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7.0 ENVIRONMENTAL EFFECTS

This section describes the potential environmental effects from the construction and operation activities of the Project. An ER, which addresses the environmental effects of the Project in greater detail, has been submitted concurrently with this report.

Compared with conventional mining, ISR operations have the following advantages in terms of environmental effects.

(1) ISR results in significantly less permanent surface disturbance since pits, shafts, overburden and waste piles, haul roads, and tailings disposal facilities are not needed.

(2) No mill tailings are produced. Therefore, the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISR is generally less than one percent of that produced by conventional milling methods.

(3) 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 dust from these sources are eliminated.

(4) The tailings produced by conventional mills contain essentially all of the Ra-226 originally present in the ore. By comparison, less than five percent of the radium in an orebody is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings, and the potential for radiation exposure is significantly less than that associated with conventional mining and milling.

(5) By removing the solid wastes from the site to a licensed waste disposal site, the entire Permit Area can be returned to unrestricted use within a relatively short time.

(6) ISR production results in significantly less water consumption than conventional mining and milling.

The socioeconomic advantages of ISR include:

- ability to produce from a lower grade ore,
- a smaller capital investment compared to conventional mining/milling,
- less risk to the worker (in terms of exposure to radioactive materials and safety),
- shorter lead time before production begins, and
- reduced strain on regional infrastructure, due to lower manpower requirements.

Site preparation, construction, and operations of the Project will be conducted such that potential environmental effects will be minimized to the greatest extent possible.

7.1 Site Preparation, Construction, and Operations

The Project requires the preparation, construction, and operation of the following:

- the access roads/utility corridors, including pipelines connecting the mine units to the Plant;
- the Plant, which includes the ion exchange facility and other processing circuits, the shop, the laboratory, storage areas, fuel tanks, the offices, possible living quarters, and parking;
- the Storage Ponds, which will be used in conjunction with the UIC Class I wells, located adjacent to the Plant;
- UIC Class I wells; and
- the mine units, which include header houses and injection/production/monitor wells.

Since mine unit construction will be ongoing throughout the Project, the environmental effects of mine unit preparation and construction will primarily occur during operations.

7.1.1 Land Use

During the life of the Project, a total of approximately 260 acres of the land surface will be disturbed; approximately seven percent of the total Permit Area. **Table 7.1-1** shows the itemized calculations on the areas of the expected disturbance. While some of the disturbances, such as the Plant and main access roads, are long-term (through the life of the Project), most are temporary, and will be reclaimed within months or years of disturbance. Ultimately, all disturbed areas will be reclaimed to support the post-operational land uses of the Permit Area.

The existing land uses of the Permit Area are livestock grazing and wildlife habitat. To control access and to prevent livestock damage to the wells and facilities, all mine units, Storage Ponds and other processing facilities at the Plant will be fenced for the duration of the Project according to BLM fencing specifications. Since the region, in general, has similar attributes supportive of livestock grazing and wildlife habitat, and the area of long-term disturbance accounts only a small portion of the Permit Area, the Project should not have a significant impact to the existing land use.

Cumulative adverse impacts to the land uses are not foreseen. The majority of the Permit Area will not be disturbed; and an abundance of similar land is available surrounding the Permit Area. In addition, the Project will conform to the land use regulations of Sweetwater County as well as the Regional Management Plan of the BLM (BLM, 2004c and 1987). Mitigation and monitoring measures on topsoil protection, erosion control, revegetation, and wildlife are presented in **Section 4.0** of the ER.

7.1.2 Transportation

During the Project, the materials transported to and from the Permit Area will be classified as: 1) shipments of construction materials, process chemicals, office supplies, and related materials from suppliers to the Plant; 2) shipments of waste material to be disposed of off-site; and 3) shipment of yellowcake slurry to an off-site drying facility.

The planned network of on-site roads is portrayed in **Figure 2.1-1.** These roads will be maintained and improved as appropriate. On-site access will be restricted through appropriate signage, fences, gates, and security.

The off-site transportation routes will be comprised of pre-existing BLM, county, state, and federal roads. These routes will not be substantially impacted with transport vehicles to and from the Permit Area. If improvements to off-site roads are needed, permits will be obtained from the BLM, and all relevant guidelines will be followed.

Detailed discussion on transportation impacts and risk analysis are presented in **Section 4.2** of the ER. Transportation accident prevention and response are discussed in **Section 7.4.7** of this report.

Records of shipping, driver training, truck safety certifications, and on-site road maintenance will be kept at the LC ISR, LLC office.

7.1.3 Soils

Soils will be impacted during the Project due to the removal of vegetation and topsoil for the construction of primary and secondary access roads, the Plant, the Storage Ponds, header houses, field lay-down areas (for construction equipment and materials), mud pits and pipelines. As shown in **Table 7.1-1**, the total area of soil removal during the project is approximately 58 acres (less than 1.5 percent of the Permit Area). Vegetation and soil removal from the construction of mud pits and pipelines will be temporary (short-term) with reclamation being completed within weeks. Equipment lay-down areas will be reclaimed after mine unit construction, and header houses in each mine unit will be reclaimed after restoration is complete. The impacts from road and plant construction will coincide with the life of the Project).

There will be two-track (tertiary) access roads throughout the mine units during field construction and operation. Although topsoil and vegetation will not be removed, traveling on these roads will result in soil compaction. Soil compaction will change the soil structure and reduce soil productivity. These impacts, however, will all be short-term (e.g., during the construction of a mine unit or through the life of the mine unit).

Access to the Permit Area will be restricted and vehicular traffic will be minimized during operations. This will reduce the occurrence of compacted soils. Compacted soils will be broken up by the discing/ripping procedures in preparation for seeding during surface reclamation.

Soil erosion and sedimentation will be reduced by: minimizing vegetation removal; surfacing common-use roads with gravel; establishing speed limits; reclaiming areas in a timely manner; installing engineering controls; and implementing other best management practices, such as dust suppression, when necessary.

Mitigation and monitoring of impacts on soils are discussed in **Section 4.3** of the ER.

7.1.4 Geology

There will be no impact on geology during site preparation and construction.

The removal of uranium from the target sandstones will result in permanent change in the geochemical composition of these rocks.

No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid (bleed) will be less than one percent. Following completion of groundwater restoration, groundwater levels will re-equilibrate to approximate pre-operational levels.

