	Dry	2.2E-03	3.2E-01	Dry	6.4E-02
	Ra^{226}	<	7.0E-10	3.0E-10	Dry	5.0E-10	<	Dry	6.0E+10

All units in µCi/ml unless otherwise stated

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2006-2007

Sample Location	Radionuclide	2006				2007			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-1	U^{Nat}	1.8E-07	1.6E-10	Dry	3.8E-08	8.2E-09	1.2E-08	Dry	Dry
	U^{Nat} (mg/L)	2.6E-01	2.3E-04	Dry	5.5E-02	1.2E-02	1.7E-02	Dry	Dry
	Ra^{226}	<	<	Dry	<	<	<	Dry	Dry
SW-2	U^{Nat}	<	Dry	Dry	Dry	Dry	5.6E-10	Dry	Dry
	U^{Nat} (mg/L)	<	Dry	Dry	Dry	Dry	8.1E-04	Dry	Dry
	Ra^{226}	<	<	Dry	Dry	Dry	1.1E-09	Dry	Dry
SW-3	U^{Nat}	<	Dry	Dry	Dry	Dry	8.1E-09	1.6E-08	Dry
	U^{Nat} (mg/L)	<	Dry	Dry	Dry	Dry	1.2E-02	2.3E-02	Dry
	Ra^{226}	6.0E-10	Dry	Dry	Dry	Dry	6.2E-09	1.8E-09	Dry
SW-4	U^{Nat}	<	Dry	Dry	Dry	4.2E-10	2.8E-10	Dry	Dry
	U^{Nat} (mg/L)	<	Dry	Dry	Dry	6.1E-04	4.1E-04	Dry	Dry
	Ra^{226}	<	Dry	Dry	Dry	<	7.0E-10	Dry	Dry
SW-5	U^{Nat}	<	Dry	<	Dry	1.8E-09	<	6.1E-10	frozen
	U^{Nat} (mg/L)	<	Dry	<	Dry		<	8.8E-04	frozen
	Ra^{226}	<	Dry	<	Dry	<	<	<	frozen
SW-6	U^{Nat}	<	2.0E-07	4.1E-09	4.1E-10	<	<	4.1E-10	frozen
	U^{Nat} (mg/L)	<	2.9E-01	5.9E-03	5.9E-04			5.9E-04	frozen
	Ra^{226}	<	<	5.0E-10	<	<	<	<	frozen
SW-7	U^{Nat}	<	2.0E-07	<	5.1E-09	2.1E-10	3.5E-10	1.2E-09	frozen
	U^{Nat} (mg/L)	<	2.9E-01	<	7.4E-03	3.0E-04	5.1E-04	1.7E-03	frozen
	Ra^{226}	<	<	6.1E-10	<	<	<	<	frozen
SW-8	U^{Nat}	<	5.0E-10	<	7.0E-09	2.5E-09	3.4E-10	1.2E-09	frozen
	U^{Nat} (mg/L)	<	7.3E-04	<	1.0E-02	3.6E-03	4.9E-04	1.7E-03	frozen
	Ra^{226}	5.0E-10	2.8E-09	<	<	<	<	<	frozen
SW-9	U^{Nat}	6.8E-10	6.8E-10	Dry	Dry	1.7E-09	2.8E-10	Dry	Dry
	U^{Nat} (mg/L)	9.9E-04	9.9E-04	Dry	Dry	2.5E-03	4.1E-04	Dry	Dry
	Ra^{226}	<	<	Dry	Dry	8.0E-10	<	Dry	Dry
SW-10	U^{Nat}	<	Dry	6.9E-09	Dry	1.4E-09	2.8E-10	8.8E-10	Dry
	U^{Nat} (mg/L)	<	Dry	1.0E-02	Dry	2.0E-03	4.1E-04	1.3E-03	Dry
	Ra^{226}	6.0E+10	Dry	1.0E-09	Dry	<	1.8E-09	<	Dry

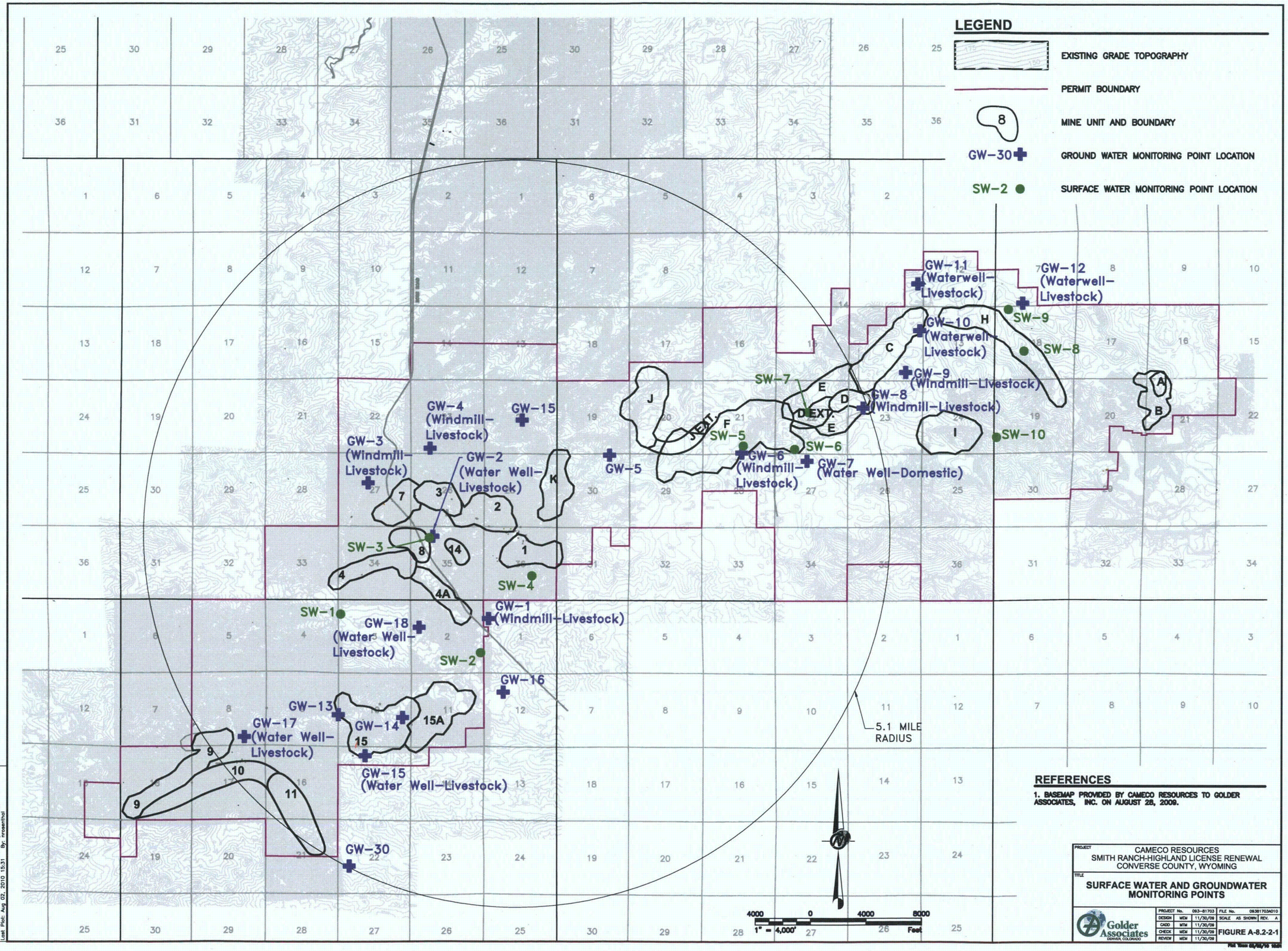
All units in µCi/ml unless otherwise stated

TABLE A-8.2-2-1
SURFACE WATER MONITORING
HISTORICAL REVIEW
2008-2009

Sample Location	Radionuclide	2008				2009			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
SW-1	U^{Nat}	Dry	1.1E-08	Dry	Dry	Dry	Dry		
	U^{Nat} (mg/L)	Dry	1.6E-02	Dry	Dry	Dry	Dry		
	Ra^{226}	Dry	1.0E-10	Dry	Dry	Dry	Dry		
SW-2	U^{Nat}	Dry	Dry	Dry	Dry	Dry	Dry		
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	Dry	Dry		
	Ra^{226}	Dry	Dry	Dry	Dry	Dry	Dry		
SW-3	U^{Nat}	Dry	2.3E-08	8.5E-08	Dry	2.6E-09	3.0E-09		
	U^{Nat} (mg/L)	Dry	3.3E-02	1.2E-01	Dry	3.8E-03	4.4E-03		
	Ra^{226}	Dry	7.4E-09	2.2E-10	Dry	5.8E-10	8.3 E-10		
SW-4	U^{Nat}	Dry	1.3E-09	Dry	Dry	6.1E-10	<		
	U^{Nat} (mg/L)	Dry	1.9E-03	Dry	Dry	8.8E-04	<		
	Ra^{226}	Dry	1.0E-09	Dry	Dry	2.3E-10	<		
SW-5	U^{Nat}	Dry	1.8E-09	6.8E-10	3.4E-10	4.1E-10	4.1E-10		
	U^{Nat} (mg/L)	Dry	2.6E-03	9.9E-04	4.9E-04	5.9E-04	5.9E-04		
	Ra^{226}	Dry	3.4E-09	2.2E-10	2.2 E-10	1.2E-10	5.0 E-11		
SW-6	U^{Nat}	Dry	<	2.0E-10	2.7E-10	<	<		
	U^{Nat} (mg/L)	Dry	<	2.9E-04	3.9E-04	<	<		
	Ra^{226}	Dry	5.1E-09	2.2E-11	2.2E-10	5.0E-11	<		
SW-7	U^{Nat}	4.1E-10	Dry	6.1E-10	Dry	<	<		
	U^{Nat} (mg/L)	Dry	Dry	8.8E-04	Dry	<	<		
	Ra^{226}	9.0E-10	<	2.2 E-10	Dry	<	<		
SW-8	U^{Nat}	5.4E-10	1.6E-09	5.4E-10	2.1E-09	3.0E-10	2.0E-10		
	U^{Nat} (mg/L)	Dry	2.3E-03	7.8E-04	3.0E-03	4.4E-04	2.9E-04		
	Ra^{226}	2.0 E-10	2.0 E-10	2.2 E-10	2.2 E-10	<	2.2 E-10		
SW-9	U^{Nat}	4.1E-10	5.4E-10	Dry	Dry	2.0E-10	<		
	U^{Nat} (mg/L)	Dry	7.8E-04	Dry	Dry	2.9E-04	<		
	Ra^{226}	2.0E-10	6.0E-10	Dry	Dry	2.0E-11	<		
SW-10	U^{Nat}	Dry	Dry	Dry	Dry	4.1E-10	7.0E-10		
	U^{Nat} (mg/L)	Dry	Dry	Dry	Dry	5.9E-04	1.0E-03		
	Ra^{226}	Dry	Dry	Dry	Dry	8.0E-11	3.2 E-10		

All units in µCi/ml unless otherwise stated

FIGURES FOR APPENDIX A-8.2-2



REFERENCES

1. BASEMAP PROVIDED BY CAMECO RESOURCES TO GOLDER ASSOCIATES, INC. ON AUGUST 28, 2009.

PROJECT
CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE
SURFACE WATER AND GROUNDWATER MONITORING POINTS

Golder Associates
DENVER, COLORADO

PROJECT No.	093-81703	FILE No.	09381703A010
DESIGN	MEM	11/30/09	SCALE AS SHOWN REV. A
CADD	MTM	11/30/09	
CHECK	MEM	11/30/09	FIGURE A-8.2-2-1
REVIEW	MEM	11/30/09	

Dwg Name: N:\09\093-81703_A ... E RENEWAL\09381703A010.dwg
Layout Name: FIG A-8.2-2-1 Machine: DEN1-L-NROSENTH
Last Update: Aug 02, 2010 15:28 By: nrosenthal
Last Plot: Aug 02, 2010 15:31 By: nrosenthal

APPENDIX A-8.3

HISTORICAL RADIOLOGICAL AND NON-RADIOLOGICAL ASSESSMENTS

Appendix A-8.3 Historical Radiological and Non-Radiological Assessments

1.0 BACKGROUND

The ISR technology has become an acceptable method of extraction and processing of uranium from low grade ore bodies. It has the distinct advantage of being able to extract uranium from much lower grade ore without the need for significant surface disturbance and with the potential for fewer environmental releases and occupational exposures as compared to conventional uranium mining and milling.

The NRC conducted a study of the risk and consequences associated with ISR technology, including groundwater restoration, and published a report NUREG/CR-6733 (A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees; NRC, 2001f) where they addressed radiological exposures, chemical exposures, and consequences of accidents. Most of the processes involved in the ISR method of uranium mining are not a significant source of radiological exposure to workers and to the environment. The most significant potential for exposure and release occurs in the yellowcake drying and packaging operations in the process, which is the last processing step for ISR. Cameco Resources employs an ALARA program to continually keep the potential for excessive exposures to a minimum and performs several occupational health assessments to monitor the effectiveness of the program.

While the title of Appendix A-8, "*Environmental effects of site operations including data on radiological and non-radiological effects, accidents, and the economic and social effects of operations*" does not specifically address occupational health assessments, Appendix A-8 is a logical location in the License Renewal Submittal to provide this information, and thus it is presented in this section.

2.0 RADIOLOGICAL ASSESSMENTS

Exposure to radiation and radioactive materials is measured by a combination of airborne particulate monitoring, direct reading dosimeters, and bioassay sampling. Radiation doses are calculated by summing the dose from direct radiation (normally gamma-ray exposure) and the dose from radionuclides taken into the body normally through inhalation or ingestion. Cameco Resources complies with NRC regulations in 10 CFR Part 20 that require licensees to meet the occupational TEDE limit of 5,000 mrem (5 rem) per year, and also require the licensees to assure that doses are ALARA.

The dose limit described above is in addition to dose received from ubiquitous environmental sources of background radiation, doses from medical procedures, and doses from consumer products. Collectively, the radiation dose from these sources is commonly referred to as background radiation dose. In 2009, the National Council on Radiation Protection and Measurement (NCRP) updated detailed information on the exposure of the US population to ionizing radiation in Report No. 160, "*Ionizing Radiation Exposure of the Population of the United States*" (NCRP, 2009). The report concluded that the average TEDE from the three sources of background ionizing radiation to a member of the US population is currently 611 mrem (0.6 rem) per year. The dose was split almost equally between ubiquitous

environmental sources of background radiation and doses from medical procedures. The annual dose to individuals is highly variable, mostly due to exposure to indoor radon and medical procedures. The exposure to indoor radon is largely dependent on geographic area and building construction methods.

In evaluating occupational radiation exposures over time and the success of the ALARA program, assessing any exceedances of regulatory limits is a good measure of success. Compliance with the ALARA program has driven management and workers to make engineering and procedural improvements to more than compensate for any additional radiation doses associated with changes in processes or aging of the plant. Changes in production (changes to the number of satellite facilities and well fields) are expected to change the number of employees and the total dose received at the site. Therefore, in evaluating occupation radiation doses, the metrics of average radiation dose and maximum doses have been used for assessing true performance in limiting radiation doses to each worker to levels in accordance with the ALARA program. The specific assessment programs used to evaluate the effectiveness of the ALARA program are listed in Section 4.0 of this section.

3.0 NON-RADIOLOGICAL ASSESSMENTS

In the ISR process, certain chemicals are also used by Cameco Resources and are safely managed to reduce environmental and occupational exposures. These chemicals include sodium carbonate, carbon dioxide, oxygen, sulfuric acid, hydrochloric acid, sodium sulfide, hydrogen sulfide gas, hydrogen peroxide, sodium chloride, barium chloride, and anhydrous ammonia. These chemicals are trucked to the site and normally stored in tanks or dry storage areas near the CPP or satellite facilities. Anhydrous ammonia, hydrogen peroxide and sulfuric acid are all stored outside the CPP in a chemical tank farm where they are segregated from process areas until their point of use. All outside bulk liquid storage tanks are contained within concrete curbed secondary containment structures. Hydrochloric acid and sodium sulfide are also stored outside of process areas and have secondary containment structures. The secondary containment at these storage facilities minimizes the potential for environmental releases in case of tank or pipe failures or accidental spills. Most accidental spills normally involve wet materials from which dispersal into the air is minimal, unless allowed to dry and be dispersed by the wind. Therefore, occupational exposure is the most likely concern from routine use of chemicals and accidental releases.

The Smith Ranch-Highland Operation-EHS Management System Emergency Procedures Manual-comprised of eight volume that provide procedures, quality assurance and programs regarding training pertaining to hazardous and non-radiologic materials (including spill release) management. The EHS Management System was referenced in NRC license SUA-1548 Amendment No. 11 and herein incorporated by reference.

As a part of Cameco Resources' EHS Management System, a risk assessment was completed as a part of the effort to identify and mitigate risks associated with the chemicals used at the site to acceptable levels. The risk assessment process identified anhydrous ammonia as the hazardous chemical with the greatest potential for impacts to chemical and radiological safety. To mitigate risks associated with anhydrous ammonia, the following steps have been taken as a part of standard operating procedures (SOPs), Industrial Safety Manual and Emergency Procedure Manuals that are components of Cameco Resources' EHS Management System:

- Anhydrous ammonia storage is limited to 80% of tank capacity;
- Strict unloading procedures are utilized to make sure the 80% capacity limit is not reached and to prevent spills;
- Safety controls are in-place consisting of a process area ammonia detector and alarm and emergency shut off solenoid for isolation of the ammonia distribution system in the case of a release; and
- Measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training and emergency preparedness are conducted in accordance with OSHA Process Safety Management Program which also incorporates EPAs' Risk Management Program regulations to minimize potential impacts to the public and environment.

As a result of these measures, there have been no accidents involving anhydrous ammonia since the last License Renewal submittal on November 15, 1999.

4.0 APPENDIX ORGANIZATION

This appendix presents the specific historical radiological assessments that have been performed for the SR-HUP during the last license period, as required by NUREG-1569 Appendix A for a License Renewal submittal. The appendix is organized into the following sub-appendices:

- Appendix A-8.3-1: Historical Radiation Monitoring Program Assessment
- Appendix A-8.3-2: Historical Results of Radiation Dose Calculations
- Appendix A-8.3-3: Historical Bioassay Program Assessment
- Appendix A-8.3-4: Historical Occupational Exposure Rate Monitoring Assessment

APPENDIX A-8.3-1

HISTORICAL RADIATION MONITORING PROGRAM ASSESSMENT

1.0 HISTORICAL RESULTS OF AIRBORNE RADIATION MONITORING (OCCUPATIONAL)

Periodic measurements of airborne concentration of natural uranium and Rn^{222} progeny in various work areas associated with the SR-HUP facility were made from 1999 through to present. These data are valuable in evaluating Cameco Resources' performance in limiting airborne radionuclides in the workplace and are discussed in this section. Worker radiation doses and soluble uranium intakes are also valuable measures of Cameco Resources' commitment to keep radiation doses to levels meeting ALARA objectives, and an evaluation of these data are provided in Appendices A-8.3-2 and A-8.3-3, respectively.

2.0 REGULATORY REQUIREMENTS

As will be discussed in other sections of this appendix, Subpart C of 10 CFR Part 20 limits the TEDE limit for occupational workers to 5 rems/year, shallow dose equivalent to the skin to 50 rems/year, and dose equivalent to the embryo/fetus of a pregnant worker to 0.5 rem during the entire pregnancy. In order to limit the internal dose from radionuclide intakes, the NRC requires that work areas be routinely monitored and posted according to their exposure rate classification. In addition, radiation work permits for conducting non-routine tasks must contain information regarding radiation levels in the work areas. For the SR-HUP, inhalation is the most likely pathway for an intake of radionuclides and ultimately an internal dose. Thus, monitoring programs that evaluate work area airborne radionuclide concentrations are the most effective tool to evaluate and limit workplace internal doses due to inhalation of radioactive material.

NRC's Regulatory Guide 8.30, "*Health Physics Surveys in Uranium Recovery Facilities*," suggests that airborne soluble uranium measurements be conducted weekly in airborne radioactivity areas (areas with the potential for air concentrations to be greater than 1 Derived Air Concentration [DAC] $5x10^{-10}$ µCi/ml), and monthly in areas not designated as airborne radioactivity areas to determine toxicological intakes and radiobiological doses. Measurement of Rn^{222} progeny should be collected monthly in areas where Rn^{222} progeny routinely exceeds 10 percent of the DAC, and increased to weekly if Rn^{222} progeny exceeds 25 percent of the DAC 0.08 pCi/ml).

Buildings (or rooms within buildings) that contain or have the potential for airborne radionuclide concentrations exceeding 1 DAC are posted with the sign, "Caution Airborne Radioactivity Area". This posting provides workers and managers with a warning that is helpful in minimizing radiation doses.

3.0 MONITORING RESULTS

Monitoring results for airborne radionuclides in the workplace are presented in the following sections. Section 3.1 presents the results for airborne natural uranium. Note: The trend analysis provided within

this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data were unavailable at the time that this submittal was being prepared.

Section 3.2 presents the results for airborne Rn^{222} progeny.

3.1 Monitoring Results for Airborne Natural Uranium Monitoring

The yellowcake filter press and dryer rooms of the CPP are areas where the data set from 1999 to 2009 is complete, and also correspond to areas with the highest potential for airborne releases of natural uranium. Natural uranium measurements were discontinued at the satellite processing plant (SR-1) in 2001 as a result of a performance-based license review. This review concluded that airborne natural uranium is not expected to be present because uranium is bonded to resin in ion exchange columns and the loaded resin is transferred to the CPP via tanker/trailer. This assumption is supported by historic data provided in annual ALARA reports prepared by Cameco Resources. Airborne natural uranium measurements in the pilot plant were discontinued in 2003 because no yellowcake was processed or stored within the building.

Airborne uranium data from the yellowcake and dryer rooms of the CPP from 1999 through 2009 have been used to assess Cameco Resources' performance in limiting air concentrations of U in the workplace at the SR-HUP. Table A.8.3-1A presents data from 1999 through 2009. The average and maximum measured concentrations were, excluding the maximum measurement in 1999, well below the DAC for soluble natural uranium of 5 x 10-10 µCi/ml. As indicated in the 1999 ALARA report (RAMC, 2000b), 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 U concentrations over the years of interest and continued downtrends in the ALARA levels can be seen. The maximum airborne concentration is generally associated with periods when drying and packaging is taking place. In these instances, respiratory protection is required to be worn by workers in these areas. Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data were unavailable at the time that this submittal was being prepared.

TABLE A-8.3-1A

Natural Uranium Concentrations in Air Expressed as a Percent of the Derived Air Concentration (DAC)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Average	5.89	4.55	1.26	1.48	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	93.98	21.31	16.66	17.65	24.00	22.00	14.60	15.00	9.40	5.40

3.2 Monitoring Results for Airborne Radon-222 Progeny Monitoring

Airborne Rn^{222} progeny monitoring was conducted in the SR structures for the periods indicated below (and continue to present):

- Pilot Plant 1999-2004
- CPP 1999-2009
- Satellite Plant SR-1 1999-2009
- Satellite Plant No. 1 2000-2009
- Satellite Plant No. 2 2000-2009
- Satellite Plant No. 3 2000-2009
- Header Houses 2000-2009

Monitoring was discontinued in the Pilot Plant in October of 2004 as a result of a SERP (SERP report No. 2004-5; PRI, 2004d) to eliminate the restricted area designation of the pilot plant. Inspections at Satellite Plant No. 1 were changed to monthly in 2006 after the plant was placed on stand-by and power shutdown. The inspection changes were approved by a SERP (SERP No 2005-4; PRI, 2005b).

Rn^{222} progeny monitoring is reported in units of a working level (WL), which is any combination of Rn^{222} progeny in one liter of air that would result in emission of 1.3 x 105 mega electron volts of potential alpha energy. The DAC for Rn^{222} progeny is 0.33 WL. Table A.8.3-1B below 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, and do not exceed, 10 percent 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. Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data were unavailable at the time that this submittal was being prepared.

TABLE A-8.3-1B

Radon-222 Progeny Concentrations in Air for Smith Ranch Facility Structures Expressed as a Percent of the Derived Air Concentration (DAC)

Location	Statistic	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Pilot Plant	Average	3.0	6.1	3.0	3.0	3.1	2.0	-	-	-	-
	Maximum	9.1	18.2	12.1	15.2	24.2	24.2	-	-	-	-
CPP	Average	6.1	3.0	6.1	3.0	3.1	4.0	4.0	5.0	2.0	2.7
	Maximum	57.6	30.3	175.8	36.4	24.2	24.2	24.2	51.5	24.2	24.2
SR-1	Average	6.1	6.1	3.0	6.1	6.1	5.0	2.0	1.0	1.5	1.5
	Maximum	81.8	172.7	175.8	78.8	24.2	24.2	24.2	24.2	24.2	24.2
*Satellite No 1	Average	-	3.1	3.1	3.0	3.1	3.0	2.0	2.0	-	-
	Maximum	-	-	-	-	24.2	24.2	24.2	24.2	-	-

TABLE A-8.3-1B

Radon-222 Progeny Concentrations in Air for Smith Ranch Facility Structures Expressed as a Percent of the Derived Air Concentration (DAC)

Location	Statistic	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
*Satellite No 2	Average	-	4.0	2.8	2.7	6.1	5.0	3.0	3.0	5.0	3.0
	Maximum	-	-	-	-	63.6	24.2	24.2	24.2	27.6	24.2
*Satellite No 3	Average	-	3.9	3.3	3.6	9.1	7.0	4.0	3.0	2.0	2.0
	Maximum	-	-	-	-	24.2	24.2	24.2	24.2	24.2	24.2
*Header Houses	Average	-	1.8	2.3	2.3	3.1	6.00	4	3	2.7	2.4
	Maximum	-	-	-	-	24.2	24.2	24.2	24.2	24.2	27.3

*Data prior to 2003 are associated with Highlands Uranium Project prior to incorporation into the Smith Ranch license.

4.0 AIRBORNE NATURAL URANIUM AND RADON PROGENY TREND ANALYSES

Trend analyses for airborne radionuclides in the workplace are presented in the following sections. Section 4.1 presents the trend analyses for airborne natural uranium. Section 4.2 presents the trend analyses for airborne Rn^{222} progeny. Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data were unavailable at the time that this submittal was being prepared. Trend Analysis for Airborne Natural U Concentrations

Trend analyses were performed on the set of data in Table A-8.3-1A as shown in Figure A-8.3-1-1. Data were tested for trends with the Mann-Kendall test (see Appendix A.8.4). If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope (see Appendix A.8.4).

The set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements less than or equal to 10. The results of the test are p-values of $0.0.006 < \alpha = 0.05$ for the average U air concentration and $0.004 < \alpha = 0.05$ for the maximum U air concentration, denoting that there is a statistically significant negative (i.e., downward) trend for both parameters.

The slope of the trend determines the magnitude of the trend and the direction (increasing or decreasing). Because a statistically significant negative trend was identified for both the average and maximum airborne U concentrations, the slope for both parameters were determined using the methods describe above. The slopes were -0.1 and -2.6 for the average and maximum airborne U concentrations, respectively, indicating a statistically significant negative trend for both parameters.

4.1 Trend Analysis for Airborne Radon-222 Progeny Concentrations

Trend analyses were performed on the average Rn^{222} concentration expressed as a percentage of the DAC as shown in Table A-8.3-1B and Figures A-8.3-1-2 and A-8.3-1-3. Data were tested for trends with the Mann-Kendall test. If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope (see Appendix A.8.4).