Changes to the aquifer pressure may impact the transmissivity of the Lost Creek Fault. Overall, the pressure of the produced aquifer will be decreased during operation and restoration activities. Locally, increases in pressure due to injection wells will be balanced by the production wells. It is highly unlikely that the planned ISR operations will reactivate the Fault, and less likely still the fault would generate a destructive earthquake. In this regard, the Fault, while laterally extensive in the Permit Area, is not considered a major structural feature in the Great Divide Basin.

7.1.5 Hydrology

Unlike conventional mining where large and permanent alterations to the hydrologic regime are common, impacts on surface and groundwater by ISR activities will be relatively small in scale and temporary in duration. Detailed discussions on impacts of hydrology are presented in **Section 4.5** of the ER.

7.1.5.1 Surface Water

As presented in **Section 2.7** of this report, surface water is very limited, and there are no perennial streams in the Permit Area. Surface water flow is infrequent due to the high infiltration capacity, low annual precipitation, and high evaporation rate. Some intermittent and localized flow could occur near springs, but none have been located within the Permit Area. Potential impacts on surface water from the Project will be minimal. There is no aquatic life or wetlands within the Permit Area.

To minimize impacts to surface water, the location of facilities and roads in ephemeral drainages will be avoided. Pipelines and roads will cross ephemeral drainage channels. Pipelines will be buried under the channels. Once the pipelines are buried, the channel configuration will be reestablished and the disturbed area will be seeded as soon as possible. Culverts and ditches as well as other engineering controls will be installed when necessary to allow continued drainage.

Native groundwater will be discharged to the surface during pump testing, well installation, and monitor well sampling. This discharge will be controlled to assure that no water will get into nearby surface water drainage.

In Wyoming, the EPA has delegated the implementation of the WYPDES permit program to the WDEQ. LC ISR, LLC will obtain a WYPDES permit for storm water discharge. Under this permit, LC ISR, LLC will implement measures to control the erosion and deposition of sediment.

Adverse impacts to surface water are not anticipated due to the absence of nearby surface water bodies and due to the control measures that will be implemented according to the WYPDES permit that will be obtained from WDEQ.

Water-use permits with legal descriptions inside and within two miles of the Permit Area were queried using the WSEO Water Rights Database (WSEO, 2006). According to the query, surface-water-use permits do not exist inside and within two miles of the Permit Area. Since the closed system of ISR operations does not involve the use of or discharge to surface water, the Project has no foreseeable impact to surface-water uses.

7.1.5.2 Groundwater

Potential impacts to groundwater from the Project include changes to groundwater levels and quality, due to either consumption of groundwater or the ISR process.

Within the Permit Area

Groundwater levels will be affected during the life of each mine unit. Cones of depression will be created to control the movement of fluids during operation; and the produced aquifer will be swept during reclamation. Since the operation of mine units will be sequential, a limited amount of groundwater will be affected at one time.

An evaluation of groundwater impacts due to drawdown of the production zone during ISR and restoration operations has been presented in **Section 3.2.7.3**. Based on the operational design and available hydrology, groundwater impacts, and consumption related to the operations are anticipated to be small. Data from the pump tests conducted at the Project indicate that the ore-bearing aquifer has permeability (hydraulic conductivity), porosity, and storativity that are consistent with other successful ISR projects in Wyoming. Groundwater consumption of the Project is expected to be 0.5 percent to 1.5 percent of the total production flow. An additional consumptive volume will be used during aquifer restoration, particularly during the groundwater sweep phase. It is expected that the net consumption for the entire operation will be on the order of 175 gpm for the project life. Much of this consumptive use is during the restoration phase, especially during groundwater sweep. As discussed in **Section 3.2.7.3**, because of the limited thickness of the HJ Sand, consumptive use of groundwater could potentially lower water levels in the Permit Area by more than 100 feet.

Water levels will be routinely measured in the production zone and overlying and underlying aquifers. Sudden changes in water levels within the production zone may indicate that the mine unit flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer or underlying aquifers may be an indication of fluid migration from the production zone. Adjustments to well flow rates or complete shut down of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also be an indication of casing failure in a production, injection or monitor well. Isolation and shut down of individual wells can be used to determine the well causing the water level increases.

Groundwater quality within the pattern areas of each mine unit will be altered during operation activities. The groundwater of the ore-bearing aquifer will be used, treated, and recycled to recover uranium in solution. In order to dissolve the uranium, the chemistry of the target aquifer will be altered within the pattern area. However, groundwater impacts to the production zone outside the monitor well ring are not expected. Further, no water quality impacts to the overlying or underlying aquifers are anticipated. A Class III UIC permit will be obtained from WDEQ-LQD and an aquifer exemption obtained from WDEQ/EPA.

To ensure the production fluids are contained within the designated area of the ore-bearing aquifer, the production zone and overlying and underlying aquifer monitor wells will be sampled semi-monthly. An extensive water-sampling program will be conducted prior to, during and following ISR operations to identify any potential impacts to hydrology of the area. Groundwater restoration requirements will also help ensure the protection of the affected groundwater resources.

Outside the Permit Area

Currently, groundwater is not used for domestic or irrigation purposes inside the Permit Area and within two miles of the Permit Area boundary. The majority of the groundwater-use permits filed in the vicinity of the Permit Area are for monitoring or miscellaneous purposes related to operations and do not represent consumptive use of groundwater.

BLM has four active wells (and four associated stock ponds), located outside of the Permit Area, but within one mile of the permit boundary, for livestock use (**Figure 2.2-4**). As discussed previously, little (if any) impacts on these water uses are expected. Two of the wells (Boundary Well No. 4775 and Battle Spring Wells No. 4777) are less than 300 feet deep, shallower than the proposed ISR depths in the HJ Horizon. The East Eagle Nest Draw Well is also relatively shallow (370 feet deep) compared to the depth of the top of the primary ore zone of interest, the HJ Sand (400 feet). The Battle Spring Draw Well No. 4551, at 900 feet deep, is much deeper than the HJ Sand. Although the specific screened interval of this well is not known, the relative depth of this well reduces the potential for impacts from the Project.

The potential impacts to the wells will be minimized by altering ISR operations on different sides of the Fault, and potential production from different sands (e.g., the KM Sand as approved in future permit submittals). Any water level declines in the four BLM wells are not expected to impact the water quality in these wells because of the relative similarity in the water quality at these depths. Throughout the phases of the Project, LC ISR, LLC will monitor water levels in these wells and correspond with BLM to ensure that these wells are not impacted in a manner that restricts the intended use.

7.1.6 Ecology

The majority of impacts on ecology will occur during site preparation and facility construction, which require the removal of vegetation, decreasing wildlife habitat. There is no wetland or aquatic life in the Permit Area. Detailed discussion on ecological impacts, mitigation and monitoring are presented in **Section 4.6** of the ER.

7.1.6.1 Vegetation

During the lifetime of the project, the total area of vegetation removal will be about 58 acres (see **Table 7.1-1**), less than 1.5 percent of the Permit Area. The two vegetation types disturbed by construction activities include the Lowland Big Sagebrush Shrubland (30 percent) and the Upland Big Sagebrush Shrubland (70 percent).

Near half of the vegetation removal area (pipelines and mud pits) will be reclaimed within a few weeks to a few months. WDEQ and BLM approved seed mix will be used for revegetation.

Vegetation of the Permit Area will also be impacted by traveling on the two-track access roads within the mine units during field construction and operations. Although these roads do not require vegetation removal, extensive traveling will cause vegetation stress and may take months or even years to recover. Impacts of this kind occur mostly during field construction phase.

The Project is not likely to adversely affect sensitive plant species because federally- and state-listed or proposed endangered or threatened species or proposed or designated critical habitats do not occur within the Permit Area. LC ISR, LLC will take vegetation protection into account while planning for field development. Detailed mitigation and reclamation measures are presented in **Section 4.6** of the ER.

7.1.6.2 Wildlife

Potential impacts of the Project on wildlife include: direct and indirect loss and/or modification of habitat; increased mortality from collision with vehicles; increased poaching or hunting due to improved access; possible mortality (of small mammals, birds, reptiles, and amphibians) from construction activities; possible mortality from exposure to toxic compounds or chemicals; displacement of wildlife due to increased human activity; and increased disruption/stress to wildlife using the sagebrush habitats at or near the Permit Area.

Direct impacts to wildlife habitat will occur in areas that are physically altered by the construction of roads, the Plant, the Storage Pond(s), mud pits/wells, header houses, and pipelines. Indirect impacts will occur from an increased human presence, dust, and noise. Indirect impacts may displace or preclude wildlife use near areas of human use/disturbance.

Human activity (noise, traffic, human presence) in each mine unit will decline after initial drilling, construction, and start-up. Wildlife use of areas adjacent to ISR operations is anticipated to increase as animals become habituated to the activity. Contemporaneous revegetation of disturbed areas will help minimize habitat loss and provide quality forage. Previous ISR sites that have implemented active revegetation programs have become attractive to wildlife, principally deer and antelope.

LC ISR, LLC will follow BLM and WGFD guidelines on wildlife protection while planning and conducting ISR operations at the Project. Site-specific monitoring programs will be implemented per federal and state guidelines. Detailed mitigation and monitoring measures are presented in **Section 4.6** of the ER.

7.1.7 Air Quality

Air quality impacts which may result from construction and operation activities will be primarily fugitive dust and engine exhaust emissions. Based on experience at other ISR facilities, these types of emissions are not expected to be significant. Detailed discussion on air quality impacts, mitigation and monitoring are presented in **Section 4.7** of the ER.

Fugitive dust may be generated by vehicular traffic, earth-moving activities during construction and wind erosion of disturbed areas. These will be intermittent, quickly dispersed and should not represent significant air emission impacts. To reduce fugitive dust, on-site speed limits will be established and disturbed land will be revegetated during the first available seeding window after construction is complete. Should fugitive dust become an issue, other mitigation measures, such as applying water to the unpaved roads, will be implemented.

Gaseous emissions (e.g., carbon dioxide, carbon monoxide, nitrogen oxides, oxygen, radon, sulfur dioxide, and volatile organic compounds) may be released to the atmosphere from operating of diesel drilling rigs and gasoline powered service vehicles during construction, as well as from vents and exhausts at the Plant and mine units during operations. These emissions will be dispersed rapidly and will not cause any exceedance of any applicable air quality standards in the Permit Area. Engines will be regularly maintained and pollution prevention equipment will be used to ensure that emissions are minimized.

7.1.8 Noise

Noise impacts were assessed by comparing background noise levels with projected noise levels during construction and operation activities. The proximity of sensitive receptors was considered in the impacts analysis. The closest residence, church, or school is around 15 miles from the northeast Project boundary (e.g., Bairoil) and will be more than 16 miles from the nearest mine unit.

Most of the noise will be generated during site preparation and mine unit construction when heavy trucks and equipment will generate high levels of noise at the construction site. By the time these noises reach the nearest residential area (14 to 16 miles away), however, they will have attenuated below background noise level (e.g., not audible) and well below the 55-dBA (A-weighted decibel) guideline to protect against activity interference and annoyance (EPA, 1978).

Mine unit construction will occur only during daylight hours. The 70-dBA, 24-hour average sound energy guideline for hearing protection (EPA, 1978) will not be exceeded on-site.

Noises generated during ISR operation will be at significantly lower levels than those from the site preparation and construction phase. No exceedance of any applicable noise criteria for off-site receptors or for on-site personnel is expected.

7.1.9 Cultural Resources

Potential impacts on cultural resources occur mainly during site preparation and construction phase, especially when vegetation and top soil removal is involved. Detailed discussion on cultural resource impacts, mitigation, and monitoring is presented in **Section 4.8** of the ER.

Class I and III archeological studies were performed for the entire project area, as described in Section 2.4, and submitted to BLM for review. Three prehistoric archaeological sites were identified in the Permit Area as meeting the eligibility criteria of the NRHP.

LC ISR, LLC commits to abiding by the requirements of the National Historic Preservation Act and the Archeological Resources Protection Act and their implementing regulations. In addition, LC ISR, LLC commits to ceasing work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs. LC ISR, LLC will make every effort to avoid disturbing any of the potential NRHP sites. Site boundaries will be clearly marked and a buffer around the sites will be maintained. Construction and operation activities that occur near significant properties will be monitored by an archaeologist. In the event that significant sites cannot be avoided, LC ISR, LLC will prepare site-specific treatment plans to guide data recovery excavations. Prior to implementation, the treatment plan(s) will be subject to review and approval by BLM and the Wyoming SHPO, and will be subject to review and comment by concerned Native American groups.

Cultural resource monitoring is recommended in the immediate vicinity of significant sites that are to be avoided. Proposed mitigation actions for cultural resource impacts will be in accordance with BLM and SHPO requirements.

7.1.10 Visual/Scenic Resources

The Project will result in temporary, minor impacts to visual and scenic resources. The Project will maintain the visual resource classification of the area, Visual Resource Class III, as described in **Section 2.4.2**.