The set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements less than or equal to 10. The results of these tests are shown in Table A-8.3-1C. The results of the test are p-values of $0.012 < \alpha = 0.05$ for the SR-1 location and $0.025 < \alpha = 0.05$ for the Satellite No 1 location, denoting that there is a statistically significant negative trend for the average Rn^{222} concentration at these locations. For all other monitored locations, p-values were greater than 0.05, denoting no significant trend.

The slope of the statistically significant trend determines the magnitude of the trend and the direction (increasing or decreasing). Because a statistically significant trend was identified for the SR-1 and Satellite No 1 locations, the slopes for these locations were determined using the methods describe above. The slopes were -0.6 and -0.1 for SR-1 and Satellite No. 1, respectively, indicating a statistically significant negative trend in Rn^{222} progeny concentrations for both locations.

TABLE A-8.3-1C

Trend Analyses of Concentrations of Radon Progeny in Air

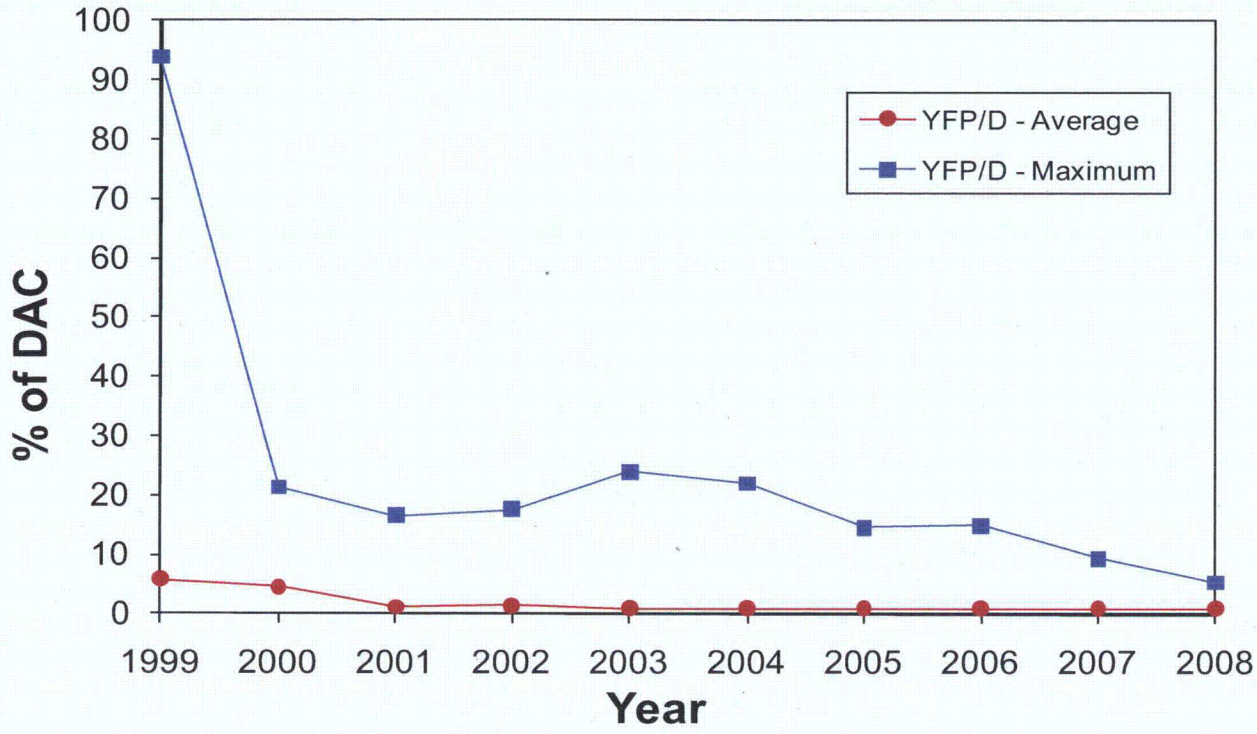
Location	Radionuclides	Data Trend Direction	P-Value
Central Processing Plant	Rn^{222} Progeny – Average	Stable	0.317
Pilot Plant	Rn^{222} Progeny – Average	Stable	0.298
Satellite Plant SR-1	Rn^{222} Progeny – Average	Negative	0.012
Satellite Plant No. 1	Rn^{222} Progeny – Average	Negative	0.025
Satellite Plant No. 2	Rn^{222} Progeny – Average	Stable	0.460
Satellite Plant No. 3	Rn^{222} Progeny – Average	Stable	0.075
Header Houses	Rn^{222} Progeny – Average	Stable	0.209

5.0 SUMMARY OF AIRBORNE RADIATION MONITORING (OCCUPATIONAL)

Occupational airborne radioactivity concentrations at the Smith Ranch facility 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 percent of the DAC. Annual average air concentrations for natural uranium and Rn^{222} progeny are well below the 25 percent DAC action level in all cases. Since 1999, there has been one case (in 1999) where the 25 percent DAC action level was exceeded for natural uranium maximum concentrations, but there have

been none since that time. There were several exceedances of the 25 percent DAC action level for maximum Rn^{222} progeny concentrations during the 1999 to 2003 time period at the CPP, SR-1 and Satellite No. 2, but these maximum concentrations have been below or very close to the 25 percent DAC action level from 2004 through 2008. In each exceedance case, an appropriate investigation and corrective action was performed. Additionally, the annual average air concentrations are below the 10 percent DAC criteria where occupational monitoring of airborne radionuclides is required by 10 CFR § 20.1502. No increasing trends of workplace airborne radioactivity were identified. This demonstrates that Cameco Resources is limiting occupational airborne radioactivity concentrations to levels which are ALARA. The occupational doses resulting from airborne radioactivity in the workplace is discussed in Appendix A.8.3-2.

FIGURES FOR APPENDIX A-8.3-1



Golder Associates Denver, Colorado

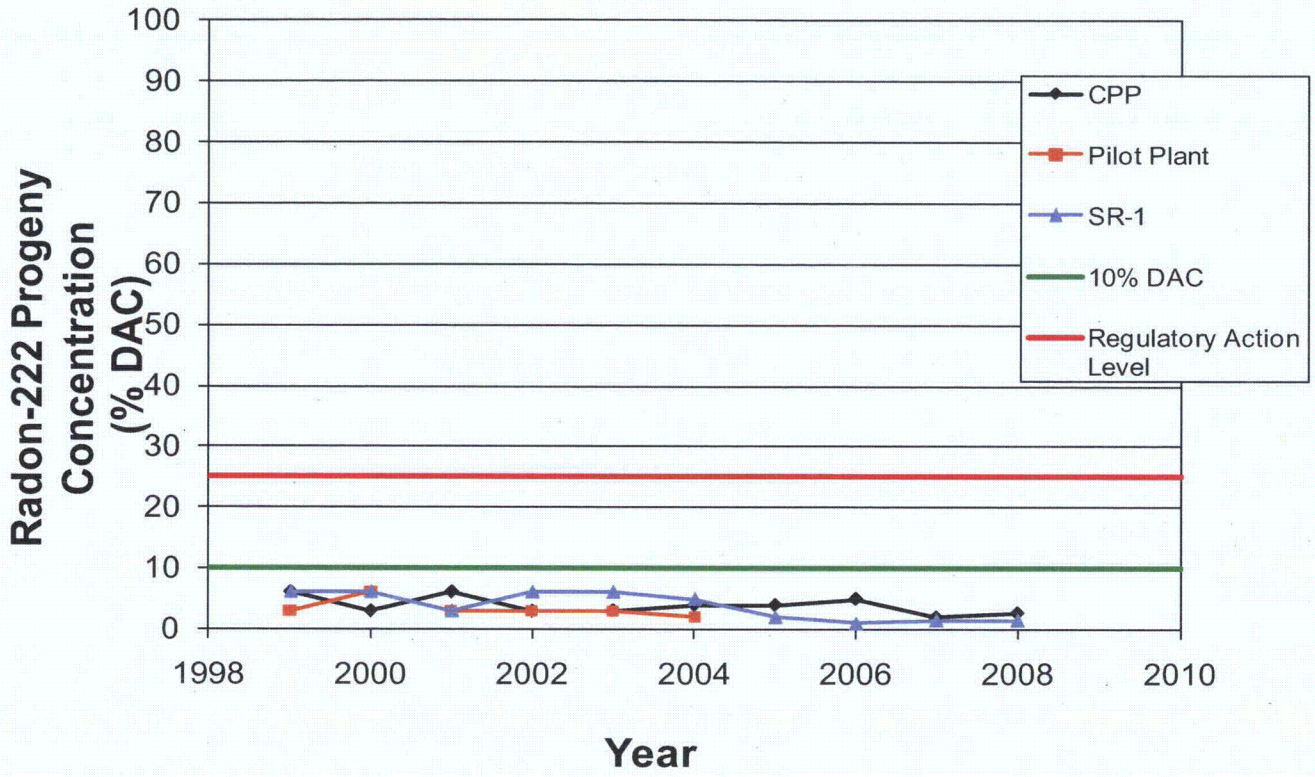
TITLE

Yearly Maximum and Annual Average Natural Uranium Concentrations at the CPP Yellowcake Filter Press/Dryer

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-1-1

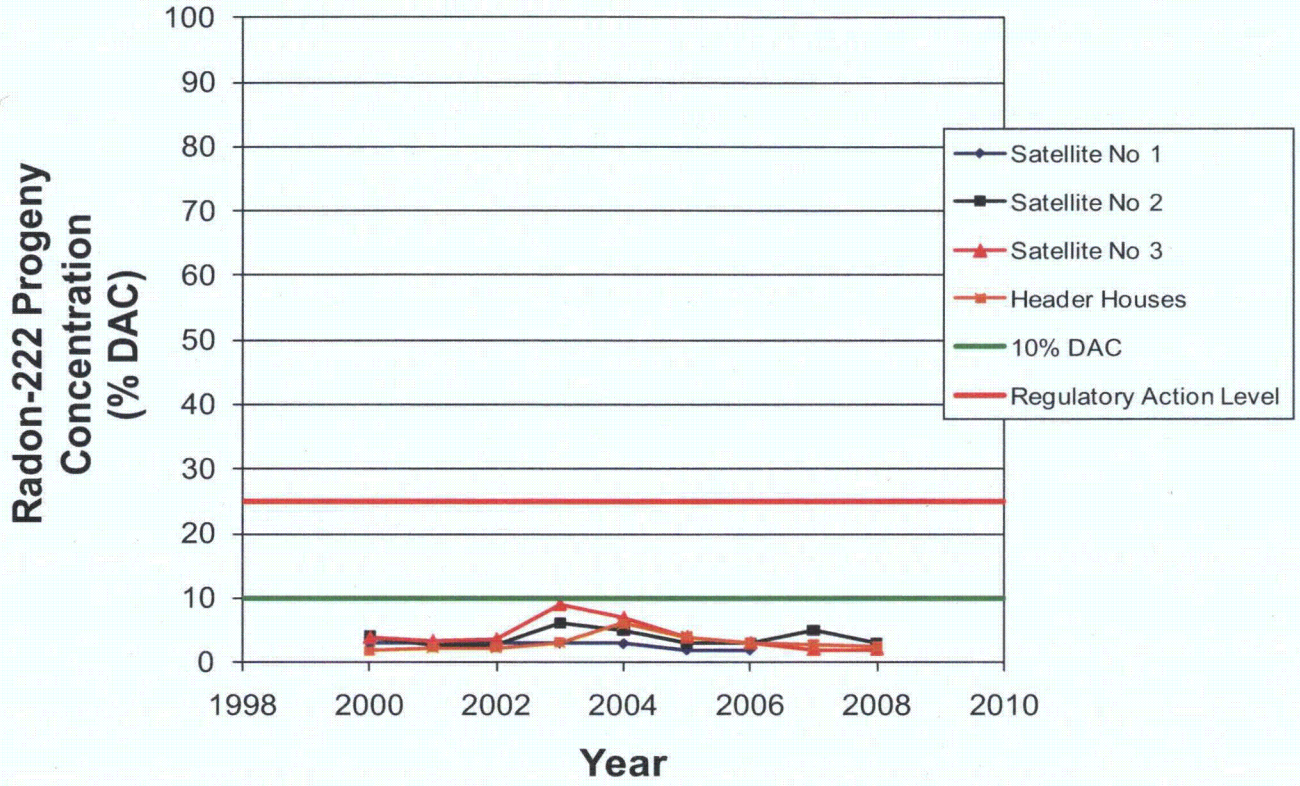


Golder Associates
Denver, Colorado

TITLE
Annual Average Radon-222 Progeny Concentrations at the CPP, Pilot Plant and SR-1 Buildings

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-1-2



Golder Associates Denver, Colorado

TITLE **Annual Average Radon-222 Progeny Concentrations at the Satellite 1, 2, 3 and Header House Buildings**

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-1-3

APPENDIX A-8.3-2

HISTORICAL RESULTS OF RADIATION DOSE CALCULATIONS

Appendix A-8.3-2 Historical Results of Radiation Dose Calculations

1.0 OVERVIEW

The NRC requires strict adherence to radiation worker monitoring requirements. Radiation dose exposure data were reviewed and evaluated for SR-HUP (Source Material License SUA-1548) for the period of interest in this License Renewal submittal, i.e., the last half of 1999 through 2008. Review of this data is required for a License Renewal, as outlined in NUREG-1569 Appendix A, to demonstrate that the licensed facilities are operating in a safe and effective manner. The regulatory requirements, worker exposures, ALARA implementation, trend analyses and summary of historical results are provided in this section. It will be shown that Cameco Resources' employees continue to receive very low radiation doses, well below the regulatory limits, with the level of dose generally correlated with the job classification.

2.0 REGULATORY REQUIREMENTS

NRC licensees are required to develop and implement a radiation protection program that limits radiation doses to levels that are ALARA and within the occupational dose limits (10 CFR 20.1101 and 10 CFR 20.1201, respectively). Administrative controls (such as procedures) and engineering controls are used to the extent practical to reduce radiation exposures.

Occupational dose limits are specified in 10 CFR 20.1201. The annual limits are the more limiting of: (i) a TEDE of 5 rem/year; (ii) the sum of the deep-dose equivalent and the committed dose to any organ (with exception of the lens of the eye) of 50 rem/year; (iii) the dose to the lens of the eye of 15 rem/year; and (iv) the dose to the skin or any extremity of 50 rem/year. In addition to the annual dose limits, the soluble uranium intake by a worker may not exceed 10 milligrams (mg) in a week. This limit is based on the chemical toxicity of uranium. For normal ISR operations, limiting the TEDE to 5 rem/year and the intake of uranium to 10 mg/week is the primary focus of the radiation protection program since exposure conditions are not such that high extremity and organ doses are limiting.

Worker monitoring requirements are specified in 10 CFR § 20.1001 to 20.2401 (Standards for Protection Against Radiation). Pursuant to NRC License SUA-1548 License Condition 9.7 and Section 9.11 of the NRC License Renewal Submittal (NRC, 2008) employee exposures at SR-HUP and RRP are monitored in accordance with NRC Regulatory Guides 8.30, "*Health Physics Surveys in Uranium Recovery Facilities,*" and NRC Regulatory Guide 8.34, "*Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.*" Routine employee external doses are determined and recorded for those employees likely to receive more than 10 percent of the allowable occupational dose limit (i.e. 0.5 rem). External exposures are determined using personnel dosimeters that are exchanged quarterly, or at the end of a task, depending on the expected exposure potential. Routine employee internal doses are determined and recorded for those employees likely to receive an intake of more than 10 percent of the Annual Limit on Intake (ALI) from RA^{222} daughters or uranium. Internal doses are determined by calculation using air quality data and time of exposures, or from the results of bioassay sampling.

Non-routine doses are determined and recorded for all employees conducting non-routine work activities that require a RWP. In the event that an employee has routine and non-routine doses for a monitoring period, doses are summed to determine the total dose. In accordance with NRC regulations, internal exposures are summed (e.g. quarterly, yearly) and the TEDE calculated by adding the dose equivalent from internal exposure to the dose equivalent from external sources of radiation.

3.0 WORKER EXPOSURES AND ALARA IMPLEMENTATION

3.1 Worker Exposure

Most Cameco Resources workers do not require monitoring for radiation exposure since they do not have the potential for receiving 10 percent of the dose limits for internal or external radiation. Cameco Resources conservatively chooses to monitor more employees than required to assure compliance with this requirement. For example, workers in the well fields are only occasionally exposed to radiation-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, which may have slightly elevated RA^{222} progeny.

Maintenance workers perform various repair and maintenance functions throughout the site, including within the CPP, during which time they may come into contact with radioactive materials. Average annual external doses to maintenance workers, as measured by radiation dosimeters, ranged from 26 to 150 mrem/year over the years 2002 through 2008 as shown in Table A-8.3-2A, less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring.

Operators within the satellite plants are exposed to direct radiation primarily from Ra^{226} buildup in the tanks and the reverse osmosis (RO) equipment used in groundwater restoration. During transfer of the IX resin, a limited amount of RA^{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 years of airborne particulate sampling for uranium at the satellite plants, 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 radiation dosimeters, ranged from 56 to 232 mrem/year over the time period from 2002 through 2008, less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring.

Laboratory workers routinely work with process samples and therefore have direct radiation exposure from the samples. Their average annual dose equivalent, as measured by the radiation dosimeters, ranged from 65 to 112 mrem/year over the time period from 2002 through 2008, less than the 0.5 rem (500 mrem) dose limits used for determining required monitoring.

While there are few workers in the SR CPP, this group potentially receives the highest radiation dose. Direct radiation from the process vessels arising primarily from Ra-226 buildup, RA^{222} releases within the CPP from resin transfer, and exposure to airborne yellowcake during drying and packaging operations can contribute to workers dose. During yellowcake drying and packaging, workers use respiratory protection to limit inhalation. The average annual external dose equivalent to CPP workers, as measured by the radiation dosimeters, ranged from 249 to 498 mrem/year as indicated in Table A-8.3-2A during the 2002 to 2008 time period.

TABLE A-8.3-2A

Average Annual Radiation Dosimeter Reading (mrem)

Workers	2002	2003	2004	2005	2006	2007	2008
CPP	363	250	286	305	249	498	336
Lab	110	96	65	98	103	112	104
Satellite SR-1	204	130	87	111	179	124	56
Satellite-2	132	138	145	188	108	169	125
Satellite-3	102	145	140	146	165	232	147
Maintenance	26	90	98	150	82	76	35

Note: The Annual Dose Limit for a Radiation Worker, 5000 mrem/year-10 CFR 20.1201

The TEDE for each CPP worker is obtained by adding the dose equivalent from internal exposure to the external dose equivalent measured by the radiation dosimeter. For most workers, the dose equivalent from internal exposure is very small and can be neglected. The minimum, maximum, and average TEDE for site workers is summarized in Table A-8.3-2B for the time period of 1999 through 2008. 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 received 1080 mrem, or 22 percent of the allowable limit. This was a result of the improper storage of their TLD badge when off-sight. Figure A-8.3-2-1 displays a plot of those values. To put this into perspective, the average US radiation worker received approximately 300 mrems per year.

TABLE A-8.3-2B

Annual Total Effective Dose Equivalent For CPP Workers in mrem for Each Year

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Average	-	-	-	492	433	498	478	419	619	475	
Minimum	-	-	-	396	378	416	433	88	239	274	
Maximum	301	583	1080	714	495	537	546	779	902	583	

The "*Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities*" by the NRC (NRC, 2009e) cites the occupational doses measured at the Crow Butte ISR facility in Davis County, Nebraska (also owned by Cameco Resources) 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 A-8.3-2B for the SR-HUP.

3.2 ALARA Implementation

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.

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 RA^{222} in the buildings.
- ***Calendar Year 2001:*** P-traps located on tanks in both the plant and satellite have been extended with a clear plastic tube allowing operators to easily recognize when traps require additional water to minimize the potential escape of Ra^{222}. The sump located under the shaker deck has been vented through the ceiling of the plant to assist in the removal of potential Ra^{222}.
- ***Calendar Year 2002:*** An in-depth risk screening and assessment was conducted for seventeen 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 Ra^{222} during resin transfers.
- ***Calendar Year 2003:*** It was recommended that the Hammermill and associated piping systems be redesigned at the HUP to minimize the release of airborne particulates during drying operations (was not implemented because the HUP was placed in standby).
- ***Calendar Year 2004:*** A new dryer bag house was constructed, and CPP exhaust fans and resin traps were installed. Motor activated value (MAV) was installed on injection trunk line in the header houses in the I-well field prior to bringing the well field on line. The MAV reduces the amount of injection fluid potentially released in an upset condition.
- ***Calendar Year 2005:*** Improvements were made to dryer A, and a drum vibrator and audible alarms were installed on Ra^{222} prisms (monitors).
- ***Calendar Year 2006:*** Maintenance and improvements on Dryer A were made. Ventilation fans on 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 Ra^{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 Resources 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 Ra^{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 (JHA) for work in the CPP, installing shaker deck ventilation, and restricting access to radiation areas.

4.0 TREND ANALYSES

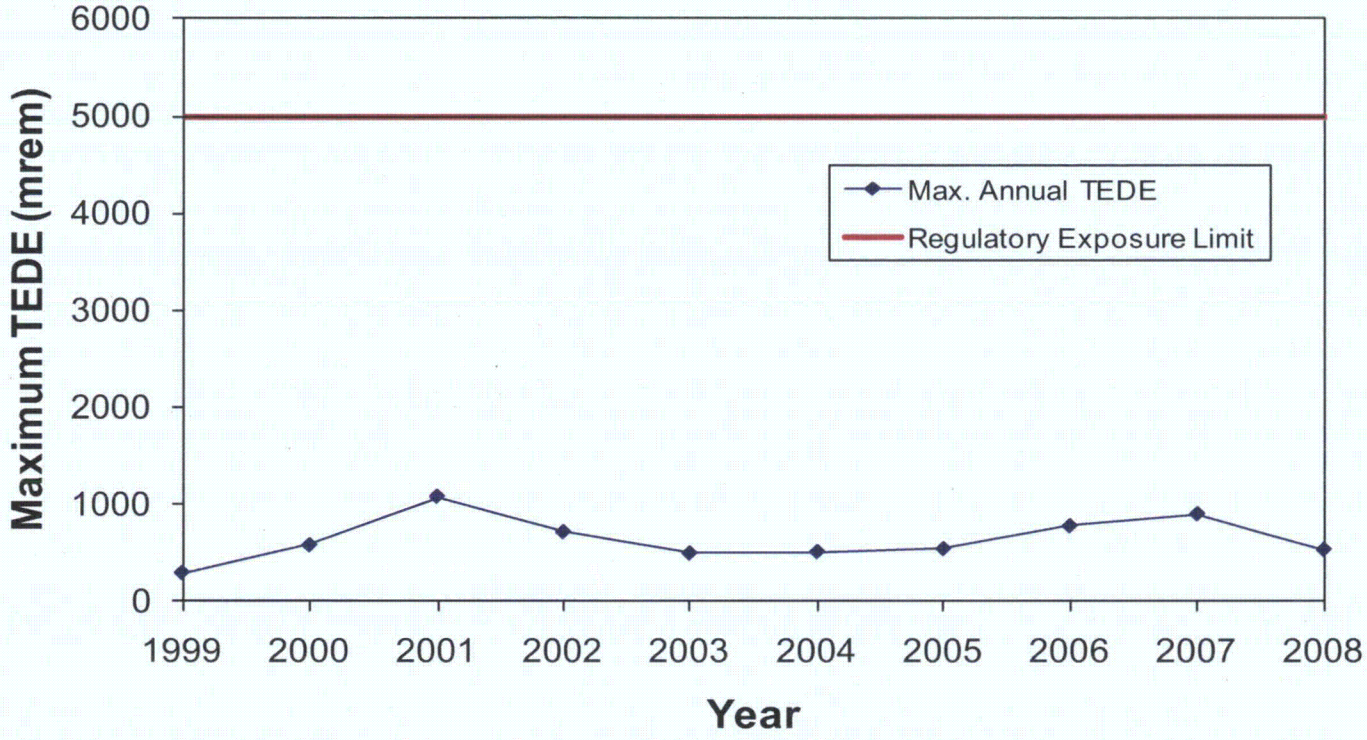
Trend analyses were performed on the set of data shown in Figure A-8.3-2-1. Data were tested for trends with the Mann-Kendall test. If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope.

The set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements less than or equal to 10. The result of the test is a p-value of 0.242 > α = 0.05, denoting that there is no statistically significant trend. Because of the lack of a statistically significant trend, no slope of the trend was estimated.

5.0 SUMMARY OF HISTORICAL RESULTS OF RADIATION DOSES TO WORKERS

The maximum TEDEs reported for workers at the SR-HUP 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 (RAMC, 1999). External dose equivalents described in Section 3.1 of this Appendix represent the largest component of the TEDE. It is clear, as demonstrated by completed actions described in Section 3.2 of this Appendix, that Cameco Resources is committed to continually evaluating sources of worker exposures to ionizing radiation and implementing improvements in order to maintain occupational radiation doses at levels which are in compliance with ALARA.

FIGURES FOR APPENDIX A-8.3-2



Golder Associates
Denver, Colorado

TITLE
Maximum Annual Total Effective Dose Equivalents

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-2-1

APPENDIX A-8.3-3

HISTORICAL BIOASSAY PROGRAM ASSESSMENT

1.0 OVERVIEW

NRC licensees are required to limit intakes to workers in areas with airborne radionuclides by applying engineering controls, controlling access, limiting exposure times, and through the use of respiratory protection (in that order). Respiratory protection measures, when applied properly, will reduce intakes to acceptable levels. However, a bioassay program provides additional assurance that the respiratory program is effective and provides a quantitative method for estimating intakes of radioactive material. Measurements of the intake of soluble (Class D) uranium by workers can be estimated from laboratory analyses of U concentrations in urine samples (bioassays), taken after intake. Urine bioassay is a sensitive method to measure soluble uranium intakes. When considering the inhalation pathway, 10 percent of a soluble uranium intake will be excreted in the daily urine output one day after the intake (ICRP, 1988). Ten days after the intake, approximately 1 percent of the potential intake would be excreted in the urine (ICRP, 1988). Since routine bioassay samples are collected from the most at risk personnel, the 10 milligram (mg) per week intake limit for soluble uranium can easily be detected via urine bioassay.

This section presents an assessment of the historical bioassay program for the SR-HUP, as required by NUREG-1569 Appendix A. Uranium intakes at the Smith Ranch Facility are closely monitored, which has allowed 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 µg/L. As demonstrated in the following sections, soluble uranium intakes at the SR-HUP are limited to levels below regulatory limits, i.e. levels which are.

2.0 REGULATORY REQUIREMENTS AND GUIDANCE

Bioassays are used to determine worker intakes when using respiratory protection as required by 10 CFR §20.1703. They are also used to ascertain the effectiveness of the health physics program, qualify the protectiveness of the respiratory protection program, and to demonstrate compliance with chemical toxicity limits for soluble uranium contained in 10 CFR 20.1201(e). Bioassays are required when workers have the potential for intakes of 0.1 ALI or more in a year, as well as for declared pregnant workers, occupationally exposed minors, and members of the public allowed access to airborne radioactivity areas.

NRC Regulatory Guide 8.22, "*Bioassay at Uranium Mills*," provides guidance to licensees that have the potential for exposure to employees from airborne yellowcake dust. All new employees and contractors submit a baseline bioassay prior to commencement of work. Employees and contractors who will handle U or contaminated materials submit a bioassay two days after completion of work. Employees are requested to submit a bioassay at termination. All workers who work routinely in yellowcake precipitation/packaging areas submit bioassays either weekly or monthly based on work location. Bioassays may be required for special situations and for activities in yellowcake areas requiring a RWP.

The regulatory guide specifies a quality control program as well as a requirement that the analytical lower limit of detection (LLD) be less than 5 µg/L. The radiation dose equivalent associated with an intake resulting in a urinalysis result of 5 µg/L would be approximately 0.06 mrem.

Table 1 in Regulatory Guide 8.22 provides action levels for concentrations of uranium in bioassay results. For concentrations less than 15 µg/L, no action is required other than to review results. For concentrations between 15 and 35 µg/L, the results should be interpreted as an indicator that uranium confinement and air sampling may not provide an adequate margin of safety. The radiation dose associated with an intake resulting in a urinalysis result between 15 and 35 µg/L would be approximately 0.17 and 0.4 mrem, respectively. A series of steps are suggested, including confirming the results through additional sampling, improving controls, and considering work restrictions for urinalysis.

Concentrations greater than 35 µg/L suggests that uranium confinement and perhaps air sampling programs may not be acceptable. Actions taken include those listed above for the 15 to 35 µg/L concentration range, and also include limiting operations until it is certain that no other workers will receive exposures in excess of 35 µg/L. Increased frequency of bioassay sampling is required and work restrictions for affected workers are also recommended for concentrations exceeding 35 µg/L. Two consecutive bioassays from the same employee with concentrations of U of 35 µg/L or greater, or a single bioassay with concentration of U of 130 µg/L or greater, is an indicator that the worker may have exceeded the regulatory limits on intake of soluble uranium. Regulatory Guide 8.22 specifies a series of additional action steps for this scenario. This is in addition, to SUA-1548 License Condition 11.3 requiring that a report be sent to the NRC within 30 days demonstrating corrective actions.

3.0 BIOASSAY RESULTS

Summaries of the bioassay results presented in the annual ALARA reports for the SR-HUP 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 the SR-HUP. An elevated baseline bioassay result only occurred once, where a contract employee was hired for a short duration and the sample result from the baseline sample was elevated. As a result, said employee was terminated. The results are presented in Table A-8.3-3A 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 than15 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 A-8.3-3A. The results of these investigations were presented in the annual ALARA audit reports.

Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data was unavailable at the time that this submittal was being prepared.

TABLE A.8.3-3A

BIOASSAY RESULTS FOR SMITH RANCH FROM 1999 THROUGH 2009

Year	Total Number Of Bioassays	Number <LLD	Number LLD to 15 µg/L	Number 15 to 35 µg/L	Number >35 µg/L
1999	408	390	0	18[a]	0
2000	388	381	0	6[b]	1 (364 µg/L)[b]
2001	304	302	0	1	1 (59 µg/L)[c]
2002	303	193	10	0	0
2003	241	236	5	0	0
2004	173	167	4	1[d]	1(61 µg/L)[d]
2005	184	183	1	0	0
2006	446	444	1	0	1 (39 µg/L)[e]
2007	509	508	0	1[f]	0
2008	529	526	2	0	1 (44 µg/L)[g]
2009					

Notes:

1. LLD = 5 µg/L;
2. Inferred causes for elevated bioassay results:
   a. Causes attributed to improper use of respirators, poor personal hygiene, and/or poor housekeeping.
   b. Personnel sneezing, water infiltration of respirator, improper use of respirator, or entering area without respirator.
   c. Believed to be from employee bringing contaminated gloves to nose or mouth.
   d. Probable improper bioassay sample handling.
   e. Maintenance worker worked without respiratory protection.
   f. Driller pulled wet piping material from well. Two elevated results were from baseline samples and are not reported here.
   g. Contract employee likely inadvertently contaminated sample.

Figure A-8.3-3-1 displays a plot of the number of bioassays collected from site employees and contractors that were above the action level of 15 µg/L over the time period applicable to this License Renewal submittal (i.e., 1999 through 2009). Over the ten year period, only 31 (0.9 percent) of the 3,485 samples that were taken exceeded the action level 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 reports. Most of the action level exceedances occurred during 1999 through 2000 and were attributed to improper personal hygiene and improper use of PPE, 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.

From 1999 through 2008, only one bioassay exceeded the action level of 130 µg/L. The event was investigated and corrective actions were taken as detailed in the letter sent to the NRC on May 12, 2000 (Accession No. ML003715494). The analysis using worst-case assumptions resulted in assigning an exposure of 0.05 percent of an ALI, which is equivalent to a TEDE of 2.5 mrem.

4.0 TREND ANALYSES

Trend analyses were performed on data from 1999 to 2008, as shown in Figure A-8.3-3-1. Data were tested for trends with the Mann-Kendall test. If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope.

The set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements less than or equal to 10. The result of the test is a p-value of $0.127 > \alpha = 0.05$, denoting that there is no statistically significant trend. Because of the lack of a statistically significant trend, no slope of the trend was estimated.

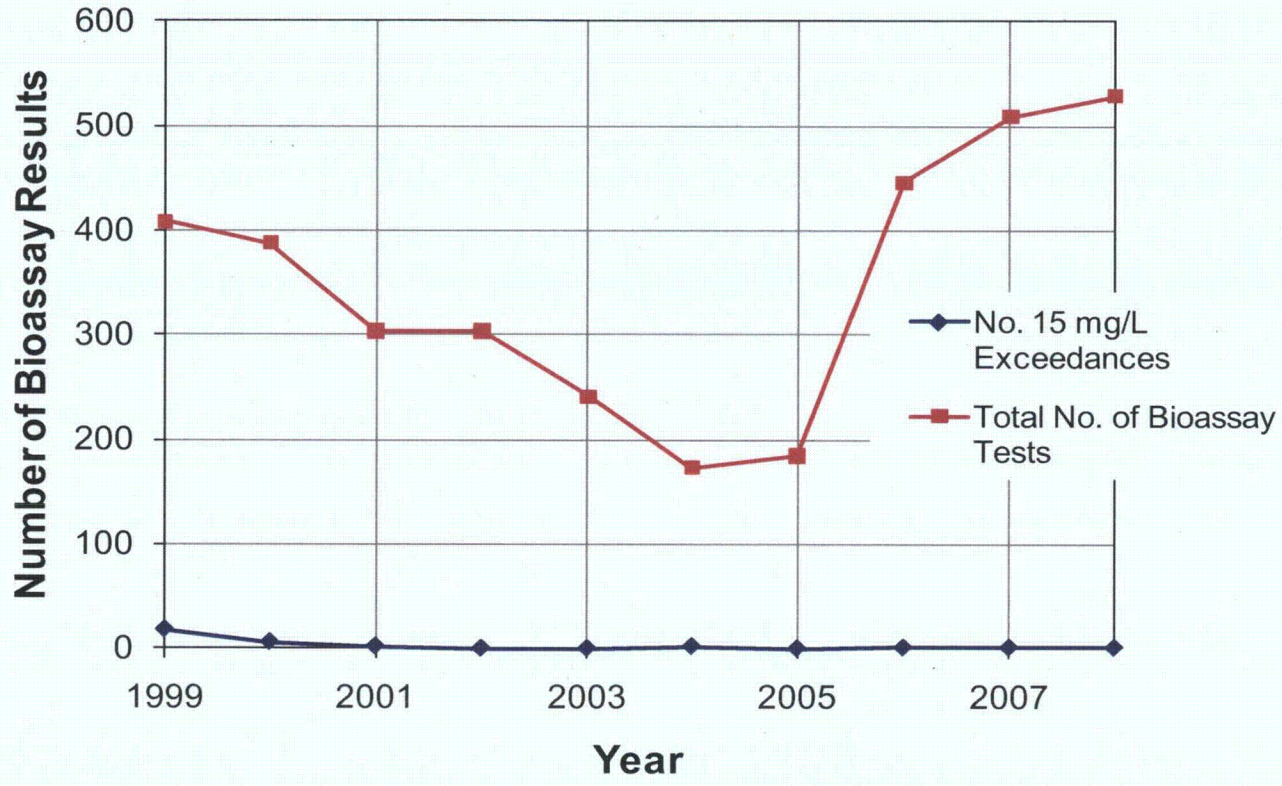
Qualitatively, there appears to be a clear reduction in the number of elevated bioassay samples from 1999 through 2008, and most of this reduction occurred over the course of two years (1999 and 2000).

Bioassay data associated with operation of the HUP 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 HUP dryer. Of these 269 samples, two samples exceeded the 15 µg/L action level, which represents less than 1 percent of the samples collected.

5.0 SUMMARY OF HISTORICAL BIOASSAY RESULTS

U intakes at the SR-HUP 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 µg/L. Since 2003, 5 samples out of 2082 collected (0.24 percent) were above the first tier action level of 15 µg/L. In each case, an appropriate investigation and corrective action was performed. Since 2003, 2064 samples out of 2082 samples collected (99 percent) were below the LLD of 5 µg/L. This demonstrates that the soluble uranium intakes for the SR-HUP are limited to levels below regulatory limits, i.e. levels which are ALARA.

FIGURES FOR APPENDIX A-8.3-3



Golder Associates Denver, Colorado

TITLE
Number of Bioassays that Exceeded 15 µg/L of Uranium in Urine with the Total Number of Bioassays Performed Each Year

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-3-1

APPENDIX A-8.3-4

HISTORICAL OCCUPATIONAL EXPOSURE RATE MONITORING ASSESSMENT

1.0 INTRODUCTION

This section presents an assessment of the historical occupational exposure rate monitoring for the SR-HUP, as required by NUREG-1569 Appendix A. Cameco Resources has made many modifications since the last License Renewal submittal to reduce the gamma exposure rates in work areas.

The review provided herein indicates that Cameco Resources has been in compliance with all of the applicable regulatory standards and license conditions pertaining to personnel exposures to radionuclides, external contamination limits and release limits to the environment during the period since the last License Renewal submittal in 1999.

2.0 EXPOSURE RATE AND SURFACE CONTAMINATION MONITORING BACKGROUND

Within an ISR uranium facility, the major source of occupational dose to workers arises from exposure to gamma rays emanating from process piping and tanks, resin tanks, and U drying and packaging operations. The build-up of 11e(2) byproduct within tanks and process piping is the primary source of gamma radiation. 11e(2) byproduct is also responsible for generating Rn^{222}, which may be released and result in a source of internal exposure. The exposure rates presented in this section do not necessarily correlate with dose equivalents to workers from direct sources of radiation. This is because workers' dosimeters respond to the product of the exposure rate and the time that the workers are exposed. The time that a worker is in a work area depends on many factors, including worker efficiency and non-routine maintenance or repair requirements.

Controlling the buildup of 11e(2) byproduct is accomplished by cleaning tanks periodically to remove 11e(2) byproduct from the surfaces. Controlling surface contamination within work areas also limits employee contamination and the potential transfer of material from the restricted area. Reducing the levels of surface contamination is achieved through good housekeeping practices and the proper planning of non-routine maintenance and repairs.

3.0 REGULATORY REQUIREMENTS

As indicated previously in other sections of this appendix, Subpart C of 10 CFR Part 20 limits the TEDE for occupational workers to 5 rems/year, shallow dose equivalent to the skin of 50 rems/year, and dose equivalent to the embryo/fetus of a pregnant worker to 0.5 rem during the entire pregnancy. In order to limit the exposure from direct radiation, the NRC requires that work areas be routinely monitored and posted according to their exposure rate classification. In addition, RWPs for conducting non-routine tasks should contain information regarding potential radiation exposures prior to and/or during completion of the work.

NRC Regulatory Guide 8.30, "*Health Physics Surveys in Uranium Recovery Facilities (URF),*" suggests that gamma radiation surveys be conducted semi-annually throughout a URF at locations representative of workers' exposure to determine posting and external dosimetry requirements. Surveys in radiation areas are to be conducted quarterly. Regulatory Guide 8.30 also recommends that surface contamination be limited to approximately 220,000 dpm/100 cm^2 so that the contamination does not contribute to unacceptable airborne radionuclide concentrations. While no measurements are required in the yellowcake production area since this corresponds to a level where yellowcake can be visually present, measurements are being taken as part of the ALARA Program. Areas where visual yellowcake is seen are routinely cleaned as part of the housekeeping in these areas.

Buildings, or rooms within buildings, that contain radioactive material must be posted with the sign, "Caution Radioactive Material". NRC License Amendment 9.8 allows Cameco Resources to post the entire controlled area as potentially containing radioactive material. In addition, areas accessible to personnel, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem in one hour at 30 cm from the source of radiation must be posted as "Caution Radiation Area". Areas where it is possible for an individual to receive 0.1 rem in one hour at 30 cm from the source are required to be posted "Caution High Radiation Area". These postings provide workers and managers with information helpful in minimizing radiation doses. There are no areas at the Smith Ranch Facility that meet the requirements for posting as "Caution High Radiation Area".

4.0 MONITORING RESULTS

4.1 Gamma-Ray Exposure Monitoring Results

The gamma-ray exposure rates were monitored within buildings as required by NRC Regulatory Guide 8.30. Because of the low reported TEDE to well field workers and the low measured exposure rates, gamma exposure rate monitoring was terminated in the well fields in 2003. For similar reasons, measurements within the Pilot Plant and Satellite Plant No. 1 were terminated in 2006. The use of portable RO units was discontinued in 2003, and thus measured exposure rates were not reported after 2003. A review of the measurements of exposure rates was performed for the facilities during the time periods listed in Table A-8.3-4A. This review consisted of evaluating the summary of the data presented in the annual ALARA audit reports.

Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data was unavailable at the time that this submittal was being prepared.

TABLE A-8.3-4A

LOCATIONS AND TIME PERIODS OF MEASUREMENTS OF EXPOSURE RATES WITHIN BUILDINGS

Location	Time Period
Pilot Plant	1999-2006
CPP	1999-2009
Satellite Plant SR-1	1999-2009
Satellite Plant No. 1	2000-2006
Satellite Plant No. 2	2000-2009
Satellite Plant No. 3	2000-2009
Portable RO Units	2000-2003

Measurements of exposure rate were reported in units of μR/hr or mR/hr. For consistency, all exposure rates are reported here in milli-Roentgens per hour (mR/hr) (1000 micro-Roentgens per hour (μR) = 1 mR).

Figure A-8.3-4-1 displays a plot of the annual averages of the data from the measurements of exposure rate over time at the Pilot Plant, CPP, and at the Satellite Plant SR-1. Figure A-8.3-4-2 displays the data for Satellite Plant Nos. 1 through 3 and the portable RO units.

4.2 Surface Contamination Monitoring

Annual summaries of the monthly surface contamination surveys within the restricted areas are presented in the ALARA audit reports. The summaries indicate that the surface contamination was maintained below the 220,000 dpm/100 cm^2 action level and demonstrates compliance with this NRC limit. Since compliance is at least partially dependent on visual inspections, no trend analysis of surface contamination monitoring has been performed.

5.0 TREND ANALYSES

Trend analyses were performed on the sets of data shown in Figure A-8.3-4-1 and Figure A-8.3-4-2, except for the set of data measured at the portable RO units. The set of data measured at the portable RO units was not analyzed because radiation exposure to this source has not existed since 2003, and is not expected to occur in the future at this site. Data were tested for trends with the Mann-Kendall test. If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope.

Each set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements less than or equal to 10. The results of the tests are summarized in Table A-8.3-4B. The trends for the Pilot Plant and Satellite Plant No. 1 are not statistically significant.

TABLE A-8.3-4B

RESULTS OF THE TREND ANALYSES OF THE DATA FROM THE MEASUREMENTS OF EXPOSURE RATE

Location	Data Trend	P-Value
Pilot Plant	Insignificant	--
CPP	Positive	0.0083
Satellite Plant SR-1	Positive	0.0046
Satellite Plant No. 1	Insignificant	--
Satellite Plant No. 2	Positive	0.016
Satellite Plant No. 3	Positive	0.031

The slopes of the trends that were statistically significant (p-value $\leq \alpha = 0.05$) were estimated using Sen's Nonparametric Estimator of Slope. The estimated slopes of the linear trends are summarized in Table A-8.3-4C. All of the statistically significant slopes are positive and equal to approximately 0.1 mR/hr per year.

TABLE A-8.3-4C

ESTIMATES OF THE STATISTICALLY SIGNIFICANT SLOPES, USING SEN'S NONPARAMETRIC ESTIMATOR OF SLOPE, OF THE DATA FROM THE MEASUREMENTS OF EXPOSURE RATE

Location	Slope (mR/hr per year)
Pilot Plant	-
CPP	0.11
Satellite Plant SR-1	0.10
Satellite Plant No. 1	-
Satellite Plant No. 2	0.10
Satellite Plant No. 3	0.12

6.0 SUMMARY

Gamma exposure rates have been measured and documented since the last license Renewal submittal in work areas within restricted areas. Since exposure to gamma radiation is the major contributor to the employee TEDE, changes in work-area gamma exposure rates are indicators for the potential changes in

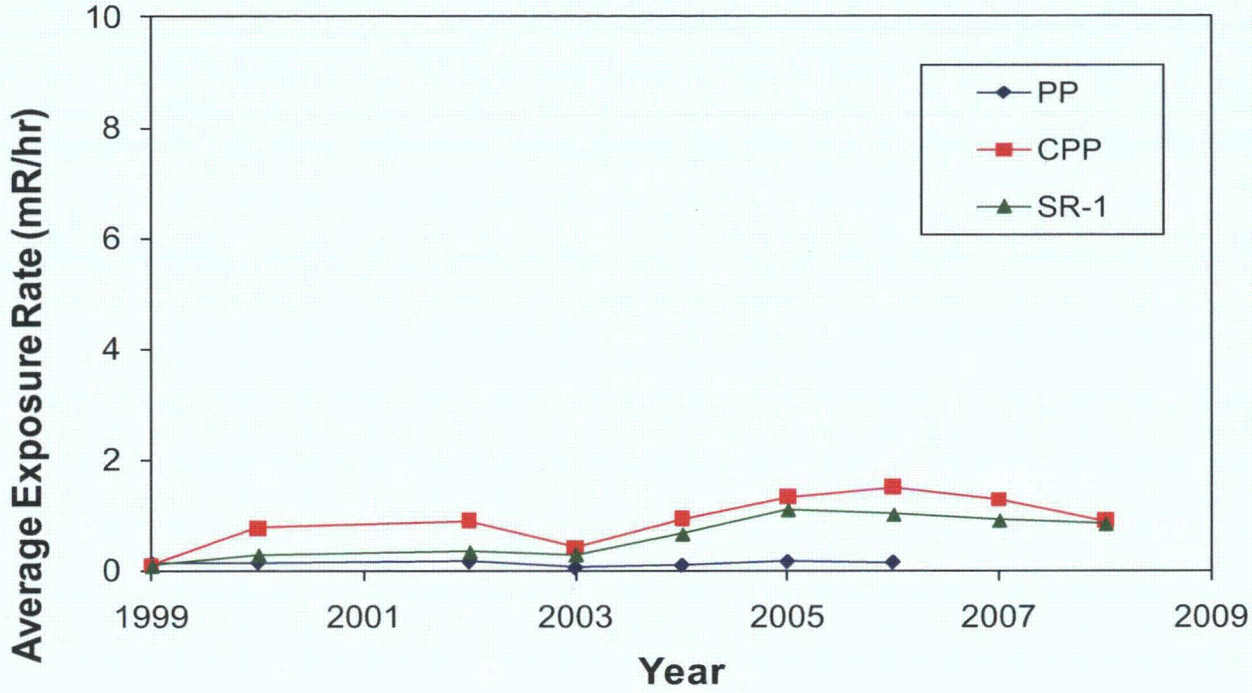
worker TEDE. As indicated earlier, the actual worker doses are dependent on the time spent in the work area.

Cameco Resources has made many modifications since the last license renewal submittal to reduce the gamma exposure rates in work areas. In 2007, several actions were taken to reduce the worker exposure, especially in the CPP, including the addition of lead shielding to a tank and administrative controls on when tanks would be cleaned, based on radiation levels. These actions resulted in significant decreases in exposure rates in the CPP in 2007 and 2008, as shown in Figure A-8.3.4-1.

The trend analysis of data from the years 2000 through 2008 indicate a positive trend for the CPP, SR-1, and the Satellite Plants Nos. 2 and 3. The data resulting from the major changes made in 2007 suggest that exposure rates at the CPP and SR-1 do not follow the upward trend, but may in fact level off, or perhaps decline. This is encouraging since these two facilities are responsible for a significant fraction of the total worker TEDE. While Cameco Resources has recognized the upward trends of the exposure rates in several of its operating areas, recent improvements have been made which may be reversing the trends. These changes, along with changes in administrative procedures and enhanced worker awareness, has resulted in limiting the average dose for all radiation workers at the Smith Ranch Facility to only ten percent of the allowable TEDE.

A review of the surface contamination data for controlled areas indicates that the levels have consistently remained within the NRC action level of 220,000 dpm/100 cm^2. As provided herein, an assessment of the historical occupational exposure rate monitoring for the SR-HUP indicates that Cameco Resources has been in compliance with all of the applicable regulatory standards and license conditions pertaining to personnel exposures to radionuclides, external contamination limits and release limits to the environment during the period since the last License Renewal submittal in 1999.

FIGURES FOR APPENDIX A-8.3-4

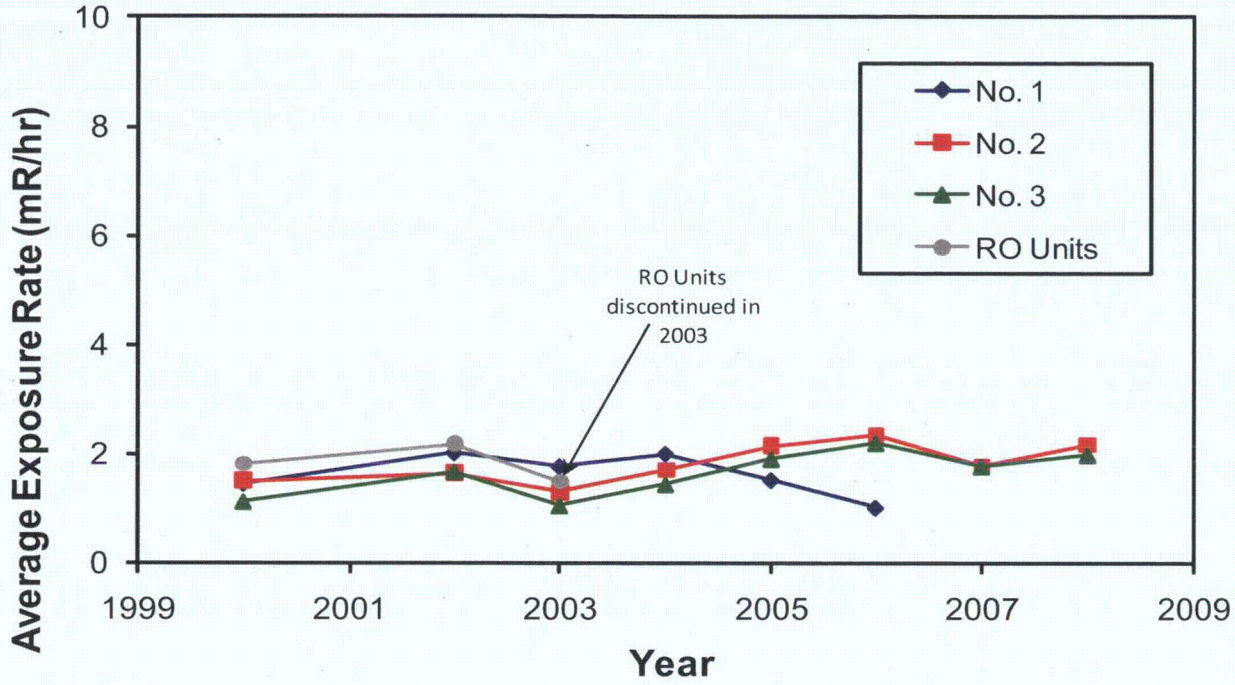


Golder Associates Denver, Colorado

TITLE
Annual Average Measured Exposure Rates at the Pilot Plant (PP), Central Processing Plant (CPP) and Satellite Plant SR-1 (SR-1)

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	ERG	DATE	May-10	JOB NO.	093-81703
CHECKED	KFM	SCALE	NTS	DWG. NO.	NA
REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO.	A-8.3-4-1



Golder Associates
Denver, Colorado

TITLE
Annual Averages of the Data from the Measured Exposure Rates at the Satellite Plants Nos. 1-3 and the Portable RO Units

CLIENT/PROJECT					
Cameco Resources Smith Ranch-Highland License Renewal	DRAWN	ERG	DATE	May-10	JOB NO. 093-81703
	CHECKED	KFM	SCALE	NTS	DWG. NO. NA
	REVIEWED	KFM	FILE NO.	09381703-MiscFigures.xls	FIGURE NO. A-8.3-4-2

APPENDIX A-8.4

HISTORICAL AIRBORNE EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM ASSESSMENT

1.0 EFFLUENT AIR MONITORING AND ENVIRONMENTAL GAMMA EXPOSURE RATES

This appendix presents a summary of the historical airborne effluent monitoring and gamma radiation exposure rate data covering the period following the last license renewal. To meet the acceptance criteria suggested in NUREG-1569 *"Standard Review Plan for In Situ Leach Uranium Extraction License Applications"* (USNRC 2003c), the data are evaluated for regulatory compliance as well as for trends. Trend analysis is required to meet the acceptance criteria identified in NUREG-1569.

Cameco Resources currently maintains five environmental monitoring stations at various locations on and around the licensed area as shown on Figure A-8.4-1. The HUP CPF and the SR 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 HUP CPF but are inactive as a result of the HUP CPF being placed in standby status. Environmental monitoring stations AS-1, AS-2 and AS-3 are equipped with high volume air samplers and take particulate samples for analysis for U^{Nat}, thorium-230 [Th^{230}], Ra^{226}, and lead-210 [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 rate. All particulate samples, track-etch detectors, and dosimeters are collected periodically and sent to an accredited outside laboratory for analysis. The air monitoring stations are located as follows:

- AS-1 (Dave's Water Well): This station monitors background conditions, upwind of both the Smith Ranch and HUP wellfields and yellowcake processing facilities.
- AS-2 (Smith Ranch 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 SR CPP Controlled Area.
- AS-4 (HUP Controlled Area): This station monitors conditions downwind of the HUP CPF Controlled Area Boundary (when the HUP CPF is operating).
- AS-5 (Fowler Ranch): This station monitors the nearest downwind resident to the HUP CPF Controlled Area (when the HUP CPF is operating).

The HUP CPF and the SRCPP have the greatest potential airborne releases to the environment compared to the satellite plants where only resin transfer occurs. AS-2 was selected as the probable location of highest exposure to the public from emissions from the Smith Ranch CPP while AS-3 is selected as the nearest resident which is approximately 4.5 miles downwind of the Smith Ranch CPP.

Monitoring results for AS-4 and AS-5 are not included in the analysis because the HUP 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 HUP CPF is not operating, per License Condition 11.6 of the NRC Source Materials License SUA-1548.

2.0 REGULATORY REQUIREMENTS

Radiation dose limits for individual members of the public are specified in 10 CFR 20 Subpart D. NRC licensees are required to monitor the radiation levels and radioactive material in effluents released to the controlled and unrestricted areas to demonstrate compliance with the 0.1 rem total effective dose equivalent limit to the public. The licensee may do this by:

- Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or
- Demonstrating that the annual average concentrations of radioactive material released in gaseous and liquid effluents at the point of exposure do not exceed the ECs in 10 CFR 20, Appendix B, Table 2 and demonstrating that the external radiation sources would not exceed 0.002 rem in an hour or 0.05 rem in a year.

The dose limits are exclusive of the dose contribution from natural background radiation and from radiation doses received from the medical use of radiation and radioactive materials. Controlled areas of the site include a small exclusion area around the processing plants, the satellite plants, process water storage ponds, and small storage areas containing licensed material. Access to the license area is open to the public and therefore the limits apply to members of the public anywhere but the controlled area.