Most of the modifications to the landscape introduced by the Project will not be visible from the public road network, which is lightly traveled. The most proximate facilities are about 5 miles from the nearest county road; and the rolling topography will hide the facilities from travelers, except from a limited number of vantage points. The Project will not affect locally important or high-quality views. The facilities will be discernable, but will not be a dominant landscape feature from a distance.

To minimize impacts to visual and scenic resources, building materials and paint will be chosen to blend with the natural environment, according to BLM guidelines. All structures will have a low profile in order to minimize the number of vantage points from which they may be visible.

ISR operations will not cause modifications to scenery or topography that will persist after restoration and reclamation.

7.1.11 Socioeconomics

While the Project will generally have a positive effect to the socioeconomics of the area, although short-term, negative indirect effects on the local government infrastructure and housing may occur due to increases in population and demand for public facilities and services. A detailed discussion on socioeconomic effects is presented in **Section 4.10** of the ER.

The local population is expected to increase as a result of increased employment opportunities generated both directly and indirectly by the Project. The increased demand for housing will likely increase housing prices (rental costs and home sales prices).

Public facilities and services that may be impacted by an increase in population include: Rawlins water and sewer distribution system and streets; the Carbon and Sweetwater County road maintenance for Mineral Exploration Road; and the BLM Sooner Road. With the additional influx in population, improvements to these public systems may be required sooner than anticipated and would have budgetary effects on local governments for capital improvement funding.

Emergency services, including fire, police, ambulance, and hospital services, should not be impacted by the increased population or employment.

Wages and salaries paid to skilled and unskilled workers on the Project will have a positive impact on local businesses such as restaurants, service stations, and retail stores. In addition to local expenditures near the Project, workers will also be contributing to their local economy in the form of expenditures for goods, services, housing, insurance, entertainment, and food. This increased economic activity may enhance the availability of goods and services, as well as cultural, educational, and recreational opportunities.

Increases in taxes and revenues would provide counties and communities with more discretionary dollars to develop infrastructure and support the population. Taxes, including severance taxes, ad valorem production, and property taxes, will accrue to the federal, state, and local governments. Other tax revenues generated from the Project will include sales, use, and lodging taxes.

7.1.12 Environmental Justice

The economic base of the region is predominately agriculture and natural resource development, except in Rawlins and Casper. Segments of the population are lower income, particularly in rural areas, due to the typical lower income of the agricultural sector. According to 2003 census data, families within the defined poverty status represented less than 12 percent of the population in Carbon County (Census Bureau, 2000a) and less than nine percent in Sweetwater County (Census Bureau, 2000a). Neither low-income (poverty status) nor minority populations will be disproportionately impacted by the Project.

7.1.13 Public and Occupational Health

In the vicinity of the Permit Area, minerals and chemicals occur naturally and from historic land uses. These minerals and chemicals may have properties that are harmful to the health of humans. During the life of the Project, human exposures to the parameters of concern will be minimized by following best management practices (BMPs) and monitoring human health and the conditions of different environments.

Considering that the Permit Area is remotely located, the potential impact to the health of the general public will be minimal. No known residence is within 14 miles of the Permit Area. However, nearby land may be accessed for recreational or livestock purposes, thereby potentially affecting the public with short-term exposure.

Public and occupational health impacts during construction and operation activities is discussed and evaluated in detail in **Section 5.0** of this report.

7.1.14 Waste Management

Airborne, liquid, and solid wastes will be produced by the Project. All of these wastes are typical of ISR projects currently operating in Wyoming. Existing BPT will be used in all aspects of waste management at the Permit Area. Detailed discussions on effluent control and waste management are presented in **Section 4.0** of this report.

Non-radioactive gaseous emissions will readily disperse in the atmosphere and will not create an adverse impact to air quality. Airborne particulates will be minimal. Fugitive dust emissions will be minimized due to the inherent nature of ISR operations and the restricted road access.

Impacts from radioactive airborne effluents are foreseen as negligible since ISR operations is conducted in a closed system consisting of wet materials and the yellowcake drying and packaging will occur off-site.

The liquid and solid wastes generated from the Project will include domestic sewage, non-radioactive wastes, and radioactive byproduct wastes. These wastes will be treated, removed, and disposed of according to the applicable local, state, and federal regulations. As such, cumulative adverse impacts to the environment are not anticipated.

7.2 Radiological Effects

ISR facility exposure pathways to radiological materials are considerably different from pathways associated with conventional uranium mining methods. First, the majority of the uranium radioactive daughter products is not removed from the orebody, but remains underground within the ore zone. Additionally, no drying of the uranium product will be performed at the Permit Area. This greatly reduces the potential radiological air particulate pathway typically associated with conventional uranium ore milling or those ISR facilities which produce dried product.

Radon will be released from the solutions at the mine units and vented from the Plant building to the atmosphere during operation or when vessels are opened for maintenance. Experience from other ISR projects show that these releases will only be a small fraction of the natural background dose contribution and will not result in a significant off-site impact.

Potential radiological impacts from the Project, described in **Section 3**, were modeled using the MILDOS-AREA model. The results of this modeling, including printouts of the model output, are presented in as **Attachment 7.2-1**. MILDOS (ANL, 1989) was originally developed to estimate doses from conventional uranium milling operations, including large area releases such as ore storage pads and tailings ponds. Inputs to the dose are limited to uranium decay chain radionuclides. MILDOS was subsequently updated in 1998 to address potential impacts of ISR operations. ISR-specific source terms, such as production wells and restoration wells, are included in the updated version (ANL, 1998).

7.2.1 Exposure Pathways

Since the Project is an ISR operation, the only source of planned radioactive emissions is radon gas, which is dissolved in the recovery solution. Radon gas may be released as the solution is brought to the surface and processed. Unplanned emissions from the site are possible as a result of accidents and engineered structure failure, which are not addressed in the MILDOS-AREA modeling.

MILDOS was used to estimate doses from radon released during the following operations:

- New wells: When drilling new wells into the orebody, drill cuttings, including ore, are transported to the surface in drilling mud. Cuttings are temporarily stored in mud pits, where Rn-222 may be released to the atmosphere.
- Producing mine units: Radon that is dissolved in the lixiviant may be released either from purge water or from gas venting at the wellhead.

- Ion Exchange facility: Radon gas may be released from the columns as a function of the volume of the columns, the porosity of the resin and the unloading rate of the column.
- Restoration activities: During the restoration of the mine units, water is circulated within and discharged from the wells in release rates similar to those from producing mine units.