The EC used for compliance purposes by Cameco Resources are those listed in 10 CFR 20 Appendix B for the radionuclides of concern. The limits and their likely solubility class are 3×10^{-12} µCi/ml for U^{nat} (Class D), 2×10^{-14} µCi/ml for Th^{230} (Class W), 9×10^{-13} µCi/ml for Ra^{226} (Class W), 6×10^{-13} µCi/ml for Pb^{210} (Class D), and 1×10^{-8} µCi/ml for Rn^{222} without daughters present.

The program complies with guidance in NRC Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills". LLD for the air particulate sampling program are specified as 1×10^{-16} µCi/ml for U^{nat}, Ra^{226}, and Th^{230}; LLD for Rn^{222} is 2×10^{-10} µCi/ml; and the LLD for Pb^{210} is 2×10^{-15} µCi/ml.

3.0 MONITORING RESULTS

3.1 Airborne Radon Results

Passive Ra^{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 Ra^{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 (SR 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 Ra^{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 concentrations of Rn^{222} 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 Ra^{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. Considering that exclusion, there were no concentrations of Rn^{222} in air above background that were above the value listed in 10 CFR 20 Appendix B for Rn-222 without daughters present.

Monitoring Location AS-2 is located downwind of the SR 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 Resources 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) is located within the well-field licensed boundary as shown in Figure A-8.4-1, is the nearest resident to and downwind of the SR CPP. It is unreasonable to assume that members of the public would have an occupancy time within the licensed 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 Ra^{222} concentrations are presented in Table A-8.4-1. 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 Ra^{222} concentrations are compared to the NRC 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 percent 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 Ra^{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 Ra^{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 particulate 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 Ra^{222}.

A statistical test was performed on the data sets to see if the net Ra^{222} concentrations at AS-2 differed from those at AS-3. The results are shown in Figure A-8.4. The measurement made in the first half of 2007 was excluded in Figure A-8.4-2 because of the invalid result of the Fence Line measurement as previously discussed.

TABLE A-8.4-1

NET Rn^{222} CONCENTRATIONS AT MONITORING LOCATIONS AS-2 AND AS-3

Year	Average Net Ra^{222} Concentration (µCi/ml) AS-3 Vollman Ranch	Percent of Effluent Concentration Guideline (%)	Average Net Ra^{222} Concentration (µCi/ml) AS-2 Smith's Ranch Down-Wind Fence Line Boundary	Percent of Effluent Concentration Guideline (%)
1999*	-4.00×10^{-10}	-4.0	-3.00×10^{-10}	-3
2000	-2.25×10^{-10}	-2.3	3.75×10^{-10}	3.75
2001	-5.00×10^{-11}	-0.50	1.00×10^{-10}	1
2002	-3.0×10^{-10}	-3.0	3.0×10^{-10}	3
2003*	-1.5×10^{-10}	-1.5	-5.0×10^{-11}	-0.50
2004	-1.6×10^{-9}	-16	-1.5×10^{-9}	-15
2005	3.0×10^{-10}	3.0	2.5×10^{-10}	2.5
2006	1.5×10^{-10}	1.5	4.5×10^{-10}	4.5
2007*	3.0×10^{-10}	3.0	4.0×10^{-10}	4.0
2008	5.0×10^{-10}	5.0	3.5×10^{-10}	3.5
2009				

* Data for 2007 for AS-2 based on second six-month period. All 1999 data based on last six-month period

The net measurements shown in Figure A-8.4-2 were analyzed with the 1-sample sign test to determine if they were statistically different from 0 µCi/ml. In addition to testing the data, the test was used to determine the 95% confidence interval for the median. The tests were conducted with the statistical software package, Minitab 15. The net measurements were not tested with parametric tests like the 1-sample t-test because the net measurements do not follow normal or symmetric distributions.

The 1-sample sign test is a nonparametric test that tests if the median of a population is equal to some predetermined value. The test does not require that the data are from a normal distribution nor does it require the data to be symmetric. If the p-value of the test is less than or equal to the level of significance ($\alpha = 0.05$), the test is significant, indicating that the median of the data is not equal to the predetermined value.

The 1-sample sign test on the net measurements made at Vollman Ranch (AS-3) yielded a p-value of 1.00 and confidence interval of the median of 0.0 µCi/ml to 4.0 x 10^{-9} µCi/ml. The 1-sample sign test on the net measurements made at the Fence Line (AS-2) yielded a p-value of 0.0768 and confidence interval of the median of -0.31 x 10^{-9} µCi/ml to 0.21 x 10^{-9} µCi/ml. Since both p-values are greater than 0.05, the net measurements of concentration of Ra^{222} in air made at Vollman Ranch and at the Fence Line are both not statistically different from 0 µCi/ml at a 95% confidence level.

This analysis supports the conclusion that the SR CPP is not a significant source of Ra^{222} release to the environment.

3.2 Air Particulate Results

Air particulates were measured quarterly during the second half of 1999 through the first half of 2009. Figures A-8.4-3 through A-8.4-7 show plots of concentrations of U^{nat}, Th^{230}, Ra^{226}, Pb^{210}, and Ra^{222}, respectively, in air measured at the background location, AS-1. Figures A-8.4-8 through A-8.4-12 show plots of concentrations of U^{nat}, Th^{230}, Ra^{226}, Pb^{210}, and Ra^{222}, respectively, in air measured at AS-2 (SR Fence Line). Figures A-8.4-13 through A-8.4-17 show plots of concentrations of U^{nat}, Th^{230}, Ra^{226}, Pb^{210}, and Rn^{222}, respectively, in air measured at AS-3 (Vollman Ranch). Much of the data were reported as below the LLD which for all radioactive particulates except Pb was 1x10^{-16}µCi/ml. The LLD for Pb^{210} was 2x10^{-15}µCi/ml. For this analysis, the LLD was used as the reported concentration when it occurred.

Since the primary effluent from the processing plant is Ra^{222} and its progeny (including Pb^{210}), it is not surprising that the concentrations of radioactive particulate are near background levels and small compared to the NRC EC. The only measureable net particulate concentration of significance is Pb^{210}, which is a decay product of Ra^{222}. The net Pb^{210} concentrations at AS-2 and AS-3 are shown in Figure A-8.4-18, where zero values and negative values are not included in the graphical presentation. The net annual average data for Pb^{210} for the fence line (AS-2) and Vollman Ranch (AS-3) locations is given in Table A-8.4-2 along with the percent of the EC Guideline. The data show that for the years 2004-2008, the average annual concentration of Pb^{210} was less than one percent of the EC. For the years prior to 2004, the average net concentrations varied significantly, from -15% of the EC to 17 % of the EC. 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 Resources 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).

Note: The trend analysis provided within this section covers the period from 2000 to 2008. The 2009 ALARA Report with the necessary data were unavailable at the time that this submittal was being prepared.

TABLE A-8.4-2

NET LEAD-210 CONCENTRATIONS AT MONITORING LOCATIONS AS-2 AND AS-3

Year	Average Net Pb-210 Concentration (µCi/ml) AS-3 Vollman Ranch (µCi/ml)	Percent of Effluent Concentration Guideline (%)	Average Net Pb-210 Concentration (µCi/ml) AS-2 Smith's Ranch Down-Wind Fenceline Boundary (µCi/ml)	Percent of Effluent Concentration Guideline (%)
1999	-9.25×10^{-14}	-15	-9.25×10^{-14}	-15
2000	-4.25×10^{-15}	-0.71	-4.25×10^{-15}	-0.7
2001	1.01×10^{-13}	17	-4.00×10^{-15}	-0.7
2003	2.05×10^{-14}	3.4	8.47×10^{-16}	0.14
2004	4.2×10^{-16}	0.070	-5.32×10^{-15}	-0.89
2005	2.28×10^{-15}	0.38	-3.44×10^{-15}	-0.57
2006	1.92×10^{-15}	0.32	-1.01×10^{-15}	-0.17
2007	2.23×10^{-15}	0.37	-3.70×10^{-15}	-0.62
2008	-4.88×10^{-16}	-0.081	1.10×10^{-15}	0.18

* Data for 1999 based on second six-month period

The concentrations of the other radionuclides of concern (U^{nat}, Ra^{226}, and Th^{230}) all were measured to be a small fraction of the EC 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 concentrations and do not contribute significantly if at all to public dose from site operations.

3.3 Radon and Radioactive Particulate Trend Analyses

Trend analyses were performed on the data for air concentrations of U^{nat}, Th^{230}, Ra^{226}, and Pb^{210} measured at AS-1, AS-2, and AS-3 during the time period of 2003 through 2008. Data obtained prior to 2003 were not included in the trend analysis because there is a clear reduction in long-lived radionuclide air concentrations around the beginning of 2003. This may be associated with the HUP dryer shutdown or an off-site source such as open-pit strip mining or a coal fired power plant. Trend analyses were also performed on the data for concentrations of Rn^{222} measured at AS-1, and net concentrations measured at AS-2, and AS-3 during the time period from the last half of 1999 through the present.

Data were tested for trends with the Mann-Kendall test. If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope (Sen's Slope).

3.3.1 Mann-Kendall Test

The Mann-Kendall Test is a nonparametric test for trend. It is performed by first listing the data in chronological order: $x_1, x_2 \ldots x_n$, where x_i is the datum at time i. Next, the sign, sgn(x), of each possible difference, $x_j - x_k$ where $j > k$, is determined with the following equation (Gilbert, 1987):

$$\begin{aligned} \mathrm{sgn}(x_j - x_k) &= 1 && \text{if } x_j - x_k > 0 \\ \mathrm{sgn}(x_j - x_k) &= 0 && \text{if } x_j - x_k = 0 \\ \mathrm{sgn}(x_j - x_k) &= -1 && \text{if } x_j - x_k < 0 \end{aligned} \qquad \textbf{Equation 1}$$

Then the Mann-Kendall statistic (S) is calculated using the following equation:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}(x_j - x_k) \qquad \textbf{Equation 2}$$

where n is the number of measurements. A positive S indicates a potential positive trend in the data from the measurements. Likewise, a negative S indicates a potential negative trend in the data from the measurements (Gilbert, 1987).

If the number of measurements is 10 or less, the probability (p-value) associated with S and the number of measurements can be looked up in Table A18 of *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987). If the desired confidence level (α) is greater than the probability, the positive/negative trend in the data from the measurements is statistically significant (Gilbert, 1987).

If the number of measurements is greater than 10 and there are not a lot of tied values, the variance of S, VAR(S), is calculated using the following equation:

$$\mathrm{VAR}(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5) \right] \qquad \textbf{Equation 3}$$

where q is the number of tied groups and the t_p is the number of data in the pth group (Gilbert, 1987).

Using VAR(S) and S, the test statistic Z is calculated using the following equation:

$$\begin{aligned} Z &= \frac{S-1}{[\mathrm{VAR}(S)]^{1/2}} && \text{if } S > 0 \\ Z &= 0 && \text{if } S = 0 \\ Z &= \frac{S+1}{[\mathrm{VAR}(S)]^{1/2}} && \text{if } S < 0 \end{aligned} \qquad \textbf{Equation 4}$$

If the absolute value of Z is greater than $Z_{1-\alpha/2}$ (obtained from Table A1 in Gilbert, 1987), the positive/negative trend in the data from the measurements is statistically significant (Gilbert, 1987). The value of α (level of

significance) can be found for a known Z by looking up the $(1 - \alpha/2)$ value for the Z in Table A1 (Gilbert, 1987) and solving for α. The α found using this method is called the p-value.

The p-value associated with a test statistic can be compared to a preselected level of significance to determine if the null hypothesis (in this case, suspected data trend) can be rejected in favor of the alternate hypothesis (the opposite of the null hypothesis).

If the p-value is less than the preselected level of significance (in this case, 0.05), the null hypothesis is rejected. Otherwise, the null hypothesis cannot be rejected.

3.3.2 Sen's Nonparametric Estimator of Slope

Sen's Nonparametric Estimator of Slope is a method of estimating the slope of a linear trend that is less sensitive to gross errors and outliers than linear regression methods. The slope is estimated by calculating each possible slope between two data points. The median of the calculated slopes is Sen's estimator of the slope of the linear trend (Gilbert, 1987).

3.3.3 Analyses of Air Monitoring Data

The Mann-Kendall Test was performed on the data from the measurements of concentrations of radionuclides in the air at the air monitoring stations. Each set of data was analyzed using the procedures for sets of measurements greater than 10. The results of the tests are summarized in Table A-8.4-3. In cases where the p-values was greater than 0.05, no statistically significant trend is apparent and the data trend column in Table A-8.4-3 signifies "No Trend".

TABLE A-8.4-3

RESULTS OF THE TREND ANALYSES OF THE DATA FROM THE MEASUREMENTS OF RADIONUCLIDES IN THE AIR AT THE AIR MONITORING STATIONS

Radionuclide	AS-1 (Background)		AS-2*		AS-3*	
	Data Trend	*P-Value*	*Data Trend*	*P-Value*	*Data Trend*	*P-Value*
U^{nat}	No Trend	0.1902	No trend	0.0910	Negative Trend	0.0278
Th^{230}	No Trend	0.2714	Positive Trend	0.0366	No Trend	0.2340
Ra^{226}	No Trend	0.9680	No trend	0.2542	No Trend	1.0000
Pb^{210}	No Trend	0.7794	No Trend	0.3682	No Trend	0.2040
Rn^{222}	No Trend	0.9124	No Trend	0.308	No Trend	0.194

* Trends for Rn^{222} were based on net Rn^{222} concentrations.

The slopes of the trends that were statistically significant, p-value $\leq \alpha = 0.05$, were estimated using Sen's Nonparametric Estimator of Slope. The estimated slopes of the linear trends in the other radionuclides measured in the air are summarized in Table A-8.4-4.

TABLE A-8.4-4

ESTIMATES OF SLOPES* USING SEN'S NONPARAMETRIC ESTIMATOR OF SLOPE FOR RADIONUCLIDES IN THE AIR AT THE AIR MONITORING ATATIONS (μCI/ML PER HALF-YEAR)

Radionuclide	AS-1 (Background)	AS-2	AS-3
U^{nat}	-	-1.04×10^{-17}	-
Th^{230}	-	0	-
Ra^{226}	-	-	-
Pb^{210}	-	-	-
Rn^{222}	-	-	-

The reason for the statistically significant trend in the data for Th^{230} measured at AS-2 being zero is that most of the data collected after 2002 were at the limits of detection. The negative trend in U^{Nat} concentration and stable concentrations of other long lived radionuclides at AS-2 and AS-3 demonstrates that the processing facility's emission of long lived radionuclides are low and are being controlled to levels which are ALARA. The stable trend in the data for the net Rn^{222} measured at AS-2 and AS-3 and the analysis of net Rn^{222} concentrations presented in Section 3.1 above demonstrates the SR CPP is not a significant source of Ra^{222} release to the environment. The data also demonstrate that Rn^{222} emissions from the SR CPP are below regulatory standards and are controlled to levels that are ALARA.

4.0 ENVIRONMENTAL GAMMA-RAY EXPOSURE MONITORING

Quarterly integrated measurements of gamma-ray exposure have been performed on a quarterly basis at the three air monitoring stations (AS-1, AS-2, and AS-3) using dosimeter badges, environmental TLDs and/or spherical gamma detectots.

4.1 Gamma-Ray Exposure Rate Results

Gamma-ray exposure rate (exposure) measurements at AS-1, AS-2, and AS-3 continued from the last half of 1999 through today.

From the last half of 1999 through the first half of 2002, exposure was recorded in the units of μR/hr; afterwards exposure was recorded in the units of mR/qtr (mR per quarter). For consistency, the data in the units of μR/hr were converted to units of mR/qtr using the following equation:

$$\text{Exposure (mR/qtr)} = \text{Exposure } (\mu\text{R/hr}) * \frac{24\text{ hr}}{\text{d}} * \frac{365\text{ d}}{\text{yr}} * \frac{1\text{ yr}}{4\text{ qtr}} * \frac{1\text{ mR}}{10^3\ \mu\text{R}} \qquad \textbf{Equation 5}$$

Figures A-8.4-19 through A-8.4-21 display plots of the data over time at AS-1, AS-2, and AS-3, respectively.

The plots all show low exposure with time. A slight increase in the background location (AS-1) can be seen which is also seen in the on-site data that hasn't been corrected for the background location response.

The net exposure for the AS-2 and AS-3 shown on Figure A-8.4-20 do not show this slight increase. The trend analysis data in Section 4.2 demonstrate that there is not a statistically significant trend for net exposure at the AS-2 and AS-3 locations. This suggests that there may be another source of radiation such as the nearby power plant or coal mining operations that is affecting all readings at the site. Figure A-8.4-21 shows the annual exposure for the AS-2 and AS-3 locations from the years 2000 through 2009 The average annual exposure rate at the nearest residence (AS-3) is generally less than that at the background location (AS-1), with a net annual average exposure rate of approximately -3.6 mrem/year. The average net annual exposure rate at AS-2 averages 19.3 mR/y from 1999-2009. The maximum annual exposure occurred in 2005 when the annual net exposure rate was 29 mR/year, or approximately 0.029 rem/year. This is 58 percent of the limit for demonstrating compliance (0.05 rem/year) as discussed in Section 2.0. These results are expected since AS-2 is close to the processing plant where the exposure rates are influenced by direct radiation from the SR CPP. No significant increasing trend in exposure rate is evident at the AS-2 location which is an indicator that the exposure rate is at levels that are ALARA. Small differences in the gamma exposure rates at AS-3 compared to AS-1 that resulted in Vollman's Ranch exposure rates being less than background may be expected since they are physically separated by more than 5 miles. Different soil types, application of fertilizers containing radionuclides, or possibly influences by off-site sources may explain this small difference in exposure rate.

4.2 Gamma Exposure Trend Analyses

Trend analyses were performed on each set of data shown in Figures A-8.4-19 and A-8.4-20. Data were tested for trends with the Mann-Kendall test (see Section 3.3.1). If data were found to have a statistically significant trend, the slope of the trend was estimated using Sen's Nonparametric Estimator of Slope (see Section 3.3.2).

Each set of data was analyzed using the procedures for the Mann-Kendall test for sets of measurements greater than 10. The results of the tests are summarized in Table A-8.4-5.

TABLE A-8.4-5

TREND ANALYSIS RESULTS OF THE GAMMA EXPOSURE DATA.

Location	Data Trend	P-Value
AS-1 (Background)	Positive Trend	6.E-06
AS-2*	No Trend	0.816
AS-3*	No Trend	0.472

* Trend analysis was performed using background corrected (net) data.

The slopes of the trends that were statistically significant, p-value $\leq \alpha = 0.05$, were estimated using Sen's Nonparametric Estimator of Slope. The estimated slopes of the linear trends are summarized in Table A-8.4-6. The only statistically significant slope is positive.

TABLE A-8.4-6

ESTIMATES OF THE SLOPES, USING SEN'S NONPARAMETRIC ESTIMATOR OF SLOPE, OF THE DATA FROM THE MEASUREMENTS OF GAMMA EXPOSURE.

Location	Trend Slope (mR/qtr per quarter)
AS-1 (Background)	0.494
AS-2	-
AS-3	-

The slope for the trend in the exposure at the off-site background location (AS-1) is not reflected in the net data at the locations downwind of the SR CPP (AS-2 and AS-3) since the slight increase over time at AS-1 is subtracted from the values measured at AS-2 and AS-3. The data do not show a net increase in exposure rates at AS-2 and AS-3 from site activities.

5.0 SUMMARY

The monitoring program at the SR-HUP 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 EC which are contained in 10 CFR 20 Appendix B and used for compliance purposes by Cameco Resources. 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 SR-HUP Airborne Monitoring program, SR-HUP has collected over 300 samples for particulates, Rn^{222} and gamma analysis.

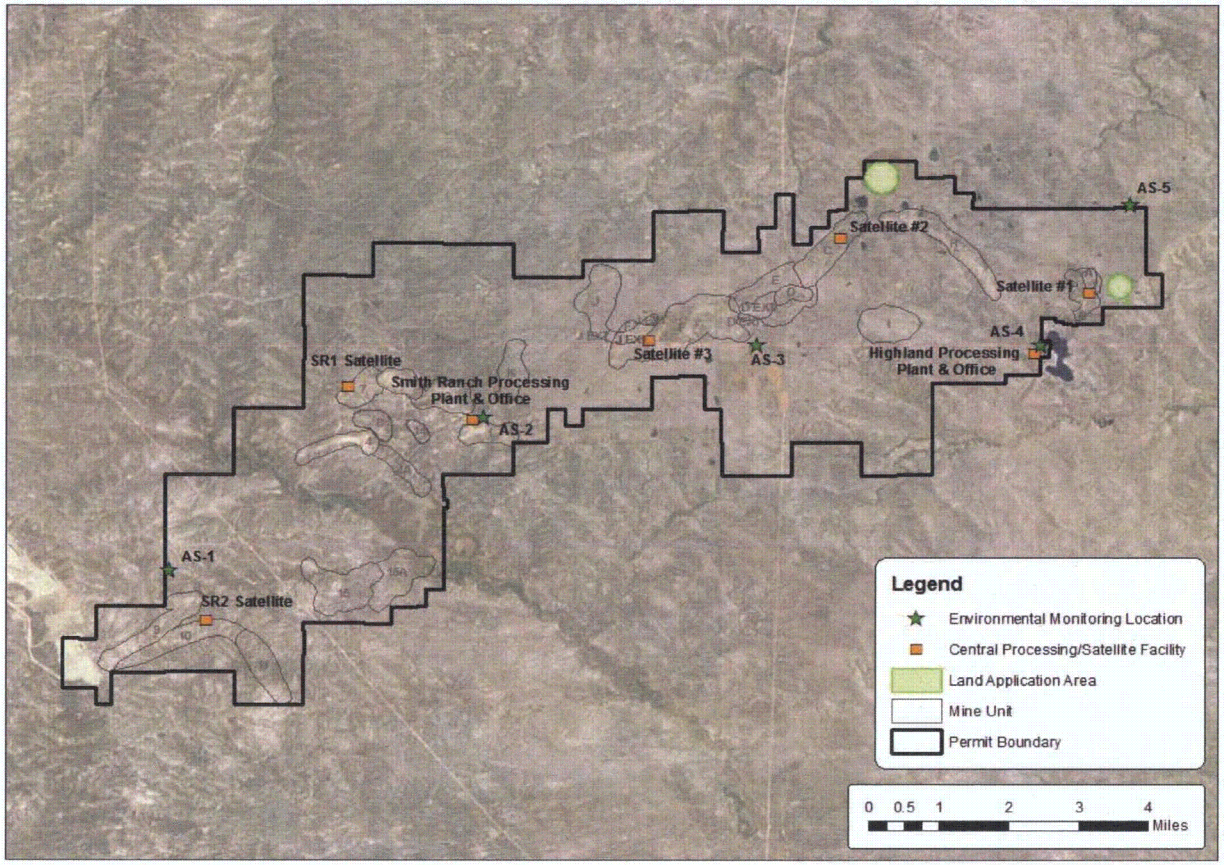
The long-lived radionuclide (i.e. U^{Nat}, Th^{230}, Ra^{226}) air concentrations are far below their respective EC even without accounting for the background concentration and are very near or identical to background concentrations. In the case of Pb^{210} air concentrations, data show that the Pb^{210} emissions are very low and even for the year when the Pb^{210} concentrations were 17 percent of the EC at Vollman Ranch, the concentrations were well within acceptable limits. The NRC agreed that this high value probably resulted from effluent from the nearby operating coal strip mine and/or power plant (NRC, 2001e).

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 EC. There appears to be an increasing trend in Rn^{222} concentrations at the AS-1 locations but this trend is likely due to the same offsite source mentioned above for Pb^{210} since Pb^{210} is a decay product of Rn^{222}. No trends are apparent for the net Rn^{222} concentrations at the AS-2 and AS-3 locations.

Net annual gamma exposures were below the 0.05 rem requirement contained in 10 CFR 20 Subpart D for all measured locations. Statistically significant positive trends were observed at the background locations at AS-1. No statistically significant trends were observed for net exposure rate data collected at the AS-2 and AS-3 locations. The analysis supports the conclusions that impacts from off-site sources are being measured at the SR-HUP monitoring stations.

All data presented here suggests that air effluents at SR-HUP are below regulatory requirements and in most cases are near or identical to background concentrations. The data show that the SR-HUP has and continues to keep environmental impacts from site operations to levels that are compliant with applicable regulations and that are ALARA.

FIGURES FOR APPENDIX A-8.4



Golder Associates — Denver, Colorado

TITLE

Location of Radiological Air Monitoring Stations

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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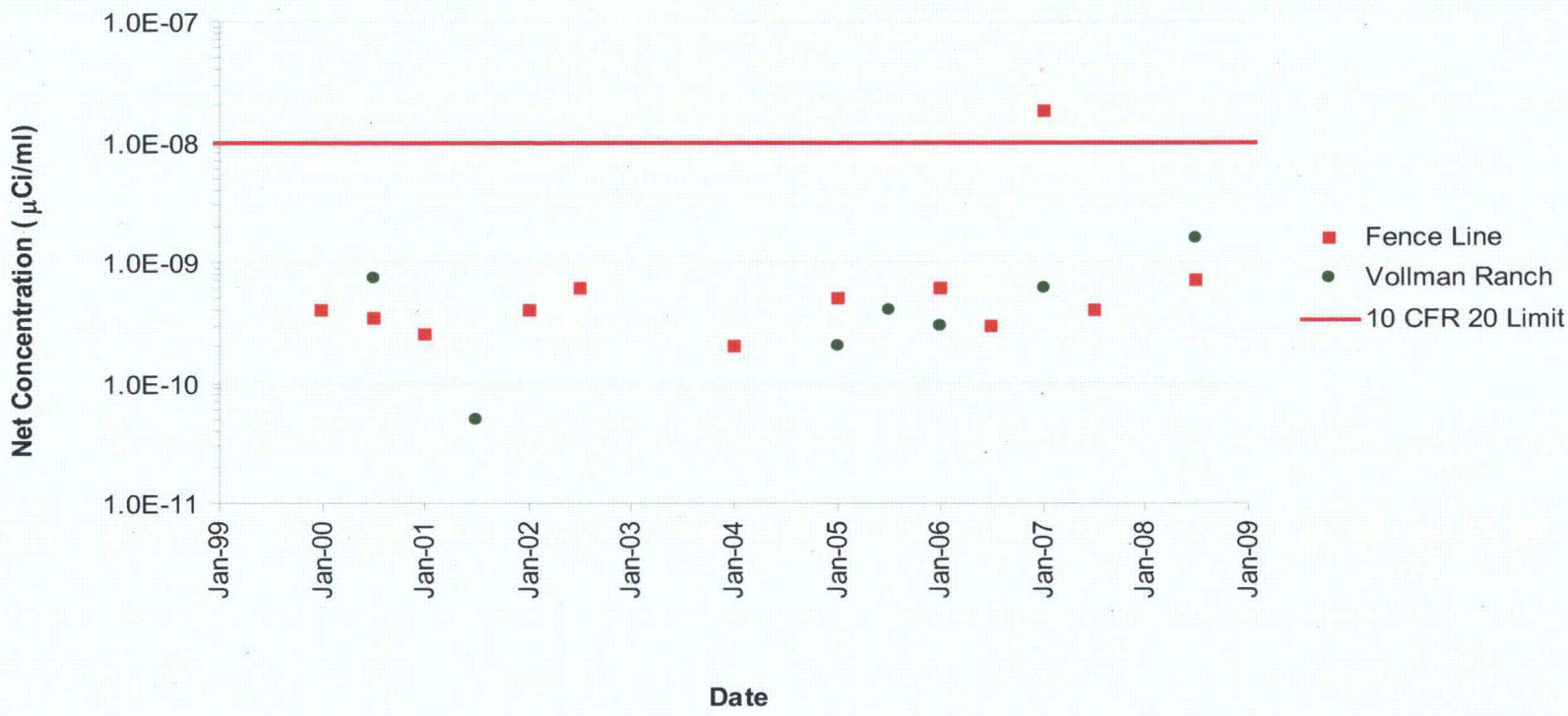

Golder Associates Denver, Colorado

TITLE **Net Radon Concentrations at Fence Line (AS-2) and Vollman Ranch (AS-3) Over Time**

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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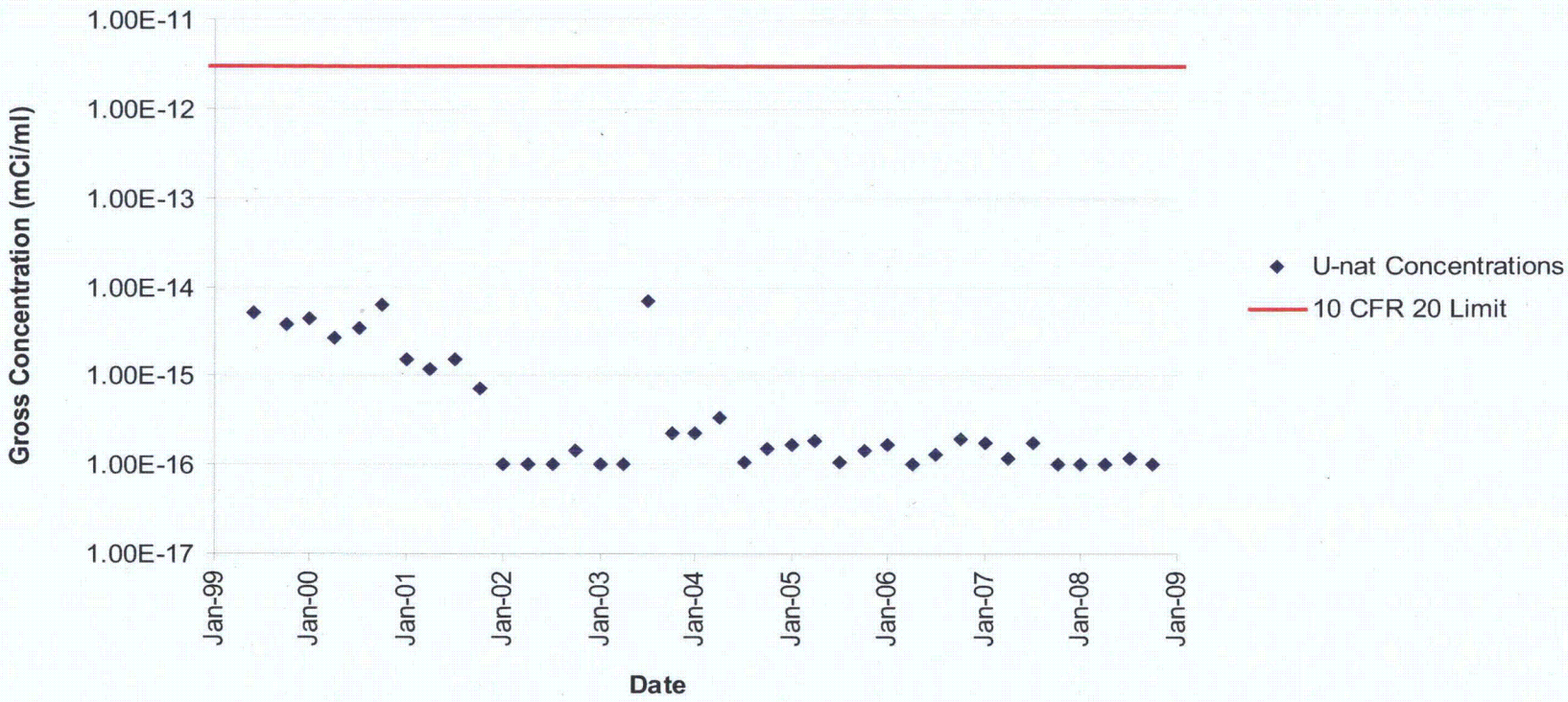

Golder Associates Denver, Colorado

TITLE

Concentrations of U-nat in Air Measured at Dave's Water Well (AS-1)

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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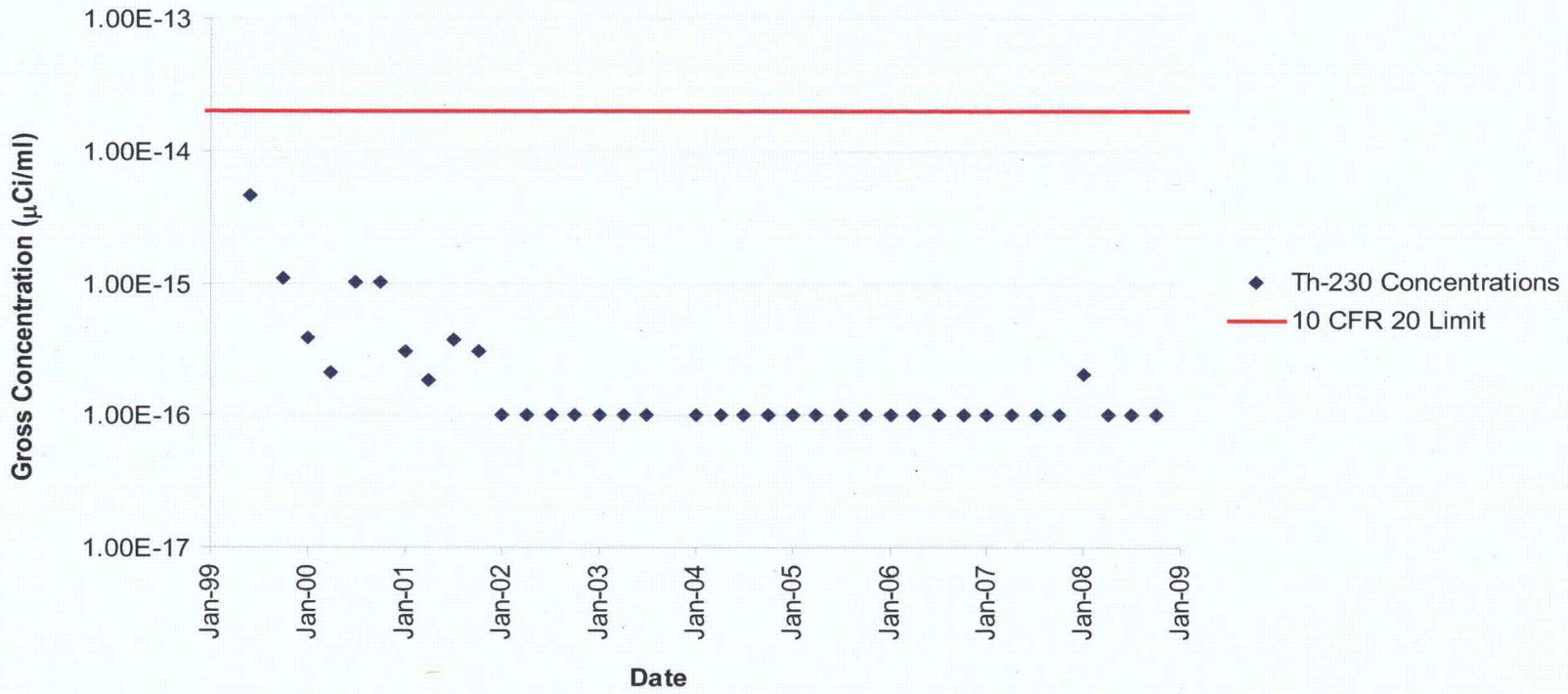

Golder Associates — Denver, Colorado

TITLE: **Concentrations of Th-230 in Air Measured at Dave's Water Well (AS-1)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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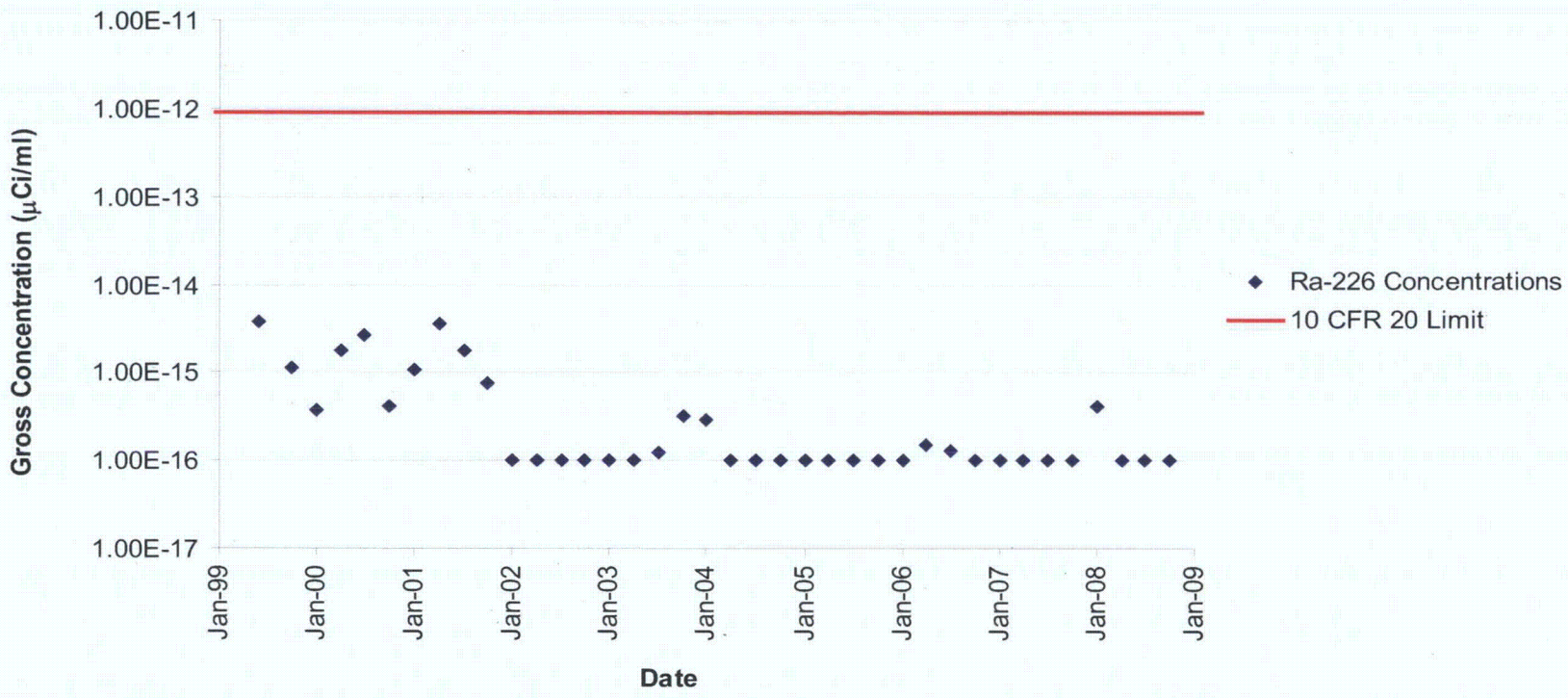

Golder Associates — Denver, Colorado

TITLE: **Concentrations of Ra-226 in Air Measured at Dave's Water Well (AS-1)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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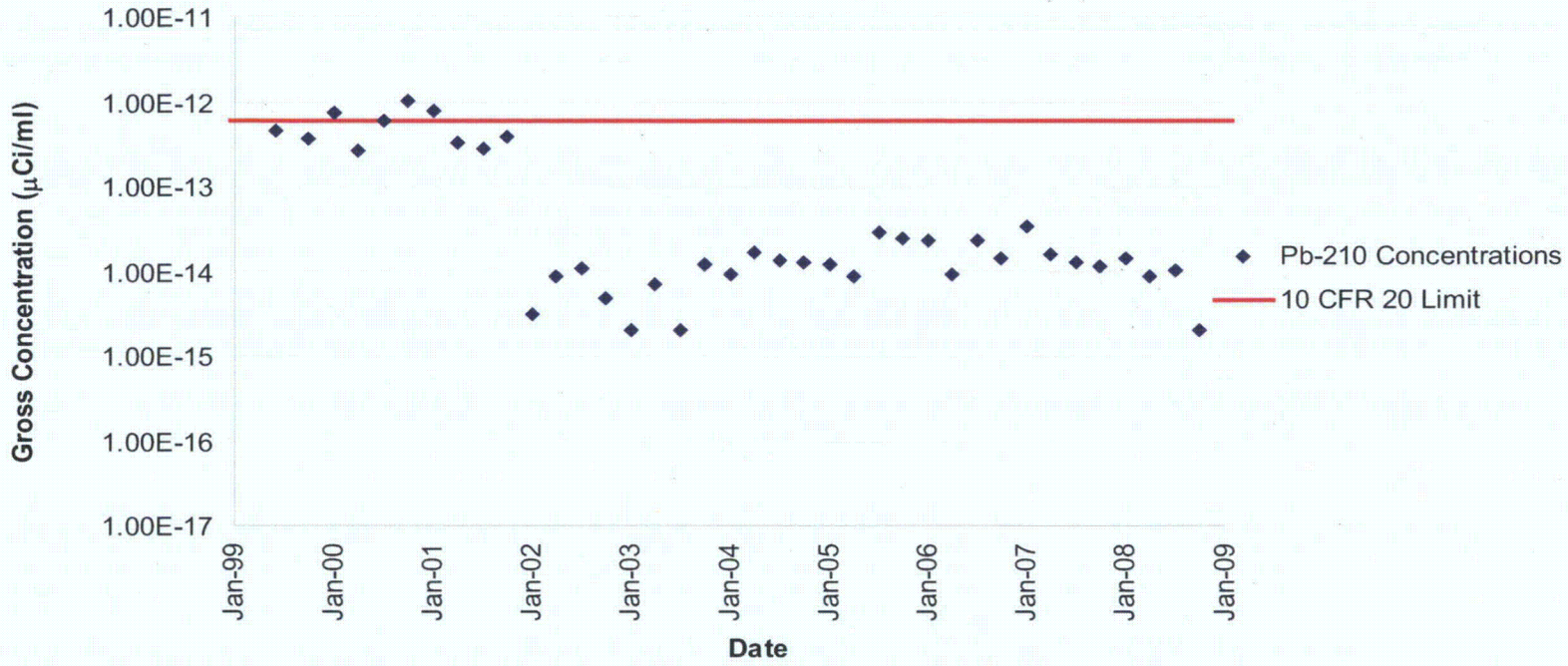

Golder Associates Denver, Colorado

TITLE

Concentrations of Pb-210 in Air Measured at Dave's Water Well (AS-1)

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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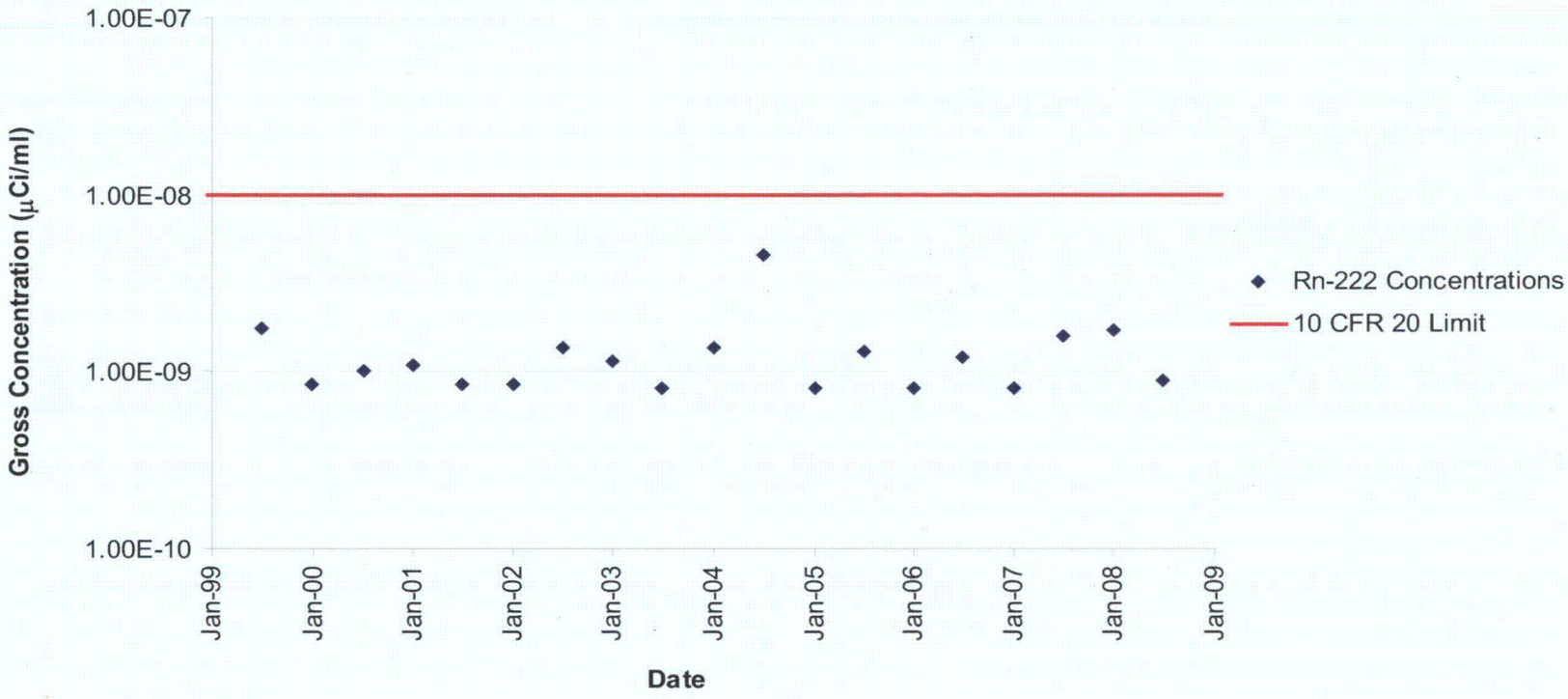

Golder Associates Denver, Colorado

TITLE

Concentrations of Rn-222 in Air Measured at Dave's Water Well (AS-1)

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

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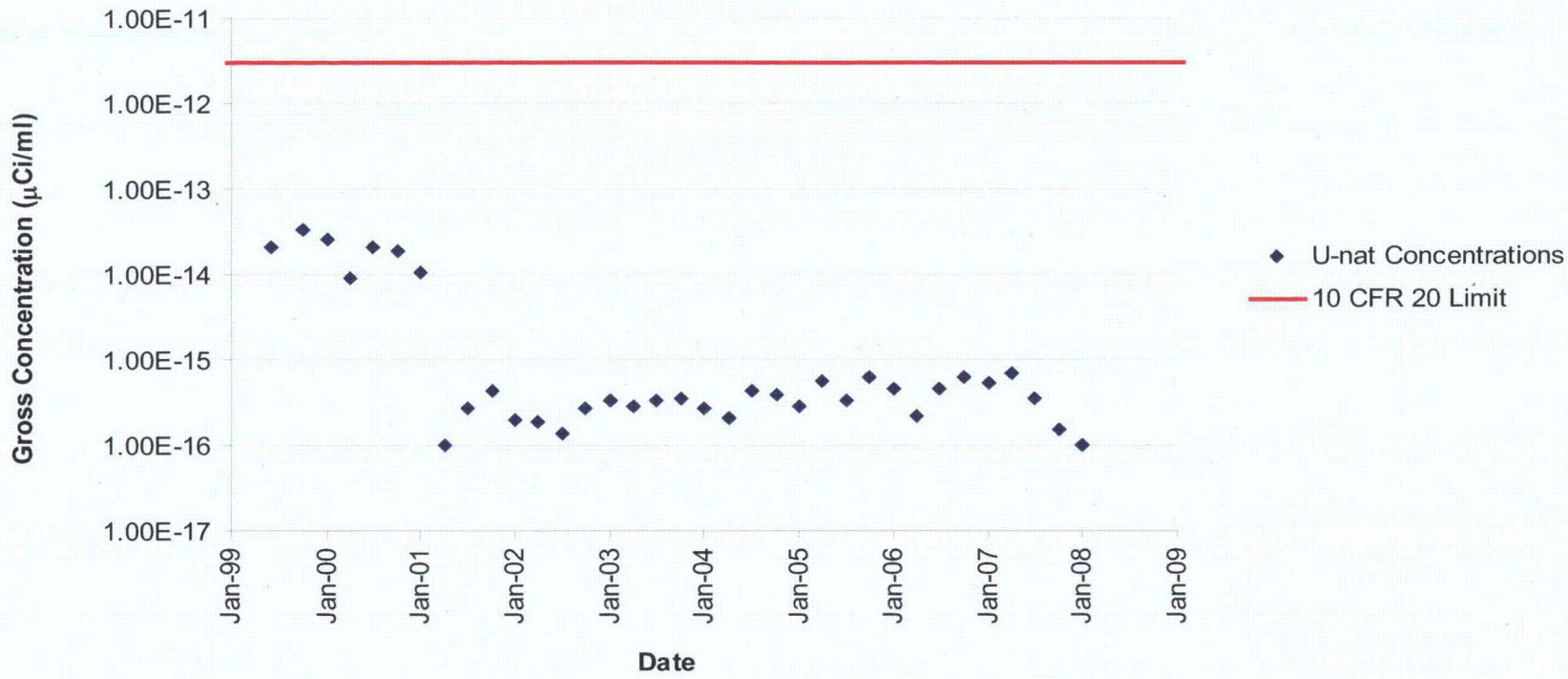

Golder Associates Denver, Colorado

TITLE

Concentrations of U-nat in Air Measured at Fence Line (AS-2)

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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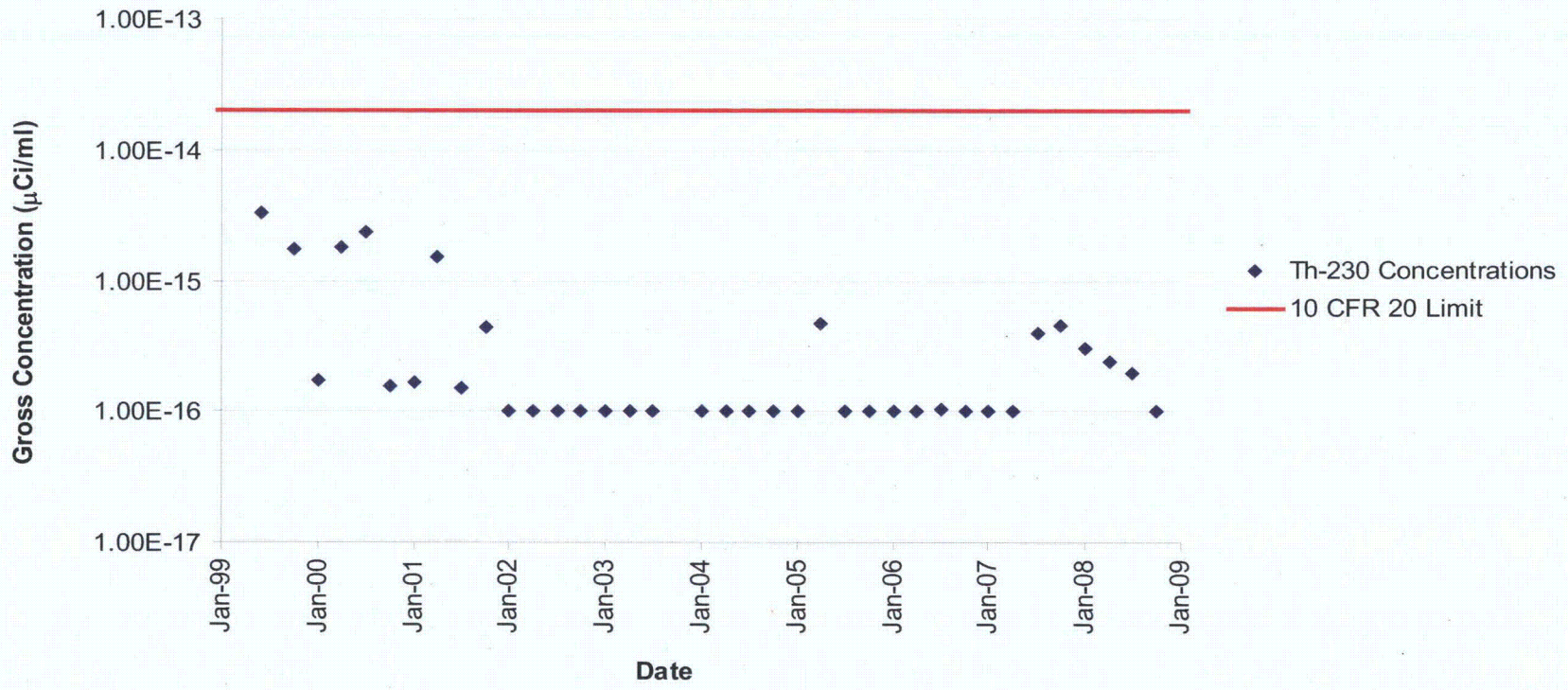

Golder Associates, Denver, Colorado	TITLE	Concentrations of Th-230 in Air Measured at Fence Line (AS-2)			
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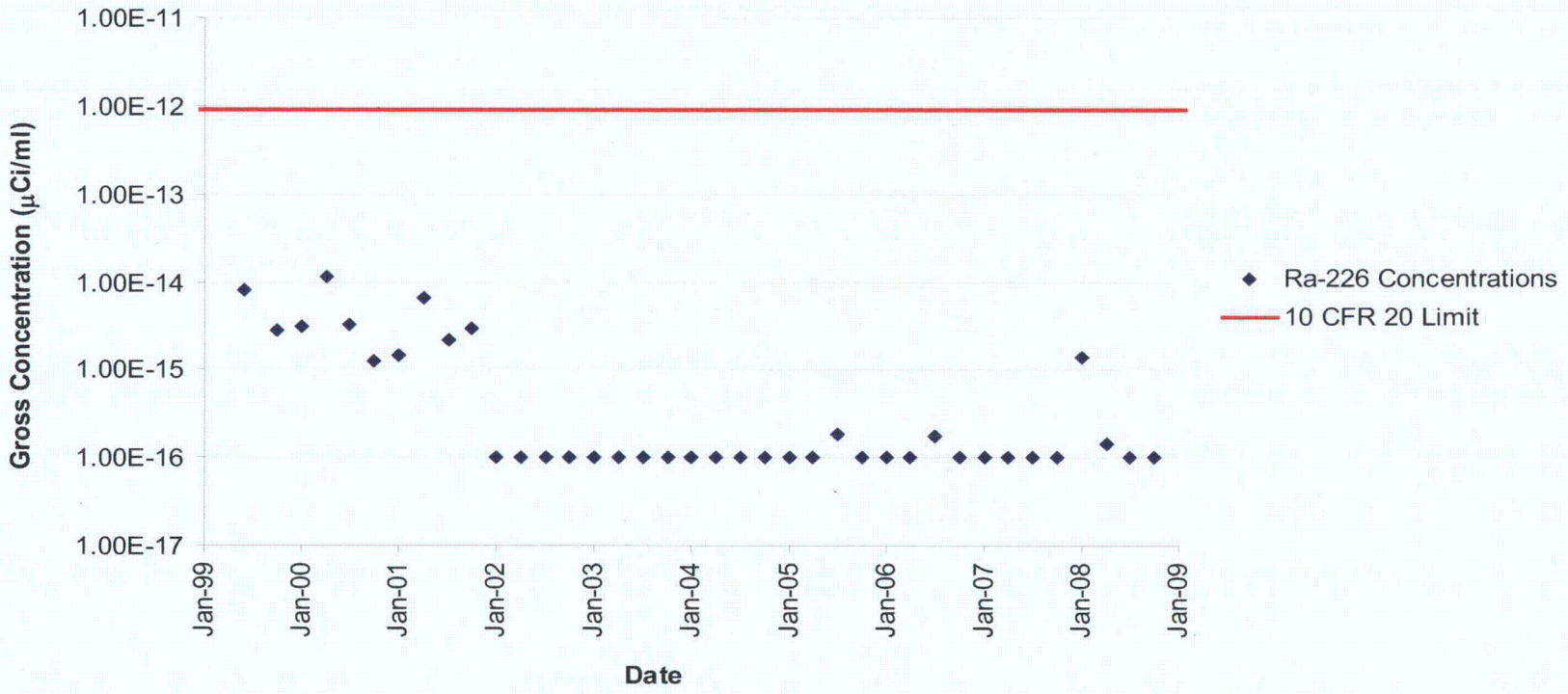
Smith Ranch-Highland License Renewal	REVIEWED	KB	FILE NO.	Figures A-8.4-All.xls	FIGURE NO. A-8.4-9