Pathways for potential human exposures are diagrammed in **Figure 7.2-1**.

7.2.1.1 Exposures from Water Pathways

Solutions in the production zones will be controlled and adequately monitored to ensure that migration does not occur. For purposes of off-site exposures, no off-site releases of water are planned or expected. Therefore, there are no quantifiable water-related pathways.

7.2.1.2 Exposures from Air Pathways

As currently planned, the only source of potential radionuclide emissions is Rn-222 release from either venting or purge water releases, as described above. Atmospheric releases of Rn-222 can result in exposure from either inhalation of contaminated air, direct gamma exposure from deposited decay products or ingestion of foodstuffs contaminated with decay products. The MILDOS-AREA computer code was used to estimate potential exposures and doses to human receptors and populations surrounding the Permit Area. The results are summarized below. A more detailed analysis of modeling results is given in **Attachment 7.2-1** of this report.

Doses to Specific Receptor Locations

Since there are no permanent residents in the vicinity of the proposed facility, a series of 17 locations were modeled around the perimeter of the Permit Area boundary as shown in **Figure 7.2-2**. The map shows modeled receptor locations, as well as centroids of each mine unit, and locations of the Plant Site One (the preferred plant location) and Plant Site Two (an alternative).

MILDOS modeling indicates that releases from the site lead to a calculated total effective maximum dose equivalent (TEDE) to a potential resident at the SEB1 boundary location of 3.01 mrem, which is well below the 100 mrem/yr 10 CFR 20 limit (**Table 7.2-1**). No other boundary location exceeds 2 mrem in a given year and most are below 1 mrem. The vast majority of the calculated dose at the SEB1 location is from production and restoration venting which occur at the centroid of the mine unit. Most mine units are upwind of the SEB1 location. Calculated receptor doses for the Plant are shown in **Figure 7.2-3a**.

Moving the Plant to the alternate location (Plant 2 in **Figure 7.2-2**) moves only the releases from the ion exchange columns and the purge water releases. This has the impact of decreasing the more northerly boundary receptor locations and generally increasing southeastern boundary receptors. Boundary location SEB1 remains the highest dose even when the alternate Plant location is used, largely because its doses are more influenced by venting releases at the mine unit than by releases from the Plant. Details of the MILDOS modeling are given in **Attachment 7.2-1**.

The 2007 and early 2008 MILDOS modeling discussed above was based on meteorological data from the Lost Soldier site. Subsequent data was collected at the Lost Creek site and a comparison of the data and its affect on the MILDOS modeling is discussed in Section 2. In response to an NRC RAI (Nov 2009 #1), a subsequent MILDOS simulation was conducted in 2010 using data from the Lost Creek meteorological station rather than the Lost Soldier station. No operational parameters were changed from the initial 2007-08 modeling. The results are compared on **Figure 7.2-3b**.

Doses to Potential Workers

Although outside the intended scope of the model, MILDOS was used to calculate annual doses to a hypothetical average worker. The worker location was modeled once for 100 m to the north, east, south and west of the Ion Exchange Facility. Calculated MILDOS TEDE values were multiplied by 0.22 (2000/8760) and averaged (**Figure 7.2-4** and **Table 7.2-2**). Calculated doses peak at less than 0.3 mrem per year. As expected from this sort of analysis, all years are well below occupational dose limits. During operation of the facility, workers at the site will be monitored and occupational doses calculated as described in **Section 5.7**.

Doses to 'Casual' Members of Public Who Enter Permit Area (e.g. a Hunter)

Figure 10 of **Attachment 7.2-1** provides results for a MILDOS assessment of doses to workers by year at a distance of 100 meters from the Plant. The results indicate the highest annual dose at an occupancy rate of 2,000 hours per year (over 80 days per year) would be about 0.3 mrem per year. It is reasonable to assume that doses at distances anywhere within the Permit Area greater than 100 meters from the Plant would be less than 0.3 mrem per year using the same assumptions and given that effluent releases from ISRs are essentially at or near ground level obviating the potential for 'looping effects' during dispersion. Accordingly, for the unlikely scenario that a member the public would casually enter and linger for five days (120 hrs) in the Permit Area (e.g., a hunter), the dose to that person would be 120/2000 x 0.3 = 1.8E-2 mrem per year. It is recognized that the exposure pathway applied in this scenario is exclusively from airborne radionuclides, as other pathways that would be applicable to a full-time resident (e.g., ground shine or ingestion of locally grown foodstuffs) would not be applicable. Verification of the modeling results will be provided by the operational environmental monitoring program described in **Section 5.7.7**.

7.2.1.3 Exposures from External Radiation

External radiation exposures that may result from releases of radioactive material are calculated within MILDOS and are included in the dose estimates summarized above.

7.2.1.4 Total Human Exposures

There are no towns of any size within 15 miles (24 km) from the mine unit or the proposed plant sites. Towns within 50 miles (80 km) from the Permit Area include the Rawlins, Jeffrey City, Wamsutter, and Bairoil, as summarized in **Table 7.2-3**. Using populations as shown in **Table 7.2-3**, population doses in person-rem per year (person-rem/yr), from the Plant Site One releases, were calculated for both TEDE and the dose to the bronchial epithelium of receptors.

Estimated doses to populations surrounding the proposed Lost Creek ISR site are summarized in **Table 7.2-4**. The maximum estimated annual population dose, 1.87E-2 person-rem within 80 km and 6.39 person-rem to all populations, occurs in 2015. While there is no regulatory limit for population dose, it is interesting to compare results in **Table 7.2-4** to exposures from natural background. Using the population data in **Table 7.2-3** for those within 80 km, and assuming 350 mrem/yr from natural background, the natural background population dose would be approximately 3.1E3 person-rem/yr, or approximately 160,000 times higher than the maximum year of the Lost Creek project to that same population.

7.2.1.5 Exposures to Flora and Fauna

Because of their relative mobility, some native animals, including small mammals and birds, may have contact with Rn-222 releases. It is possible that individual animals might have contact with higher concentrations of Rn-222 than any member of the public because of potential proximity to releases. However, the mobility of biota makes it unlikely that any individual animal will receive a constant concentration for the entire year. There are no current dosimetric standards for protection of biota. However, it has been assumed by the International Commission on Radiological Protection that if humans were protected, then biota in the same exposure environment would also be protected.