Golder Associates — Denver, Colorado

TITLE: **Concentrations of Ra-226 in Air Measured at Fence Line (AS-2)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

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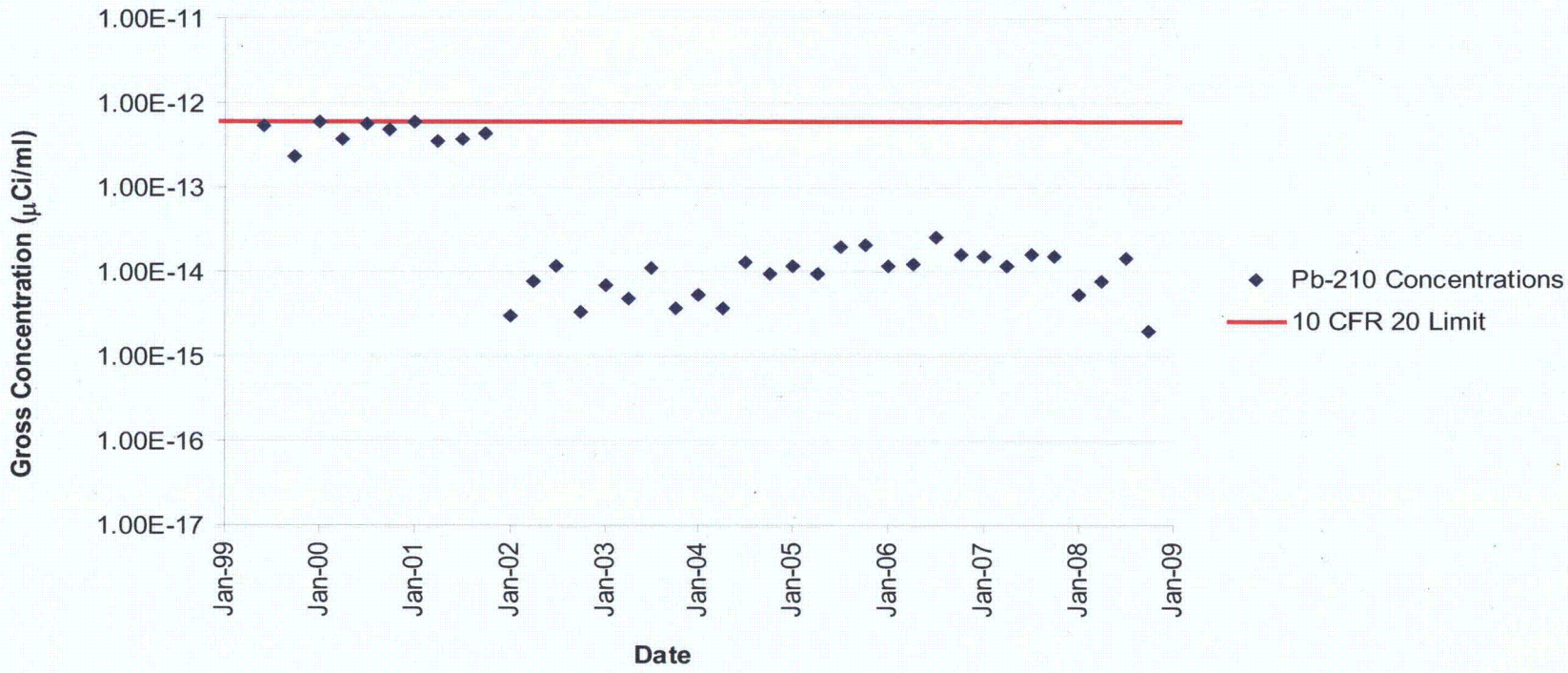

Golder Associates Denver, Colorado

TITLE **Concentrations of Pb-210 in Air Measured at Fence Line (AS-2)**

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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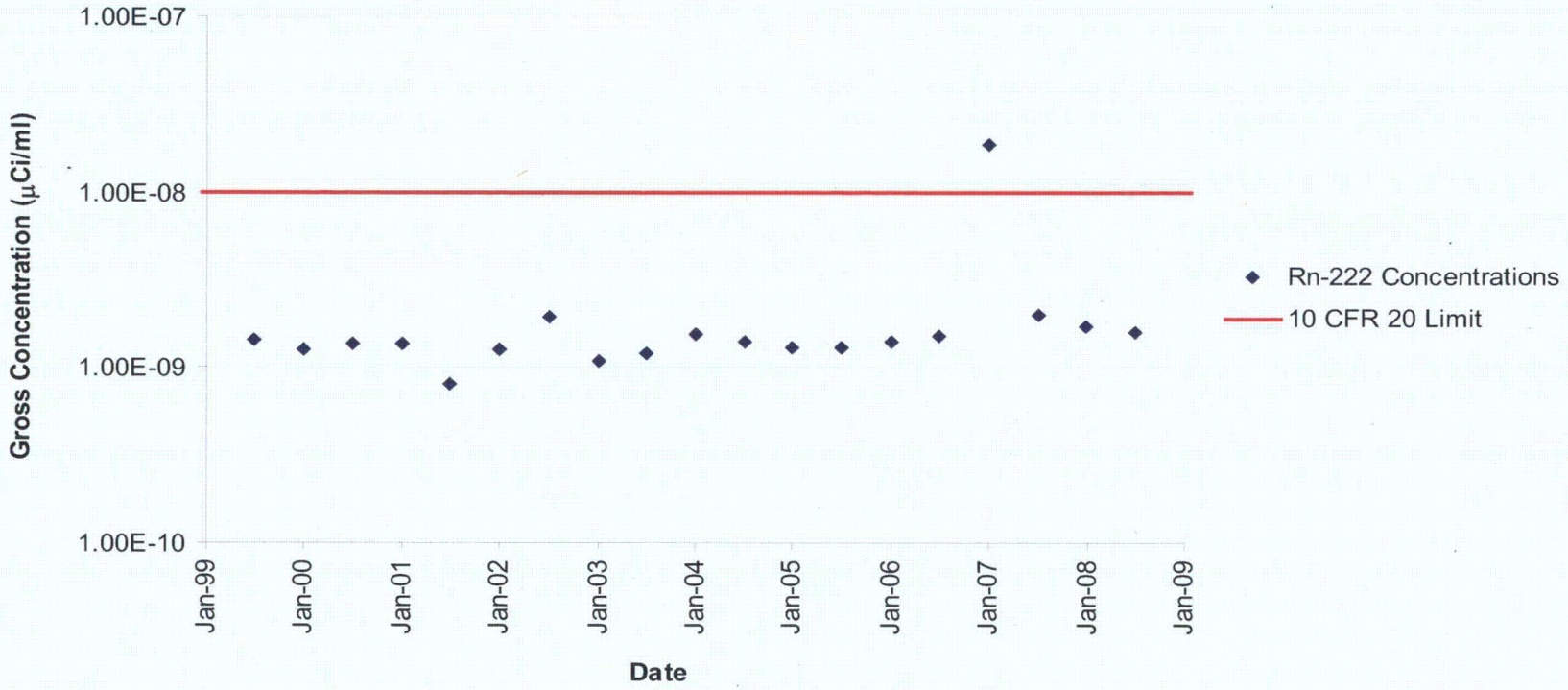

Golder Associates — Denver, Colorado

TITLE: **Concentrations of Rn-222 in Air Measured at Fence Line (AS-2)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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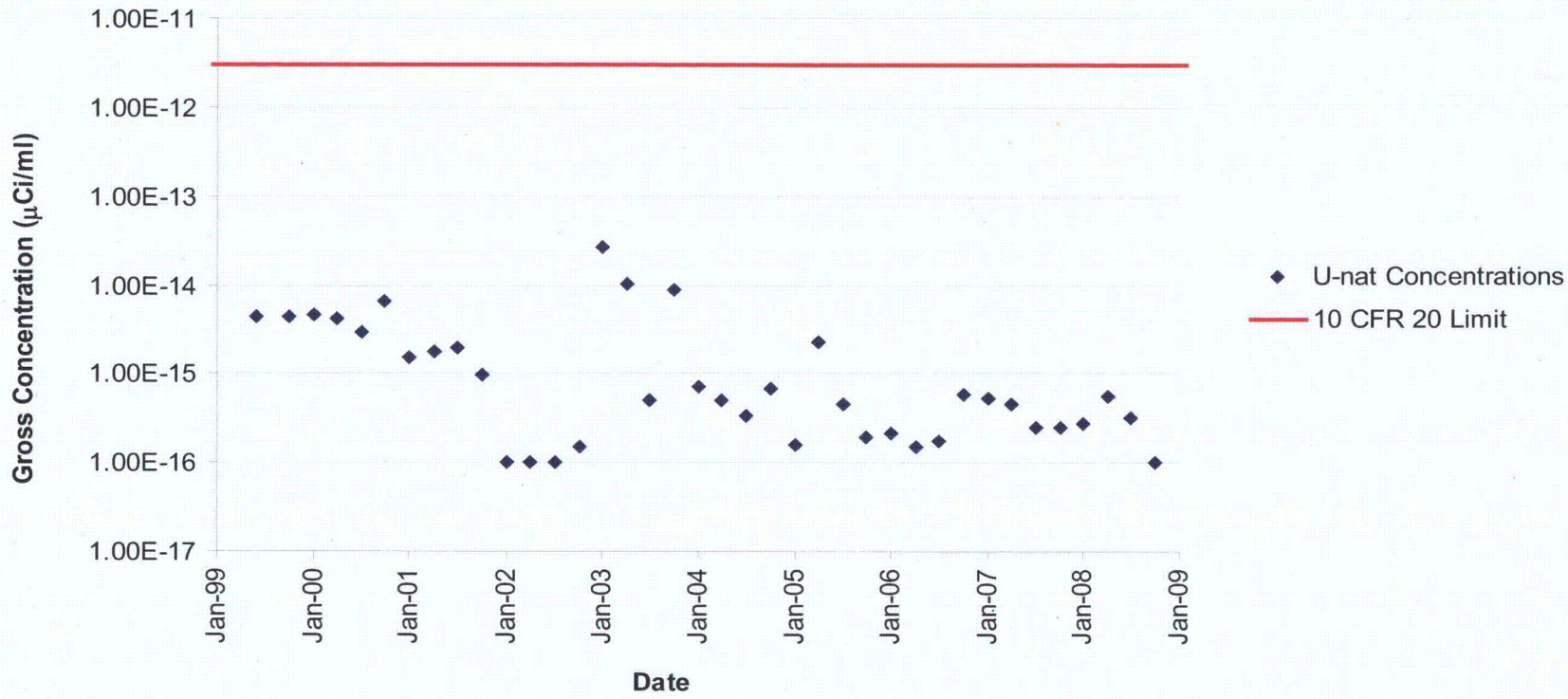

Golder Associates Denver, Colorado

TITLE: **Concentrations of U-nat in Air Measured at Vollman Ranch (AS-3)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
CHECKED	MS	SCALE	NTS	DWG. NO.	NA
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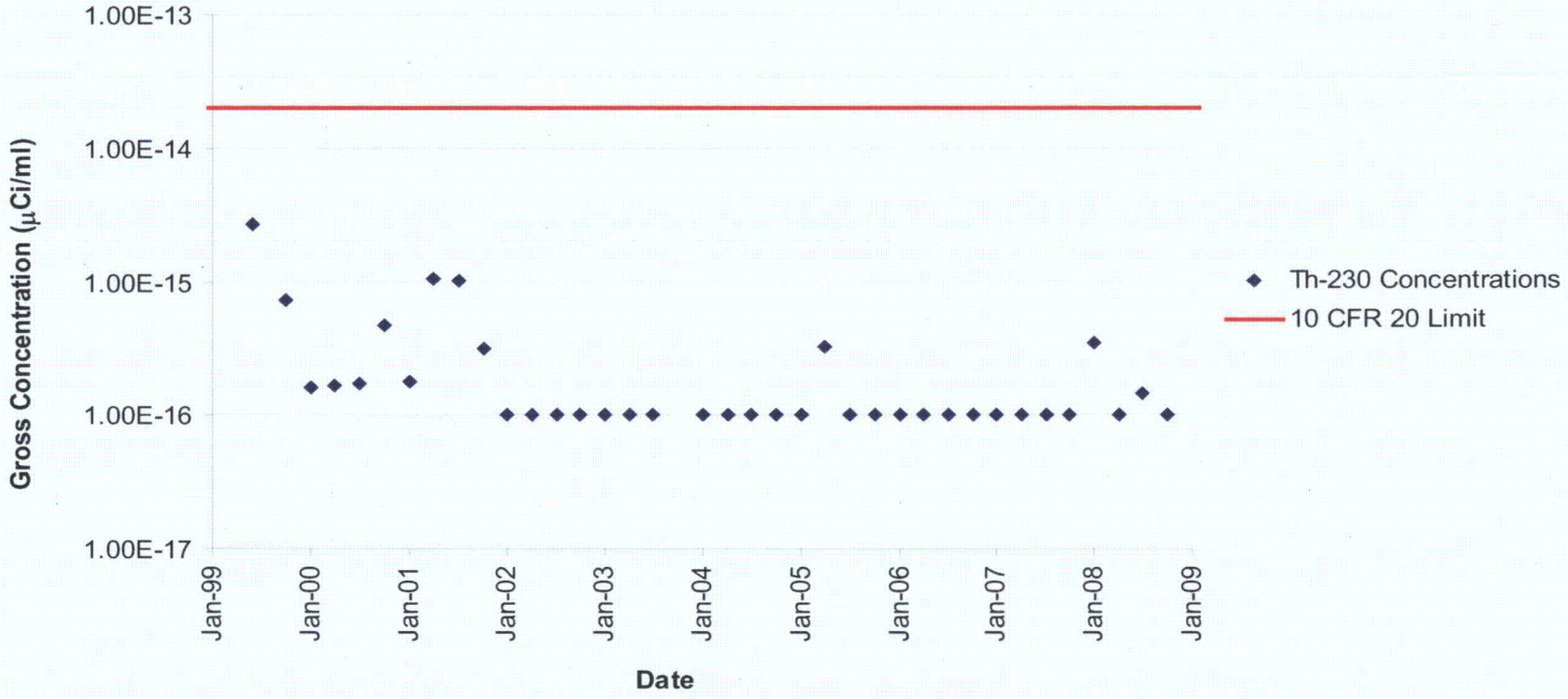

Golder Associates Denver, Colorado

TITLE

Concentrations of Th-230 in Air Measured at Vollman Ranch (AS-3)

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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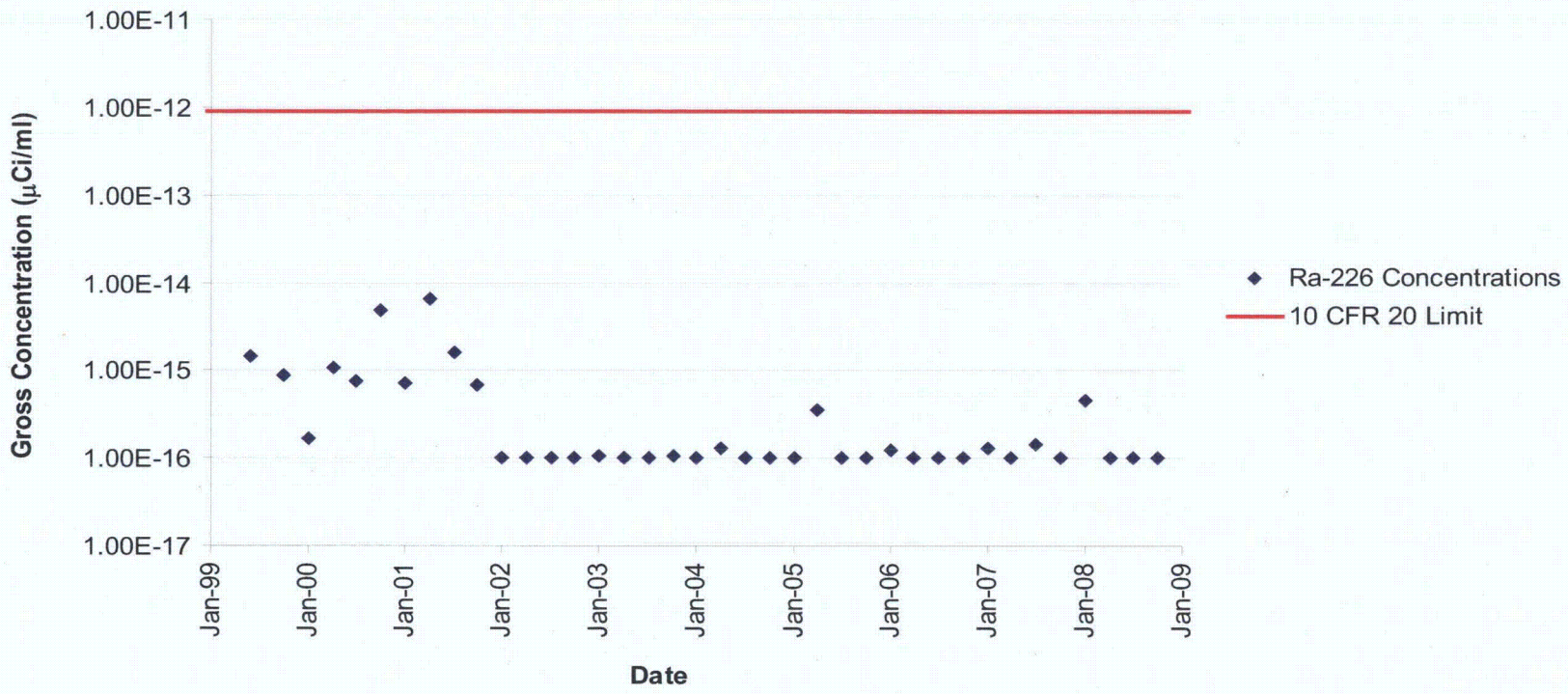

Golder Associates Denver, Colorado

TITLE: **Concentrations of Ra-226 in Air Measured at Vollman Ranch (AS-3)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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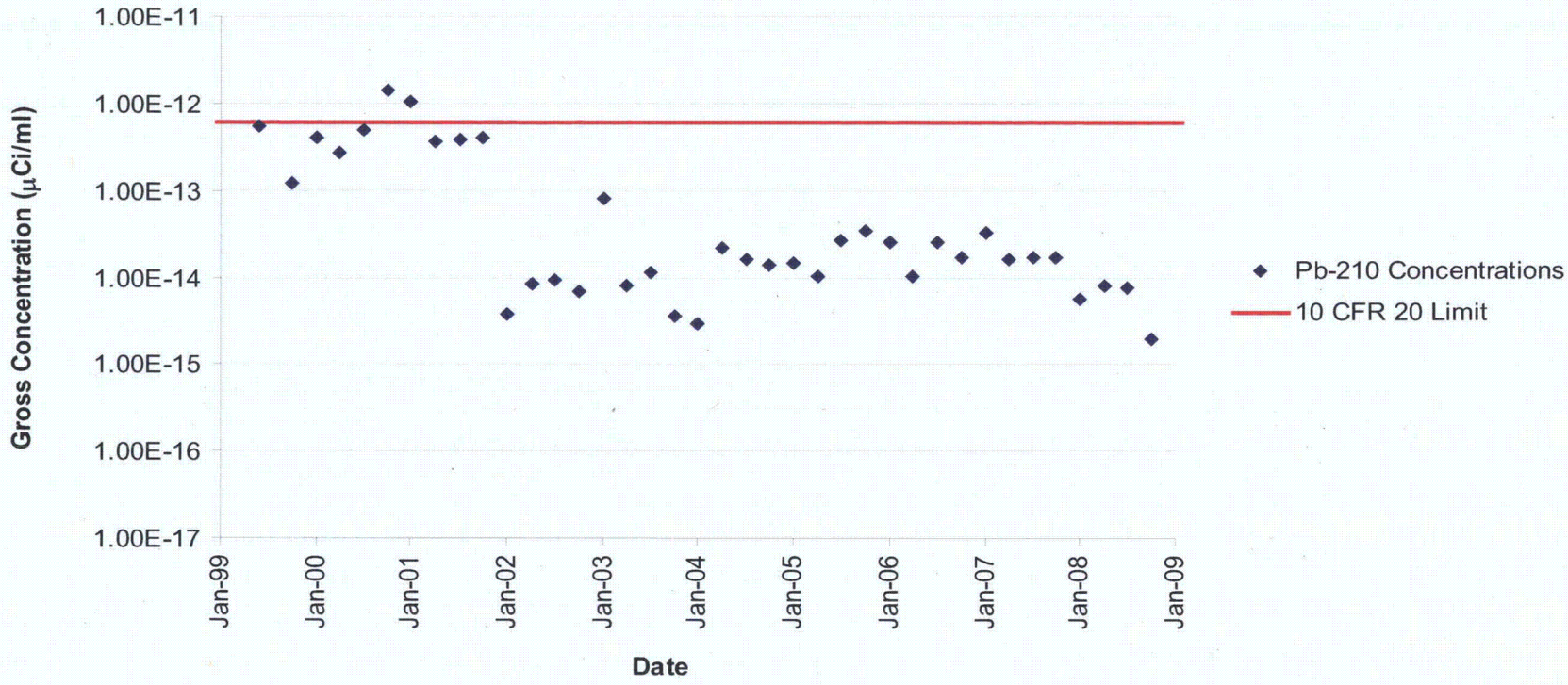

Golder Associates — Denver, Colorado

TITLE: **Concentrations of Pb-210 in Air Measured at Vollman Ranch (AS-3)**

CLIENT/PROJECT: **Cameco Resources**
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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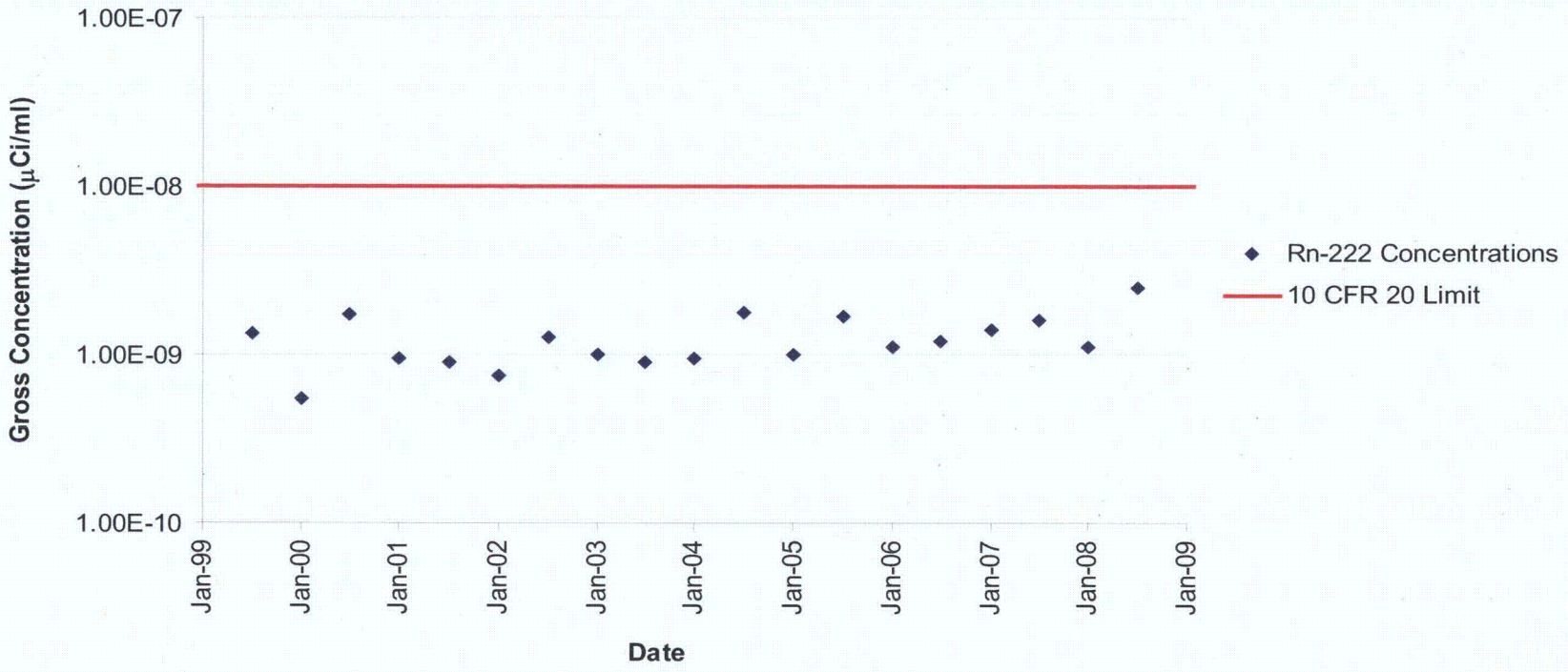

Golder Associates Denver, Colorado

TITLE **Concentrations of Rn-222 in Air Measured at Vollman Ranch (AS-3)**

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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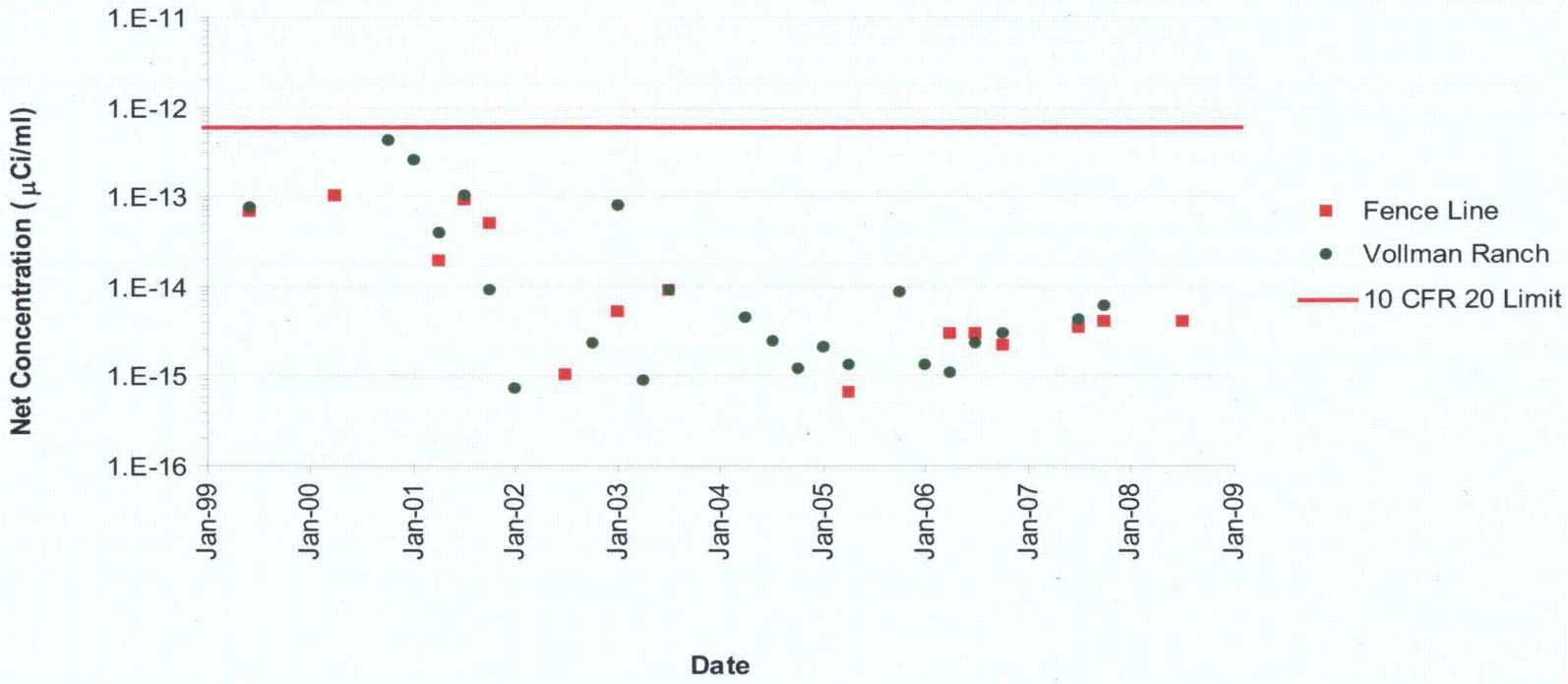