US Department of Energy (DOE) Order 5400.5 proposed a limit of one rad per day (rad/d) for aquatic organisms. Title 10 CFR Part 834, Subpart F proposes limits of one rad/d for terrestrial plants and 0.1 rad/d for terrestrial animals. Those proposed values are far higher than the doses calculated to any receptor outlined above. Therefore, it is reasonable to expect no significant impact from the contacts of biota with releases from the Plant.

In response to an NRC RAI (Nov 2008 RAI §2.9 #3), a subsequent MILDOS simulation was conducted in mid-2009 with the objective of predicting radiological activity (in particular activity from radon decay products) on the ground closer to the Plant. The 2009 MILDOS results were used to help select vegetation and soil sampling locations near the Plant, as described in **Section 2.9.3.1**. For the 2009 'near-Plant' MILDOS modeling, no operational parameters were changed from the initial 2007-08 modeling (**Section 7.2.1.2** and **Attachment 7.2-1**). Outside the Plant fence-line, the maximum value is 5,000 pCi/m^2 [average over year], located 200 m straight north of the Plant center on the Plant fence-line. Assuming that all activity resides in the top 1 cm of soil which has a density of 1.2 g/cm^3, this equates to approximately 0.4 pCi/g of soil. Over the course of a year, it is unlikely that such low concentrations would be detected in soil or vegetation sample.

7.3 Non-Radiological Effects

7.3.1 Airborne Emissions

Potential air quality impacts will primarily occur during construction and operation activities. The parameters of concern are fugitive dust and engine exhaust emissions.

The atmospheric stability of the Permit Area is low due to the winds; and any particulate and gaseous releases will be quickly dispersed. The closest off-site receptor, Bairoil, is located about 15 miles from the Permit Area and not directly downwind of the prevailing wind direction. Therefore, air emissions are not expected to cause adverse impacts to human health.

Mine unit construction and travel on unpaved roads will result in minor intermittent emissions of fugitive dust. Contemporaneous reclamation, driving under speed limits and restricting off-road traffic will minimize the presence of fugitive dust.

Gaseous emissions will result from the operation of internal combustion engines and venting from the mine units and the Plant. During construction phase, exhaust from diesel drilling rigs and gasoline-powered service vehicles will produce small amounts of carbon monoxide, sulfur dioxide and other internal combustion engine emissions. Small amounts of exhausts and gaseous oxygen and carbon dioxide may be emitted from the mine units and the Plant during production phase. These gaseous emissions will readily disperse in the atmosphere and are not expected to create an adverse impact to human health.

7.3.2 Sediment Loads

Potential sediment loading and sedimentation could occur if uncontrolled runoff carrying sediments from the disturbed areas reach the drainages within and downstream of the Permit Area. There are no perennial streams or wetlands within the Permit Area. The only time for any sediment to reach the surface water drainage and be carried downstream would be during spring snow melt when short-term sustained flow may occur. Erosion control measures will be implemented during the Project to minimize potential sediment loading to surface water drainages.

All disturbances will be revegetated as soon as possible following the disturbance. All long-term topsoil stockpiles will be fully contained and vegetated. A containment ditch and berm will be constructed around each stockpile to prevent any loss of topsoil from the stockpile until revegetation is established. Where necessary, fences, straw bales or other erosion control techniques will be used to prevent sediment from leaving the disturbed area. Purge water from monitor wells will be discharged towards diversion structures to prevent runoff onto disturbed areas.

Fuel storage and staging areas will be managed in such a manner that no off-site drainage will be allowed to enter the staging area; nor will any surface runoff initiated in the staging area be allowed to exit. This will be accomplished by berming and/or ditching the perimeter of the entire staging area. Fuel and lubricant storage areas will be bermed separately from the rest of the staging area.

Inspection, reporting, and maintenance of storm water control features will comply with WYPDES requirements.

7.3.3 Groundwater Quantity and Quality

As discussed in **Section 7.1.5** of this report, impacts to hydrology are expected to be minimal. The net consumptive use of groundwater is anticipated to be on the order of

175 gpm for the majority of the operational life of the Project. Potential impacts due to drawdown from consumptive use have been discussed previously. No impacts to groundwater quality outside the monitor well ring for each mine unit are expected.

The liquid effluent will be managed in the Storage Ponds and UIC Class I wells. There will be no discharge from the Storage Ponds. UIC Class I wells will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by WDEQ. The Class I UIC permit will require quarterly reporting to ensure that the well(s) are operated consistent with the Class I permit requirements. Based on the operation of other UIC Class I wells at ISR facilities in Wyoming, little or no non-radiological impact is expected due to the liquid effluent from the Project.

7.4 Effects of Accidents

The potential effects of credible accident scenarios, ranging from tank failure to leaking exploration drill holes, are discussed in this section, along with accident reporting requirements and clean-up criteria.

Accident Reporting Requirements

All of the accident situations discussed in this section will require reporting and sometimes emergency notification of various agencies. LCI will write and implement an Emergency Response Standard Operating Procedure (SOP) which clearly defines under what circumstances reporting is required and to which agency(ies). When radiological dose assessment is required, the SOP will provide guidance on how to determine the doses which require reporting under 10 CFR 20.2202 and 2203.

Clean-Up Criteria

With regard to radionuclides, any soil affected by a spill resulting in an exceedance of the 10 CFR 40 Appendix A Criterion 6 decommissioning standards will be cleaned up in a timely manner to prevent any harm to the environment or to employees (**Section 5.7.6.3**).

With regard to non-radionuclide hazardous constituents, any soil contaminated by a spill in such a manner that it exceeds the Toxicity Characteristics Leaching Procedure (TCLP) limits established in 40 CFR 268 will be treated or removed. In order to determine what soils exceed the TCLP limits, the Environment, Health, and Safety (EHS) Department will ensure an annual analysis of pregnant lixiviant is performed for all constituents listed in 40 CFR 268 and calculate the potential for exceeding the TCLP standard (using the same calculation method in NUREG/CR-6733). If the calculation reveals that the leachate is more than 15% of the TCLP limit, then any soil impacted by a spill will be sampled and analyzed by TCLP. The soil will be removed or treated if the analysis reveals the TCLP standard has been exceeded. LC ISR, LLC will also comply with all Wyoming Department of Environmental Quality standards with respect to soil contamination.

7.4.1 Tank Failure

The process fluids will be contained in the process tanks and vessels and piping circuits within the Plant. Alarms and automatic controls are used to monitor and keep levels within prescribed limits. In the unlikely event of a failure of a process vessel or tank in the building, the fluid would be contained within the building, collected in sumps, and pumped to other tanks or to a lined Storage Pond. The Plant will be designed with a retaining wall to contain any process and/or wash fluids. The area would then be washed down with water contained in a similar manner, eliminating any environmental impact from the failure.