Golder Associates Denver, Colorado

TITLE **Net Concentrations of Pb-210 in Air Measured at Fence Line (AS-2) and Vollman Ranch (AS-3)**

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
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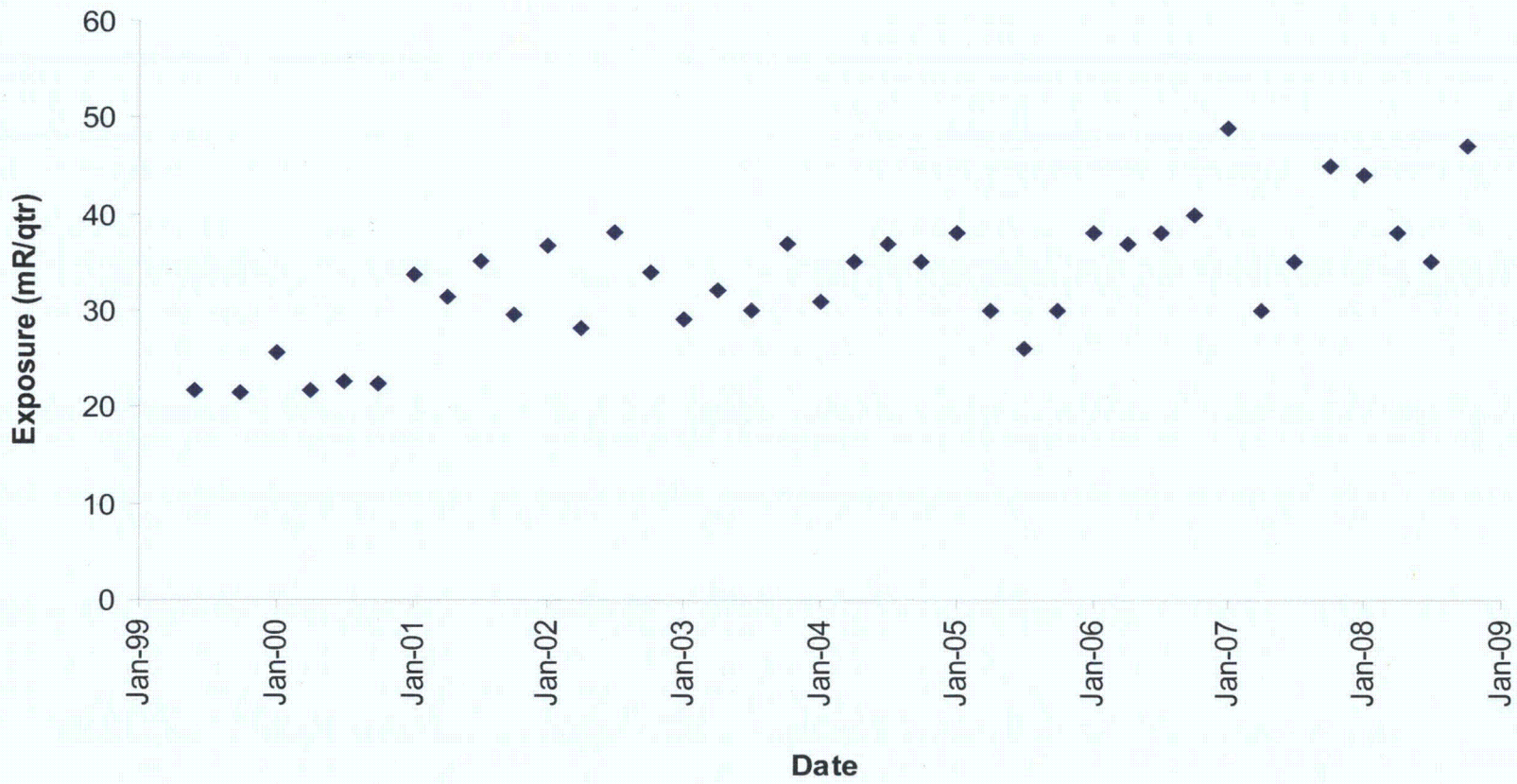


Golder Associates Denver, Colorado

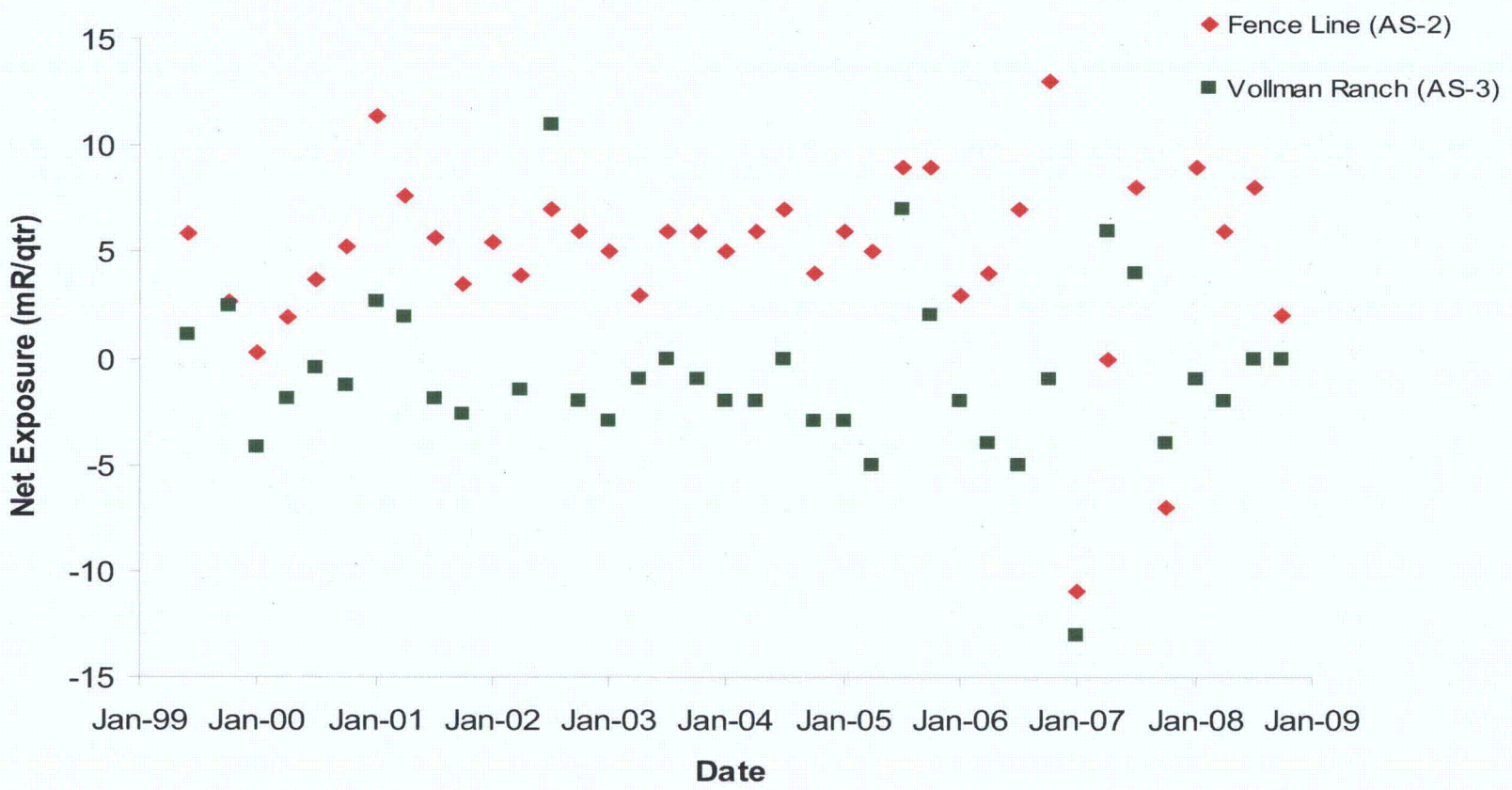
TITLE

Gamma-ray Exposure Measured at AS-1

CLIENT/PROJECT

Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
CHECKED	MS	SCALE	NTS	DWG. NO.	NA
REVIEWED	KB	FILE NO.	Figures A-8.4-All.xls	FIGURE NO.	A-8.4-19



Golder Associates
Denver, Colorado

TITLE
Net Gamma-ray Exposure Measured at AS-2 and AS-3

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
CHECKED	MS	SCALE	NTS	DWG. NO.	NA
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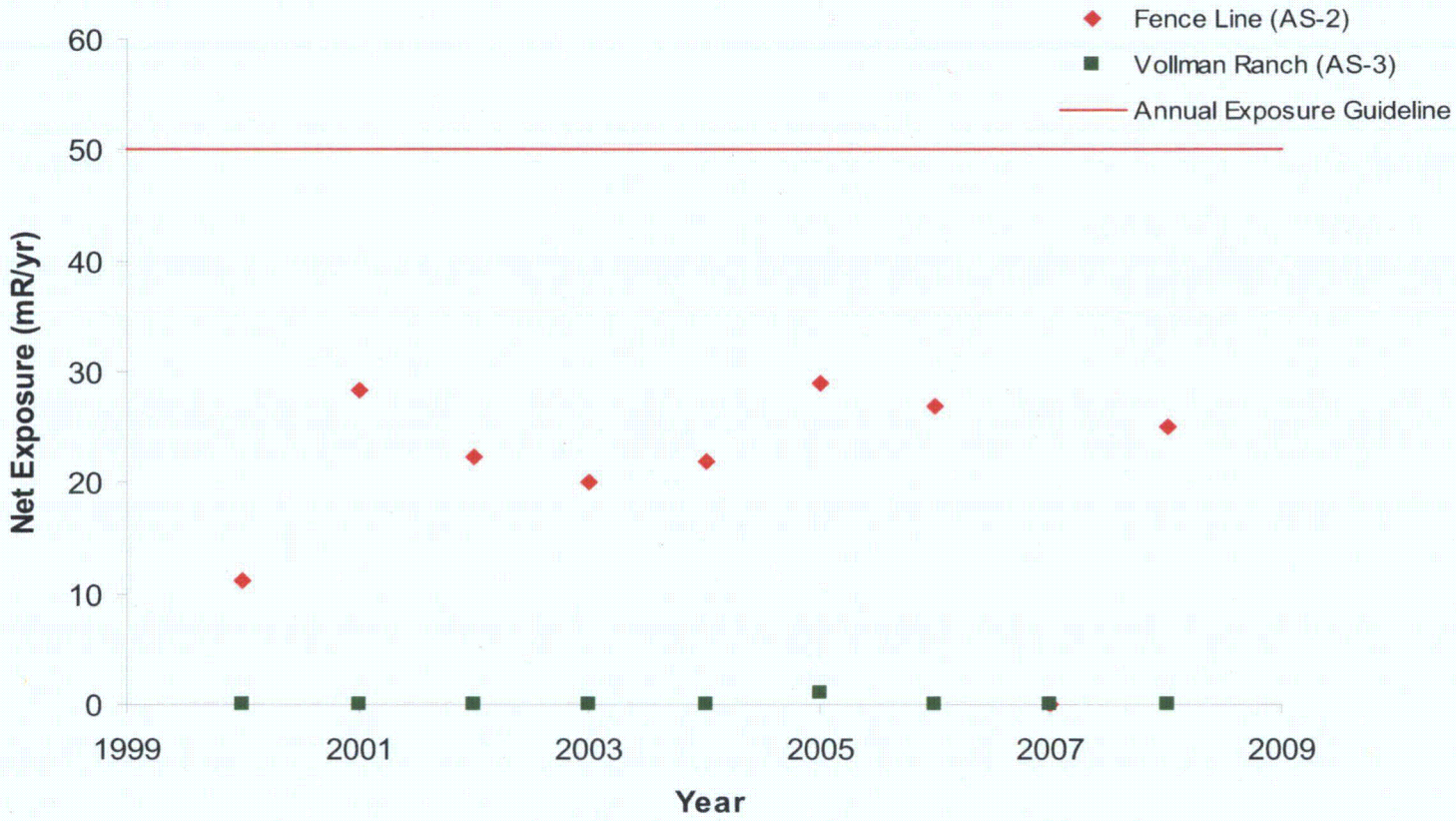


Golder Associates
Denver, Colorado

TITLE
Annual Net Gamma-ray Exposure Measured at AS-2 and AS-3

CLIENT/PROJECT
Cameco Resources
Smith Ranch-Highland License Renewal

DRAWN	MS	DATE	Mar-10	JOB NO.	093-81703
CHECKED	MS	SCALE	NTS	DWG. NO.	NA
REVIEWED	KB	FILE NO.	Figures A-8.4-All.xls	FIGURE NO.	A-8.4-21

APPENDIX A-8.5

HISTORICAL QUALITY ASSURANCE PROGRAM ASSESSMENT

1.0 QUALITY ASSURANCE PROGRAM ASSESSMENT

This appendix provides a summary of the historical quality assurance (QA) program results for the SR-HUP in support of the License Renewal submittal. Section 5.7.9.3(3) of NUREG-1569 lists the acceptance criteria for evaluating the QA program for license renewal submittals as:

- Historical QA program results are included through the most recent reporting period, preceding the submittal of the license renewal submittal;
- A discussion of the effectiveness of the historical QA program with regard to all applicable 10 CFR Part 20 regulatory requirements; and
- A discussion of long-term trends and explanations of any short-term deviations from the long term trends.

The elements of an acceptable QA program are described in NRC Regulatory Guide 4.14 "*Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations To License Termination) Effluent Streams and the Environment*" (NRC, 2007b) and include:

- Organizational Structure and Responsibilities of Managerial and Operational Personnel
- Specification of Qualifications of Personnel
- Operating Procedures and Instructions
- Records
- Quality Control in Environmental Sampling
- Quality Control in the Radioanalytical Laboratory
- Quality Control for Radioactive Effluent Monitoring Systems
- Verification and Validation
- Assessments and Audits
- Preventive and Corrective Actions

At the SR-HUP, these elements are typically addressed in Section 9 of the license renewal submittal. Section 9 was recently updated via License Amendment 13 [NRC, 2008a (refer to Appendix A-2.1)]. A TER was issued by the NRC in 2008 (NRC, 2008b) supporting the proposed changes to Section 9. QA requirements specific to certain tasks such as occupational or environmental monitoring are addressed through procedures within the site's EHS Management System Manual. Evaluations of the effectiveness and implementation of the QA program are presented in the annual ALARA audit reports conducted by Cameco Resources personnel with the assistance of independent third-party auditors and in the annual NRC license inspection reports.

To evaluate the performance of the QA program from 1999 through 2009, consistent with the acceptance criteria listed in NUREG-1569, all routine audits and NRC inspections were reviewed for QA-related items. Identified deficiencies and items of concern as well as any corrective actions are summarized in

Table A-8.5-1. QA-related deficiencies resulting from NRC inspections are provided in Appendix A-3, but are repeated here for ease of review.

There have been nine (9) QA-related items identified in routine audits and NRC inspections over the ten year licensing period. Five of the items were identified by Cameco Resources or independent audits, and four items were identified during NRC inspections. All items were addressed by implementing appropriate corrective actions. There are currently no open issues related to QA concerns.

No trend regarding the number or severity of the QA related items is apparent. The highest number of items identified in a given year was two. In some years there were no identified QA related concerns.

TABLE A-8.5-1

Quality Assurance Related Concerns and Corrective Actions Resulting From Routine Program Audits or NRC Inspections

Year	Assessment Tool	Findings Related to QA Program	Corrective Action	Number
1999	ALARA Report (RAMC, 2000b)	One quality assurance sample on 2/25/99 with a value of 21 ug/l was out of the acceptable range and believed to be either a lab or spiking error.	The health physics department provided additional training to assure all individuals involved with spiking samples were using the same methods.	1
	NRC Inspection (NRC,2000b)	None		
2000	ALARA Report (RAMC, 2001a)	None		
	NRC Inspection (NRC,2000d)	A site technician calibrated radiation instruments without following one step in the site procedure. This is a violation of LC 9.10	Licensee responded on September 8, 2000, demonstrating that the quality of measurements had not been compromised. A review of procedure compliance and additional training were implemented which was confirmed by the NRC on March 9, 2001 (ML010710325).	2
2001	ALARA Report (RAMC, 2002a)	None		
	NRC Inspection (NRC, 2001b) (NRC, 2001e)	None		
2002	ALARA Report (PRI, 2003a)	During 2002, it was determined that some personnel, especially those with the highest dose, were not storing their dosimeters with the control badge while away from work.	PRI management issued a memo discussing program requirements and posted signs reminding all operators of the importance of properly storing the dosimeter when not in use. Spot checks of the control badge rack were done to assure compliance.	3
	NRC Inspection (NRC, 2002b) (NRC, 2002c)	None		

TABLE A-8.5-1

Quality Assurance Related Concerns and Corrective Actions Resulting From Routine Program Audits or NRC Inspections

Year	Assessment Tool	Findings Related to QA Program	Corrective Action	Number
2003	ALARA Report (PRI, 2004a)	None		
	NRC Inspection (NRC, 2003b)	None		
2004	ALARA Report (PRI, 2005a)	Three environmental air samplers were being operated on July 28, 2004 that were beyond the six-month calibration period.	A Self-Identified Violation was reported to the NRC On August 9, 2004. A better tracking system was implemented in September 2004.	4
	NRC Inspection (NRC, 2004d)	The NRC noted that the licensee did not have a formal system to track instrumentation due for calibration. An inspector follow-up item was issued by the NRC.	A formal tracking system was implemented and the inspector follow-up item was closed during an August 25, 2005 NRC inspection.	5
2005	ALARA Report (PRI, 2006a)	A review of Quality Control (QC) data for urine bioassays indicated that the actual laboratory data for site spiked samples exceeded the spiked value by more than the guideline value of ±30%.	Spiking procedures were changed by dedicating pipettes and graduated cylinders for each standard. After this change, the spike results were well within the guideline criteria.	6
	NRC Inspection (NRC, 2005b)	An inspector follow-up item was issued addressing the issue of whether current sampling procedures used in the well-field at SR-HUP produces representative aquifer samples.	This issue was formally reviewed through the performance based license provisions. The SERP reviewed the technical issues and submitted a technical report to the NRC (NRC,2007a). This item was closed during the April 24, 2007 inspection.	7
2006	ALARA Report (PRI, 2007a)	None		
	NRC Inspection (NRC, 2006a)	None		

TABLE A-8.5-1

Quality Assurance Related Concerns and Corrective Actions Resulting From Routine Program Audits or NRC Inspections

Year	Assessment Tool	Findings Related to QA Program	Corrective Action	Number
2007	ALARA Report (PRI, 2008)	None		
	NRC Inspection (NRC, 2007d) (NRC, 2007f) (NRC, 2007g)	SERP approved appointing RSO that did not meet Reg. Guide 8.31	Nine corrective actions were identified that would be implemented to correct this deficiency. They included hiring of a training coordinator, revising several procedures to identify whether a SERP may be required for a certain action, providing information to the SERP members prior to the review, and submitting a revised Chapter 9 of the existing license renewal submittal to reflect changes in the organizational structure and responsibilities at the facility. The May 16, 2008 inspection (NRC, 2008c) reviewed the corrective actions and confirmed that the corrective actions had been implemented.	8
2008	ALARA Report (PRI,2009)	Review of QC data for urine bioassays indicated that the actual laboratory data for site spiked samples exceeded the spiked value by more than the guideline value of ±30% on one occasion. This was likely due to a new type of pipette being used.	Personnel were trained on the proper use of the new pipette.	9
	NRC Inspection (NRC, 2008c) (NRC, 2008d)	None		
2009	ALARA Report			
	NRC Inspection (NRC, 2009d)	None		

APPENDIX A-8.6

CUMULATIVE EFFECTS OF OPERATIONS

1.0 INTRODUCTION

NUREG-1569 outlines the requirements to conduct a cumulative impact analysis for license renewal submittals. NUREG-1569 states "*the staff should consider the adequacy of the cumulative impact analysis with respect to past, present and reasonably foreseeable actions. The staff should determine if the cumulative analysis adequately considered whether and to what extent the environment has been degraded, whether ongoing activities in the area are causing impacts, and the trends for activities and impacts in the area.*" The requirement to address cumulative impacts is addressed for Cameco Resources' Source Material License SUA-1548 for the SR-HUP in this appendix. Specifically, this section provides background, discussion of cumulative impacts, and conclusions.

2.0 BACKGROUND

Cumulative impacts are defined as "cumulative" in 40 CFR 1508.7 and include individually minor but collectively significant actions taking place over a period of time. It is possible an impact that may be small by itself could result in a moderate or large impact when considered in combination with the impacts of other actions on the affected resource.

Cumulative impacts from the entire SR-HUP operation were most recently addressed for the addition of Satellite SR-2, Amendment No. 12 (NRC, 2007a). There have been no changes in operations at the site since Amendment No. 12 that would alter the evaluation of cumulative impacts; hence, the conclusions from the Environmental Assessment for SR-2 (NRC, 2007a) are incorporated here by reference. The NRC addressed three areas of potential cumulative impacts from SR-HUP. These were:

- Cumulative radiological impacts;
- Cumulative impacts of subsurface disposal of liquid effluents; and
- Cumulative impacts related to conventional uranium mining and milling in the vicinity of SR-HUP.

The cumulative impacts were evaluated for site operations that included sixteen operating mine units (there are fifteen operating) and four deep injection wells, and thus the evaluations were indicative of current operations and worst case assumptions.

The monitoring of groundwater and surface water (Appendix A-8.2), employees (Appendix A-8.3) and air (Appendix A-8.4) are provided to evaluate the cumulative impacts from site operations. These monitoring programs show that the cumulative impacts from site operations are such that the environment, the public and workers are being protected as summarized in the aforementioned appendices and Appendix A-5.

3.0 SUMMARY OF CUMULATIVE IMPACTS

Cumulative radiological impacts were evaluated in Amendment No. 12 by using the *MILDOS-AREA* model. The primary source of radiological impacts to the environment is from gaseous Rn^{222}. The model was used to

assess dose commitments received by individuals and the general population from the SR-HUP operation and included cumulative impacts from the different potential sources at the site. The NRC concluded that "*NRC staff has determined that the site specific inputs to the model are representative of the actual site conditions with significant conservatism to ensure that the values are protective of the environment and the public*" (NRC, 2007a). As there have been no changes at the site that would alter these inputs since the modeling was conducted, the cumulative radiological impacts are such that the environment and public are still protected as required by 10 CFR 20.1301.

The cumulative impacts from subsurface disposal of liquid effluents was also evaluated by the NRC when the deep disposal well was proposed at Satellite SR-2. The NRC (NRC, 2007a) concluded "*the liquid effluent disposal at SR-2 is not expected to affect local stock and domestic groundwater use. Stock wells within three miles of SR-2 are completed in stratigraphic horizons that are several thousand feet above and hydraulically isolated from the zone planned for liquid effluent disposal. Domestic wells are also completed in stratigraphic horizons that are several thousand feet above and hydraulically isolated from the zone planned for liquid disposal.*" The other three deep disposal wells (SRDW #1, SRDW #2 and the non-operational RRDW #1), and the remaining six permitted deep disposal wells that are in various stages of completion, are also completed in stratigraphic units that are thousands of feet below domestic and stock wells in the area of SR-HUP. There have been no additional deep disposal wells added since the SR-2 well. As a result, the cumulative impacts from disposal of effluents in the deep wells will not have adverse cumulative impacts on the groundwater resources in the area.

Potential cumulative impacts related to conventional uranium mining and milling in the vicinity of SR-HUP are unlikely. In the southern Powder River Basin, where SR-HUP is located, uranium was historically mined via conventional methods (e.g. open pits and subsurface mine shafts) during the 1970s and 1980s. The last conventional mining operation near the site, Exxon Highland Facility near the eastern border of the SR-HUP license area, ended operations in 1984. Although conventional mining cannot be ruled out altogether for the future of the area around SR-HUP, it is very unlikely for two reasons. First, ISR operations are approximately two to three times more cost-effective than open pit /conventional mining. Second, virtually all the South Powder River uranium ore deposits are amenable to ISR development.

4.0 CONCLUSIONS

There have been no updates or changes to site operations at SR-HUP since the addition of Satellite SR-2 via Amendment No. 12 (NRC, 2007a). Cumulative radiological impacts from SR-HUP were evaluated in the Environmental Assessment by the NRC and found to meet the requirements of 10 CFR 20.1301. Also, potential cumulative impacts from deep injection wells were found to have impacts on nearby shallow groundwater users. Because of the cost-effectiveness of ISR in the South Powder River Basin, the NRC concluded that it was unlikely that conventional mining would resume in the area, and thus any corresponding cumulative impacts are also unlikely.

APPENDIX A-9

UPDATES AND CHANGES TO FACTORS THAT MAY CAUSE RECONSIDERATION OF ALTERNATIVES TO THE PROPOSED ACTION

1.0 INTRODUCTION

As part of the License Renewal Submittal for the SR-HUP, NUREG 1569 Appendix A (NRC, 2003c) states that *"updates and changes to factors that may cause reconsideration of alternatives to the proposed action"* shall be included. This appendix addresses that requirement.

2.0 BACKGROUND

NUREG-1569, Section 8.0, describes the area of review for alternatives to proposed action for original license renewal submittals. NUREG-1569 states *"the staff will review comparative reconnaissance level evaluations of available alternatives to the licensing action proposed in the in situ leach facility application in accordance with the requirements of National Environmental Policy Act of 1969 including realistic alternatives for the various processing stages. As part of this review, the staff should consider the no-action alternative"* (NRC, 2003).

3.0 ALTERNATIVES TO THE PROPOSED ACTION

Cameco Resources currently operates the Smith SR-HUP, a commercial ISR uranium mining operation located in Converse County, Wyoming, currently licensed under NRC License Number SUA-1548.

3.1 Alternate Mining Methods

Underground and open pit mining represent the two currently available alternatives to ISR for mining of the uranium deposits in the SR-HUP area (PRI, 2004e). Neither of these methods are economically viable methods for producing uranium from the local uranium-bearing deposits at this time. The following information documented in the RRP amendment to the SR-HUP license (PRI, 2007c) remains valid regarding alternate mining methods:

> *"From an environmental perspective, open pit mining or underground mining and the associated mill involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is traditionally much higher in open pit and underground mines than has been the experience at [ISR] solution mining operations.*
>
> *Both open pit and underground mining methods would require substantial dewatering to depress the potentiometric surface of the local aquifers to provide access to the ore. The ground water would contain naturally high levels of Ra-226 that would have to be removed prior to discharge resulting in additional radioactive solids that would have to be disposed of. For conventional mining, a mill tailings pond that could contain 5 to 10 million tons of solid tailings waste from the uranium mill would also be required.*
>
> *In a comparison of the overall impacts of in situ [recovery] of uranium compared with conventional mining, an NRC evaluation [NUREG-0925 (1983) Para. 2.3.5] concluded that environmental and socioeconomic advantages of in situ [recovery] include the following:*

- *Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much less.*
- *No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by in situ [recovery] is generally less than 1% of that produced by conventional milling methods [more than 948 kg (2090 lb) of tailings usually result from processing each metric ton (2200 lb) of ore].*
- *Because no ore and overburden stockpiles, or tailings pile(s), are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.*
- *The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5% of the radium in an ore body is brought to the surface when in situ [recovery] 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.*
- *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 mine site can be returned to unrestricted use within a relatively short time.*
- *Solution mining results in significantly less water consumption than conventional mining and milling.*
- *Socioeconomic advantages of in situ [recovery] include:*
  - *Ability to mine a lower grade ore;*
  - *A mining of capital investment;*
  - *Less risk to the miner;*
  - *Shorter lead time before production begins; and*
  - *Lower manpower requirements.*"

3.2 Alternative Sites for the Processing Plants

Most of the facilities and support systems for the SR-HUP site are in-place from past uranium operations. Accordingly, no alternative sites for the processing plants were considered. Additions to the existing facilities will be required, and some facilities have been added since the last License Renewal Submittal (RAMC, 1999). One satellite facility, SR-2, containing an ion exchange unit has been added since December 2004 (PRI, 2004e; NRC, 2007a), via Amendment No. 12. However, no new surface disturbances will be needed for the yellowcake processing facilities.

3.3 Alternative Energy Sources

Alternative energy sources to the use of uranium have been evaluated by the NRC. A summary of the discussion of alternative energy sources available to the United States is included in Chapter 2.2 of NUREG-0925 (NRC, 1983) prepared for the Teton Uranium ISL Project (Docket 40-8781).

3.4 Alternate Leach Solutions

Sodium carbonate/carbon dioxide leach solution was selected for the SR-HUP because of favorable performance in the pilot programs and other commercial ISR operations, with no significant adverse environmental impact (PRI, 2004e). Alternate leach solutions for extracting uranium include ammonium carbonate solutions and acidic leach solutions; however, operators of ISR facilities using these alternate leach solutions have experienced difficulty in restoring and stabilizing the aquifer (PRI, 2004e). As a result of this past experience by others, Cameco Resources has excluded the use of these alternate leach solutions from consideration for the SR-HUP.

With regard to groundwater restoration on-site, the combination of groundwater sweep, bio-remediation and RO clean water reinjection has been selected and is in process because of the proven success of the pilot program and other commercial ISR operations (PRI, 2004). A discussion of the groundwater restoration at the SR-HUP site is provided in Appendix A-11.

3.5 Liquid Waste Disposal Alternatives

Liquid wastes produced at the SR-HUP site are disposed of via the use of deep disposal wells and land application methods. A discussion of these processes is provided in the RRP amendment (PRI, 2007c), summarized as follows:

> *"The use of deep waste disposal wells in conjunction with storage/evaporation ponds to dispose of the high TDS liquid wastes that primarily results from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of wastes. The zones receiving these wastes are approximately 9,000 – 10,000 feet below the ground surface and are authorized by the State of Wyoming and the EPA UIC Program to receive such wastes.*
>
> *The use of the deep disposal wells in combination with the exiting land application (irrigation) facilities to dispose of the treated wellfield purge fluids has proven to be the most cost effective way to dispose of this relatively good quality waste water."*

3.6 No Action Alternative

The no-action alternative would allow Cameco Resources to continue mining operations in the current SR-HUP license area unless the NRC formally denied the renewal of the license submittal. Cameco Resources is required to submit a License Renewal submittal for the source material license to the NRC at least thirty days before the expiration date of the existing license. By doing so, the license will not expire until the NRC determined the final disposition of the License Renewal submittal and advised Cameco Resources of its decision. If the License Renewal submittal is not approved by the NRC, restoration and reclamation activities would then become the primary activities at the site.

If renewal of the current source material license was not granted, all activities at the SR-HUP not associated with groundwater restoration and decommissioning would cease, resulting in the loss of a

significant portion of the total employment at the site. At the completion of decommissioning activities, all employment opportunities at the SR-HUP would be terminated.

In addition to the loss of significant employment opportunities in Converse and Natrona Counties, the premature closing of the SR-HUP before commercially viable resources had been recovered would adversely affect the economic base of Converse County. A decision not to renew SUA-1548 for mining of the SR-HUP would leave a large resource unavailable for energy production supplies, with the SR-HUP being the largest ISR uranium producing facility in the United States. The SR-HUP represents an important source of domestic uranium supplies that are essential in providing a continuing source of fuel to power generation facilities.

4.0 PROPOSED ACTION

With NRC approval of Source Material License SUA-1548, Cameco Resources would continue to operate the SR-HUP ISR operation. Amendments to the license may be sought, as needed, in order to recover the uranium resources in the most effective manner.

The solution mining method is proposed over other mining methods for recovery of uranium from the uranium-bearing deposits present at the SR-HUP site because *in situ* mining is the most economical and environmentally sound method presently available for mining these reserves. This conclusion is based on the history of uranium mining in the South Powder River Basin area, which includes open pit mining, underground mining, and solution mining projects (i.e., ISR).

APPENDIX A-10

UPDATES AND CHANGES TO THE ECONOMIC COSTS AND BENEFITS FOR THE FACILITY

1.0 INTRODUCTION

Updates and changes to the economic costs and benefits for the SR-HUP are required as part of the License Renewal Submittal for Source Material License SUA-1548.

Monetary benefits continue to accrue to the surrounding community and state from the presence of the SR-HUP. This section provides a summary of the actual and projected economic benefits and costs of continued operations at SR-HUP since the last licensing action (the RR License Amendment Submittal in 2004e).

2.0 TAX REVENUES

Future tax revenues are dependent on uranium prices, which cannot be forecast with any accuracy. However, these taxes are also somewhat dependent on the number of pounds of uranium produced by SR-HUP.

The present taxes are based on a relatively consistent production rate of uranium. Table A-10-1 summarizes the Wyoming tax revenues from Cameco Resources' Wyoming projects, which includes the SR-HUP and the satellite operations (i.e., non-operational RRP, RU, NB, GH).

TABLE A-10-1

CAMECO RESOURCES' WYOMING TAX REVENUE SUMMARY 2005 THROUGH 2008

	2009*	2008	2007	2006	2005
Ad Valorem	$694,000	$ 1,204,000	$ 1,030,000	$ 744,000	$ 530,000
Property Taxes	$316,000	$ 239,000	$ 216,000	$ 207,000	$ 193,000
Sales and Use Taxes	$178,000	$ 312,000	$ 161,000	$ 53,000	$ 37,000
Severance Taxes	$456,000	$ 797,000	$ 680,000	$ 493,000	$ 222,000
Total	**$1,644,000**	**$ 2,552,000**	**$ 2,087,000**	**$ 1,497,000**	**$ 982,000**

3.0 CURRENT EMPLOYMENT STATUS

The most current staffing information available for the SR-HUP is from 2009, and presented herein. The SR-HUP employed approximately 116 employees and 42 contractors on a full-time basis in 2009. Short-term contractors and part-time employees are also used for specific projects and/or during the summer months and may add up to 7 percent to the total staffing. This level of employment achieved by Cameco Resources is significant to the local economies as outlined below.

The private employment in Converse and Natrona Counties, Wyoming, in 2008 was 38,700 out of a total labor force of 45,500. Based on these statistics, SR-HUP currently provides approximately 0.3 percent of the private employment (0.4 percent, if contractors are included) in Converse and Natrona Counties. In 2009, SR-HUP's

total payroll was over $10,37M. Of the total private Natrona and Converse County wage and salary payments of approximately $1.68B in 2008, the SR-HUP payroll represented about 0.5 percent. Cameco Resources' total employee payroll for the past five years is summarized in Table A-10-2.

TABLE A-10-2

CAMECO RESOURCES' EMPLOYEE PAYROLL 2005 THROUGH 2009 (EST.)

Year	Total Estimated Annual Payroll
2005	$ 4,593,000
2006	$ 4,952,000
2007	$ 7,443,000
2008	$ 8,387,000
2009	$ 10,370,000

The average annual income for all workers in Converse and Natrona Counties was $41,700 and $43,800 respectively. By comparison, the average wage for an employee of SR-HUP is approximately $53,000 per year. Entry level workers for SR-HUP earn a minimum of $16.15 per hour, or $33,593 per year, not including overtime, bonus or benefits.

SR-HUP actively pursues a policy of hiring and training local residents to fill all available positions. Due to the technical skills required for some positions, a small percentage of the current staff (less than 8 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal.

Cameco Resources expects that the type of positions created by any future expansion will be filled primarily with individuals from the local workforce, and would have no significant impact on services and resources such as housing, schools, hospitals, or other public facilities.

4.0 IMPACT ON THE LOCAL ECONOMY

In addition to providing a significant number of well-paid jobs in the local communities of Casper, Douglas and Glenrock, Wyoming, Cameco Resources actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area. For instance, in 2009, these local purchases were estimated at over $26M. The vast majority of these purchases were made in Converse and Natrona Counties. This level of business is expected to continue. Total SR-HUP payments made to Wyoming businesses for the past five years are summarized in Table A-10-3.

TABLE A-10-3

SR-HUP PAYMENTS TO WYOMING BUSINESSES 2005 THROUGH 2009 (EST.)

Year	Total Estimated Annual Payments
2005	$ 10,036,600
2006	$ 12,311,000
2007	$ 14,801,000
2008	$ 24,247,000
2009	$ 26,065,000

In addition, mineral royalty payments accrue to local landowners. Production royalties paid to land owners was over $2.1M in 2009.

5.0 ECONOMIC IMPACT SUMMARY

As discussed in the previous sections, approval of this License Renewal submittal would have a positive impact on the local economy. The current economic impact of the SR-HUP is summarized in Table A-10-4.

TABLE A-10-4

CURRENT ECONOMIC IMPACT OF THE SR-HUP

	Current SR-HUP Operation	Other Wyoming Projects
Employment		
Full-Time Employees	116	17
Full-Time Contractor employees	42	
Part-Time Employees and Short-term Contractors	10	20
Payroll – 2009*	$ 9,141,000	Included
Taxes		
Ad Valorem	$ 694,000	
Property Taxes	$ 316,000	--
Sales and Use Taxes	$ 178,000	--
Severance Taxes	$ 456,000	--
Total Taxes 2008	$ 1,644,000	Included
Local Purchases		
Local Purchases, 2008	$ 26,065,000	Included
Total Direct Economic Impacts	$ 40,327,000	

* - Payroll does not include full-time contractor or part-time employee salaries.

The economic impact from the SR-HUP, as summarized in Table A-10-4 shows a significant positive impact on both the local and state economies. The impacts extend to both economic and employee

opportunities afforded to the local population in higher than average paying jobs. Local businesses have also benefitted by the presence and operation of SR-HUP as Cameco Resources has a first preference for utilizing local, then state, then regional businesses to satisfy development and sustained operations.

APPENDIX A-11

RESULTS AND EFFECTIVENESS OF ANY MITIGATION PROPOSED AND IMPLEMENTED IN ORIGINAL LICENSE

1.0 INTRODUCTION

This section provides a summary of groundwater restoration for the SR-HUP (License USA-1548) during the update period, which spans from the previous license renewal (submitted November 15, 1999), through the first quarter of 2010. The purpose of restoration is to return the portion of the aquifer designated for uranium recovery to its pre-operational water quality, as determined from baseline monitoring data. Additional discussion of groundwater restoration goals are presented in Section 2.0. Section 3.0 provides a discussion of restoration activities that have occurred at the SR-HUP during the update period. These activities consist of: restoration approval by the WDEQ and the NRC for MU "A" (Section 3.1), restoration completion and approval by the WDEQ for MU "B" (Section 3.2), continuation of restoration at MU "C" (Section 3.3), commencement of restoration at MU "D" and MU "D-Ext and beginning of restoration activities at MU "1" (Section 3.4). The locations of these MUs are shown on Figure A-11-1.

2.0 BACKGROUND

Within the uranium ISR production zone, impacts from operations may include elevated levels of various constituents introduced with the production fluid (e.g., oxygen, bicarbonate, and hydrogen peroxide) and chemical species that are mobilized by the production fluid (e.g., uranium and other metals) (Miller, 2009). After uranium recovery ends, groundwater restoration is conducted to return the production zone of the aquifer to its pre-operational water quality. According to Chapter 6.1 of the NRC Application of March, 2006, if the baseline conditions are not achieved after diligent application of the best practicable technology (BPT), in accordance with the Wyoming Environmental Quality Act (§35-11-103(f)(iii)), a secondary goal is to return the groundwater to a quality consistent with the use, or uses, for which the water was suitable prior to production. In other words, the standard is to return the affected groundwater to its pre-mining Class of Use, per NUREG-1569 (Section 6.1.3.4.b) and defined by WDEQ Water Quality Rules and Regulations, Chapter 8, Section 4(d).

To return the groundwater to its pre-operational water quality, restoration is conducted through a variety of methods. NRC allows licensees the flexibility to select the restoration methods to be used for each wellfield (NRC, 2003c). During the update period, groundwater restoration has consisted of two phases:

1. Groundwater Sweep Phase: initial phase, in which groundwater is pumped from the wellfield without re-injection, causing an influx of baseline quality water from the perimeter of the mining unit, which "sweeps" the affected portion of the aquifer.
2. Groundwater Treatment Phase: groundwater recovered from the wellfield is treated with one or more of the following methods, and then re-injected into the affected portion of the aquifer:
   - Processing through the uranium recovery plant to recover additional uranium;
   - Degassing, by using a de-carbonator unit to remove residual carbon dioxide;
   - Reverse osmosis, with re-injection of the clean, permeate water; and/or
   - Addition of chemical and biological reductants to decrease the concentration of oxidized metals.

During restoration, groundwater monitoring is conducted to monitor restoration progress and to monitor for excursions. Excursions during restoration may occur from unintentional movement of restoration fluids or unintentional movement of groundwater impacted from production fluids. Monitoring for excursions is discussed in Appendix 8.2-1. At the start of restoration, wells that were used to determine baseline water quality are sampled for the parameters required by WDEQ LQD Guideline 8 to determine the end-of-injection water quality. During restoration, the monitoring wells are sampled approximately every 60 days for chloride, total alkalinity and conductivity. In accordance with the NRC Application of March 2006, following concurrence from WDEQ that restoration has been achieved in the mining area, a six month stability period is assessed to show that the restoration goal has been adequately maintained. Once restoration has been approved by WDEQ and NRC, wells are plugged in accordance with WDEQ LQD Guideline 8.

3.0 RESTORATION AT MINE UNITS

Restoration activities at MUs "1", "A", "B", and "C" are discussed in the sections below.

3.1 Mine Unit A

MU "A" was in production from January 1988 until July 1991. Restoration of groundwater at MU "A" was conducted from July 1991 to October 1998, using groundwater seep, RO treatment and the addition of chemical reductant. Restoration was completed prior to the previous license renewal and therefore is not discussed here in detail. Restoration of this mine unit was deemed complete and in accordance with the approved reclamation plan, with approval from WDEQ on November 23, 2003 and from NRC on June 19, 2005. Monitoring wells were plugged from March 2005 through May 2005.

3.2 Mine Unit B

U mineralization in the 30-Sand aquifer was mined at MU "B" from January 1988 until July 1991. Restoration of groundwater at MU "B" was conducted from July 1991 to June 2004 using groundwater sweep without re-circulation from July 1991 through July 1997, and groundwater extraction, treatment, and re-injection from July 1997 through June 2004. Treatment methods consisted of reverse osmosis and addition of a chemical (sodium sulfide) reductant and a biological reductant. Throughout the entire restoration period, 2.93 pore volumes (for MU "B", one pore volume equals 61,535,000 gallons) were treated with groundwater sweep, 13.5 pore volumes with reverse osmosis, 1.09 pore volumes with sodium sulfide addition, 0.88 pore volumes with bioremediation, and 0.92 pore volumes were re-circulated. The total consumptive use of groundwater was 5.22 pore volumes. The 13-year period required for restoration at MU "B" was more than originally anticipated, which has also been the case at other ISR uranium facilities due to the complexity of aquifer restoration (Davis and Curtis 2007). Restoration results are influenced by a number of site-specific hydrological and geochemical

characteristics, such as preoperational baseline water quality, lixiviant chemistry, aquitard thickness and continuity, aquifer mineralogy, porosity, and permeability.

The stability monitoring period for MU "B" began on June 28, 2004 with the end of active restoration and collection of samples for analysis of WDEQ LQD Guideline 8 parameters. The results of the sampling showed that for 24 of the 35 parameters, the average concentrations for the mineralized production zone monitoring wells are below or met baseline averages for the mine unit, or are below the average regional baseline concentrations. For 8 parameters, the concentrations exceeded the baseline averages, but met the Class I or II standards. For the remaining 3 parameters (alkalinity, bicarbonate, and manganese), the concentrations exceeded the baseline averages and exceeded the Class I or II standards. However, for each parameter, the average restored concentration (averaged of the mineralized production zone monitoring wells), met the pre-discharge Class IV (A) classification, thereby meeting restoration criteria. The six-month stability period was extended due to concerns from the WDEQ LQD about arsenic concentrations that exceed the Class IV (A) standard of 0.05 mg/L at three production zone monitoring wells. Results from monitoring events from 2004 to 2007 showed decreasing trends in arsenic at these wells, which are expected to continue as insoluble arsenic minerals are formed due to reducing conditions established during active restoration.

Restoration at MU "B" was approved by WDEQ on March 31, 2008 and is undergoing the approval process with the NRC.

3.3 Mine Unit C

U mineralization in the 50-Sand aquifer was mined from MU "C" from July 1989 to May 1999. Currently the mine unit is undergoing restoration. Restoration activities began in August 1997 with groundwater sweep. In July 1999, a recirculation loop between MU "C" and Satellite #2 was completed. Recirculation of MU "C" groundwater began in August 1999 to reduce the elevated concentration of U, followed by the following additional treatment methods:

- Degassing with a de-carbonator unit beginning in March 2003;
- RO units added in January and February 2006; and
- Bioremediation in March 2006 to activate naturally occurring bacteria in the aquifer.

As of July 2009, groundwater sweep has been used to remove approximately 640 acre-feet (one acre-foot equals 1.08×10^9 gallons) of the affected aquifer. An additional 7,832 acre-feet of groundwater have been removed from the affected aquifer, processed through the uranium recovery plant, and re-circulated. Of the 7,832 acre-feet re-circulated, 1,272 acre-feet have received additional treatment with RO.

During 1991, it was determined that production fluids from MU "C" entered abandoned Exxon underground mine workings that are known to exist in the area near MU "C" and MU "D". As discussed in Appendix 8.2-1, 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 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. As required in Section 4.2.1 of the approved Restoration Plan (Cameco Resources, 2009a), this group of 11 monitoring wells is sampled during restoration to assess the progress of groundwater restoration in the underground workings. Since restoration began in 1997 at MU "C", most of the additional monitoring wells show a decreasing trend for conductivity, chloride, and bicarbonate. Following complete restoration of MU "C" and MU "D", no impacts are expected from production fluid in the underground mine workings.

3.4 Mine Unit 1

Production activities at MU "1" ended during the Third Quarter 2006 and the mine unit is currently undergoing restoration. Restoration activities in the wellfield began in September 2006 with groundwater sweep and recirculation. The RO unit began operation on May 24, 2007. Bioremediation began in the third quarter of 2009.

4.0 MITIGATIVE ACTIONS REGARDING EFFECTS OF OPERATIONS AND/OR ACCIDENTS

A review of the original License Renewal Submittal with regard to mitigative actions for identified effects of mining operations and accidents indicates that proposed mitigation actions have been and continue to be effectively implemented and do not require revision.

Impacts resulting from mining operations requiring mitigation include ephemeral drainage areas whereby erosion controls have been required to effectively minimize soil impacts; monitor well drilling and road construction activities where short term disturbances (erosion and fugitive dust) may occur that have been kept to a minimum with prescribed protective steps to control top soil erosion-sedimentation taken through the practice of re-seeding disturbed areas as soon as possible, in addition to re-contouring (as necessary) that has also helped prevent soil erosion problems.

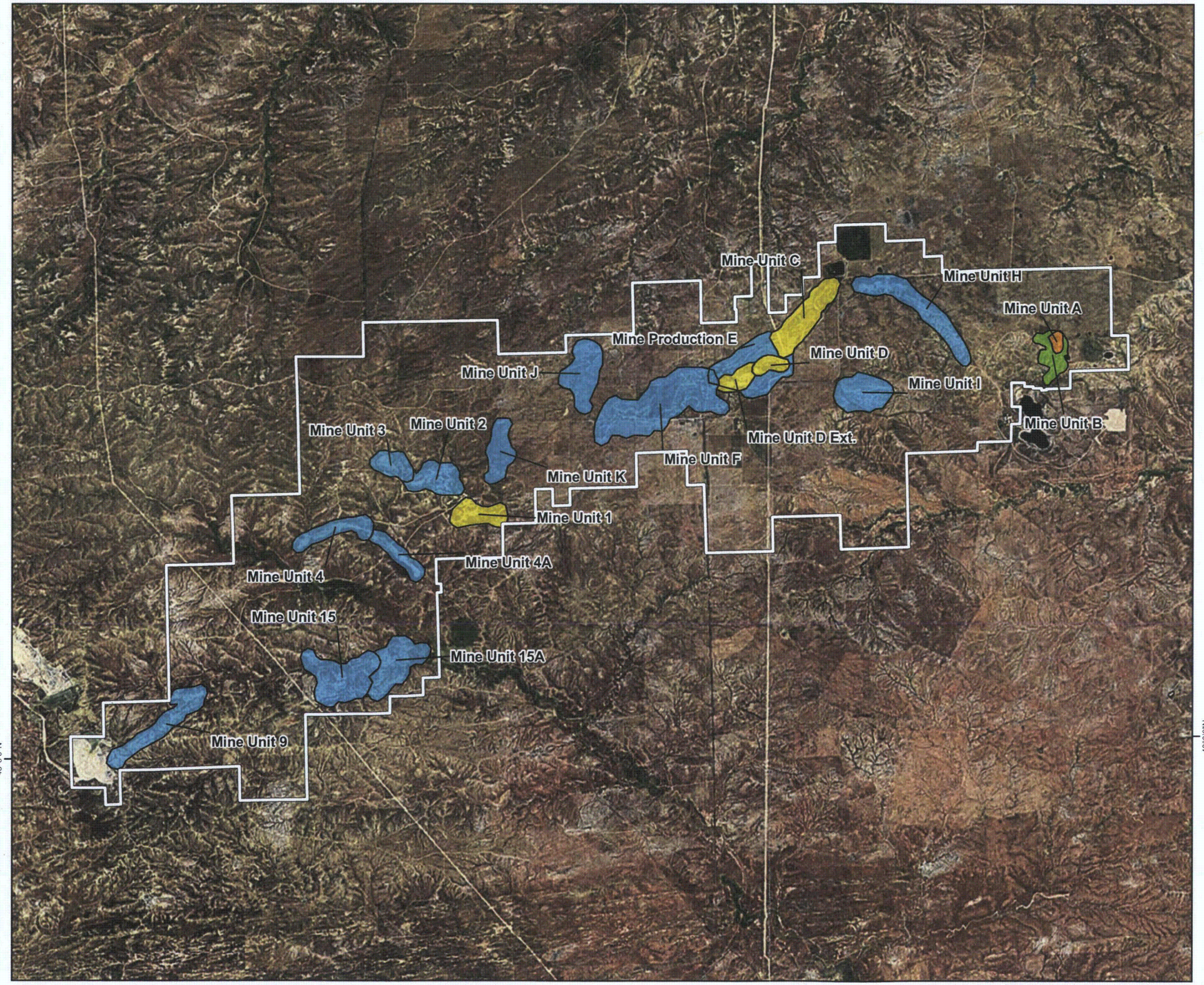
Impacts resulting from accidents requiring mitigation include tank failure (inside and outside of buildings), piping failure, fire-explosions and weather-related impacts. An evaluation of SR-HUP activities during the renewal period indicate that prescribed mitigative actions outlined within the SR-HUP License Renewal Submittal have been implemented and been effective and protective of human health and the environment. As an example, with regard to piping failures, Sections A-8.1-1 and A-8.1-2 (which details the largest release having occurred at SR-HUP) describe implementation of corrective-mitigation actions taken in response to a release.

5.0 SUMMARY AND IMPACTS

Restoration has been completed in two MU "A" and MU "B" at the SR-HUP, and is in progress in MU "C", MU "D", and MU "1".

Water quality at the restored mine units was restored to meet the pre-mining WDEQ Class of Use standards. The majority of parameters at MU "A" and MU "B" were restored to baseline conditions; however, a few parameters did not meet the baseline conditions (such as iron, manganese, selenium, radium, alkalinity, and arsenic). According to a study by the NRC (Miller, 2009), these results are typical of in-situ recovery operations. The NRC has approved 11 wellfield restorations at three existing license facilities (SR-HUP, Irrigaray/Christensen Ranch facility in Wyoming, and Crow Butte facility in Nebraska). The restoration data from these facilities have shown that restoring water quality to baseline conditions is attainable for many parameters (50 to 70 percent of the 35 parameters commonly monitored), but is not attainable for other constituents, in particular, the major and trace cations with solubilities most susceptible to the oxidation state of the aquifer (i.e., iron, manganese, As, Se, U, vanadium, and Ra^{226}) (Miller, 2009). The study also noted that impacts to the production zone aquifer for each of the approved restorations do not pose a threat to human health or the environment. Additionally, concentrations have been shown to continue to decrease after active restoration due to natural attenuation processes (Deutsch et al., 1983).

FIGURES FOR APPENDIX A-11



LEGEND

- Smith Ranch-Highland Uranium Project Boundary
- Undergoing Restoration
- Currently in Production
- Approved Restoration (WDEQ and NRC)
- Approved Restoration (WDEQ)

REFERENCES

Project and Mine Unit Boundaries: Base map provided by Cameco Resources to Golder Associates Inc. on August 28, 2009.
Projection: UTM, Zone 13 North, NAD83, Meters.

8,000 4,000 0 8,000 FEET

SCALE 1:96,000 1 INCH = 8,000 FEET
WHEN PRODUCED AT SIZE 11X17IN

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PROJECT

CAMECO RESOURCES
SMITH RANCH-HIGHLAND LICENSE RENEWAL
CONVERSE COUNTY, WYOMING

TITLE

MINE UNITS AT SMITH RANCH-HIGHLAND URANIUM PROJECT

Golder Associates
Denver, Colorado

PROJECT No.		093-81703	FILE No. 11x17_RA_SmithranchFeatures3.mxd
DESIGN	AR	12/01/2009	SCALE AS SHOWN REV 0
GIS	AR	12/01/2009	
CHECK	MEM	05/11/2010	FIGURE A-11-1
REVIEW	KFM	05/11/2010	

Map Document: M:\Cameco\ArcMap\Renewal\App\11x17_RA_SmithranchFeatures3.mxd / Modified 7/29/2010 10:53:50 AM / Plotted 7/29/2010 10:53:50 AM by aratke