No process tanks are planned outside of the Plant. If a tank or vessel were installed outside of the Plant building and were to fail, it could result in the spill of leach solution to a retention or containment system. The liquids would then be pumped to another tank or lined pond. The environmental impact of such an accident could result in some soils being contaminated, requiring controlled disposal. All areas affected by such a failure or leak would be surveyed; any contaminated soils or material requiring controlled disposal would be removed and disposed of in accordance with NRC and/or state requirements. The affected area would then be reclaimed as specified in **Section 6.0** of this report; therefore, there would be no long-term impact from such an accident.

The Plant design incorporates concrete berms designed to contain a spill of one or more vessels. The perimeter berm, surrounding the entire Plant, has a capacity of approximately 163,000 gallons. Within the perimeter berm are several internal berms that are designed to compartmentalize spills within certain areas. The heights of the internal berms are lower than the height of the perimeter berm so if the capacity of an internal bermed area is exceeded the fluid will spill into the next bermed area. A spill will have to exceed 163,000 gallons before overflowing the perimeter berm. The internal berms have individual capacities as follows:

Precipitation Room	33,000 gallons
Chemical Room	17,400 gallons
Maintenance/Future Dryer Area	31,200 gallons
Ion Exchange/Elution/Restoration	81,780 gallons

The largest tank in the Plant is approximately 21,000 gallons and the total berm containment volume is approximately 163,000 gallons. Therefore, the perimeter berm can hold the contents of several tanks.

The flow into the Plant will be approximately 6,000 gpm. Therefore, assuming a worst case pipeline break, the perimeter berm will contain 100% of the flow for 27 minutes. Numerous safety features are in place to notify the operator of a significant spill within the Plant including, but not limited to: continuous occupancy of the Plant by an operator, high sump level alarm, low injection pump suction alarm, and delta injection and production flow rate alarm.

7.4.2 Pipeline Failure

The rupture of a pipeline between the Plant and the mine units could result in a loss of either pregnant or barren solutions to the surface. To minimize the volume of fluid that could be lost, the pipeline systems will be equipped with high-pressure and low-pressure shutdown systems and flow meters. The systems will also be equipped with alarms; the operator will be alerted immediately if a major malfunction occurs. Additionally, the pipelines will have periodic valve stations that will allow the operator to minimize the volume spilled by isolating the area of concern. If the volume and/or concentration of the solutions released in such an accident did constitute an environmental concern, the area would be surveyed and the contaminated soils would be removed and disposed of according to NRC and/or state regulations. The pipelines will normally be buried approximately five to six ft bgs and will be of a corrosion-free HDPE material; therefore, the probability of such a failure, after the pipelines have been tested and placed in service, is considered small. Piping junctions will be made of either corrosion-free HDPE, stainless steel, epoxy-coated steel or a combination of the three to minimize the opportunity for a leak at a junction. The same is true for the pipelines transferring waste fluid to the UIC Class I disposal wells.

Industry experience has shown that most spills are the result of partial failures or ruptures of piping and/or fittings (NRC, 1997). Instrumentation and a physical presence in the operating area help to minimize the extent of a discharge from a pipeline failure. The Project will have Field Operators, who will be responsible for daily field review of operating systems as well as monitoring of instrumentation.

7.4.3 Pond Failure

The Storage Ponds will be constructed with leak detection systems; and these systems will be monitored daily. In the event of a leak, the fluid in the compromised unit would be transferred to the sister pond and the liner would be repaired as needed. The pond area will be surveyed and reclaimed as part of the final reclamation, eliminating any significant long-term impact.

A Storage Pond embankment failure would be the most severe type of pond failure. To minimize the risk of an embankment failure, the ponds will be inspected daily to ensure there is no significant deterioration of the embankments. Should a failure occur, all impacted areas would be surveyed, cleaned up as needed, and reclaimed.

7.4.4 Casing Failure

A casing failure in an injection well would have the potential for environmental impact because the leach fluid is injected under pressure. It is possible that this type of failure could continue for several days before being detected by the monitoring system. If such a failure did occur, the defective well would be either repaired or plugged and abandoned. If contamination of another aquifer were indicated, wells would be drilled and completed in the contaminated aquifer and then produced until concentrations of lixiviant constituents were reduced to acceptable levels, as per WDEQ approved baseline values. With proper casing, cementing, and testing procedures, the probability of such a failure is very low.

To minimize the risk of a casing failure significantly impacting the environment, should one occur, monitor wells will be completed in the aquifers above and below the ore zone. The fluid levels and quality of the water in the adjacent aquifers will be routinely monitored during operations to check for fluid movement into these aquifers. In addition, casing integrity tests will be performed on all injection wells prior to using the wells for injection and after any work that involves entering a well with a cutting tool, such as a drill bit or underreamer.

Failure of a production well casing would not normally cause an excursion; because the production wells do not operate under pressure.

7.4.5 Leaking Exploration Drill Holes

Movement of leach solution between aquifers through old exploration holes in the Permit Area is considered unlikely. Recent drill holes were abandoned with either bentonite mud or grouted. Both the mud and the grout are an effective seal against fluid interchange between the various aquifer units penetrated by the drilling. Additional well bore sealing is provided by the rapid swelling and bridging of the isolating shales between the sandstone units.

However, to ensure there is no communication between aquifers, monitor wells completed in the aquifers above and below the ore zone will be checked routinely for changes in aquifer pressure and water composition. In addition, pump tests will be conducted prior to mine unit start-up to demonstrate that no significant communication between the aquifers exists. Should leakage between aquifers through old drill holes be indicated during the tests, the old holes would be re-entered and plugged. If contamination of another aquifer was indicated, wells would be drilled and completed in the contaminated aquifer, sampled, and if needed, produced to reduce the concentration of any leach solution fluids to acceptable levels.

7.4.6 Excursions

One of the primary concerns in ISR operations, both for efficient mining and protection of the environment, is preventing excursions and, should one occur, mitigating its impact. The systems employed to achieve this objective include: regular recording and evaluation of injection and production rates and pressures, so each mine unit remains 'balanced' and the appropriate bleed rate is maintained (**Section 3.2.7**); and measuring water levels and sampling for specific parameters on a regular basis in the monitor wells, which are installed at specific locations and depths for excursion detection (**Section 3.2.2**). The excursion parameters, or Upper Control Limits (UCLs), are specific to each mine unit to be indicative of migration of lixiviant, and it is anticipated that these parameters will be chloride, conductivity, and total alkalinity. The monitoring program is described in more detail in **Section 5.7.8**, along with the control measures that will be taken should an excursion occur. Preliminary assessment of the effectiveness of these control measures is provided in **Section 3.2.7.4**, and the excursion monitoring will be tailored for each mine unit in the Hydrologic Test Plan and Report prepared for each mine unit per WDEQ.

7.4.7 Transportation Accidents

Materials transportation to and from the Project will take place in three forms: 1) shipments of yellowcake slurry from the Plant to a toll drying facility; 2) shipments of process chemicals from suppliers to the Plant; and 3) shipments of waste material to be disposed of off-site. To minimize transportation accidents, LC ISR, LLC will implement necessary prevention and response measures, such as regular road maintenance, driver safety training, using proper containers and establishing the chain of command for emergency response.

7.4.7.1 Yellowcake Slurry Shipments

The Project will regularly truck yellowcake slurry shipments (approximately 70 per year at full capacity) to licensed facilities for drying and packaging. When yellowcake slurry is transported, it is carried in specifically designed tanker trucks that are top load/unload and have a supporting superstructure. Such tanker trucks will withstand the impact of most collisions.

In the most severe conditions, an accident would result in a rupture of the tank and the release of only a portion of the slurry. During this accident, the slurry would pour onto the ground and thicken as water in the slurry soaked into the ground. The viscosity of the yellowcake slurry will reduce the chance that a spill would travel sufficient distance during a spill to enter a waterway before being contained by emergency personnel. In the unlikely event of such an accident, all yellowcake and contaminated soils would be removed and processed through a mill or disposed of at an NRC-licensed facility. All disturbed areas would then be reclaimed in accordance with all applicable state and NRC regulations.

The risk of an accident involving a yellowcake spill will be kept to a minimum by use of US DOT approved containers and exclusive-use shipments. To further reduce the environmental impact should an accident occur, personnel from LC ISR, LLC will be trained in response and cleanup and will be the primary responders in charge of cleanup of contaminated materials at the accident site.

A recent analysis of the transportation risk for trucks carrying dried yellowcake estimated that the 50-year dose commitments to the general public would be 0.14 to 2.0 man-Sievert (man-Sv), depending on the fraction of the yellowcake that was released (NRC, 1997). Exposures would likely be much lower in the worst-case Lost Creek scenario since: 1) little or no airborne release would occur due to the slurry form of the yellowcake; 2) the analysis considered the population densities in the eastern United States, which are generally much higher than Wyoming and the western US; 3) the modeled release time was 24 hours and an actual slurry spill would be contained much more quickly; and 4) the mathematical model was conservative by nearly a factor of six (DOE, 1994).

7.4.7.2 Shipment of Chemicals

The Project will receive shipments of chemicals to the Plant for the ISR operations. Examples of these are: carbon dioxide, oxygen, diesel fuel, gasoline, salt, soda ash, sulfuric acid, hydrogen peroxide and drilling mud. Local environmental impacts could occur if a truck delivering process chemicals or analytical reagents were involved in an accident. The environmental impacts would depend on the severity of the accident, the magnitude of the release, and the unique properties of the chemical. The potential for a shipping accident depends on the frequency of deliveries and the accident rates described in **Section 3.2** of the ER.

Any spills would be removed and the area would be cleaned and reclaimed. Shipments of the chemicals used in solution recovery in truck load quantities are common to many industries and present no abnormal risk. Since most of the material would be recovered or could be removed, no significant long-term environmental impact would result from a shipping accident involving these materials.

7.4.7.3 Shipments of Material for Off-site Disposal

Disposal of all 11(e)(2) byproduct waste generated by the Project will occur at an off-site, NRC-licensed disposal facility. Most shipping will occur at the end of the Project, during facility decommissioning. LC ISR, LLC is in the process of seeking access to an NRC licensed disposal facility.

All of the 11(e)(2) byproduct wastes are solid/semisolid wastes and would be easily recollected and contained in a case of an overturning accident. Cleanup and reclamation (if needed) would be conducted according to all applicable regulations and no long-term impact would be generated.

7.4.8 Other Accidents

7.4.8.1 Fires and Explosions

The fire and explosion hazard in the Permit Area will be minimal, as the Plant will not use flammable liquids in the gathering and processing of uranium into yellowcake slurry. Natural gas used for building heat or accumulation of gaseous oxygen will be the primary source for a potential fire or explosion. The products from the processing circuits will not be in a dry form; thus, the likelihood of radioactive material dispersion will be minimized in an explosion or a fire. The majority of the process tanks are not under pressure. Pressure vessels, such as those used for ion exchange and elution, will contain no flammable component, but rather ion exchange resin and lixiviant. All of the pressure vessels will have pressure relief valves installed. All of the buildings will be adequately ventilated to minimize radon exposure, which also reduces the opportunity for buildup of explosive gases in the Plant.

7.4.8.2 Tornadoes

The Project is located in Sweetwater County, Wyoming. From 1950 through 2004, 19 tornadoes have been recorded to touch down within Sweetwater County. All of these were classified as either F0, with wind speeds of 40 to 72 mph and described as gale tornadoes, or F1, with wind speeds of 73 to 112 mph and described as moderate tornadoes (Wyoming Climate Atlas – University of Wyoming, 2007). The F scales for the tornadoes is based on the Fujita Scale that is commonly used to measure the relative strength of a tornado based on the destruction.

The probability of occurrence of a tornado in the Permit Area is about one in 100,000 years to one in 1,000,000 years (Curtis and Grimes, 2007). The Permit Area is categorized as region three in relative tornado intensity. For this category, the wind speed of the "design" tornado is 240 mph, of which 190 mph is rotational and 50 mph is translational. None of the plant structures are designed to withstand a tornado of this intensity.

The nature of the operation is such that little more could be done to secure the Permit Area with advance warning than without it. The yellowcake product has the highest specific activity of any material processed at the Permit Area; however, since the material would be wet slurry, the potential environmental effects would be relatively low.

7.4.9 Power Outage

For a facility wide power outage, the only processes that would typically remain operational are the emergency and critical systems in the Plant, which are listed below. All other processes, including those related to the mine units, storage ponds, and disposal wells, would normally remain down until power is restored. Shutting down the majority of the operation until full power is restored will stop flows and reduce the chance of an undetected leak.

The emergency or critical systems in the plant that would typically remain operational are:

- General heating, ventilation, air conditioning, and lighting in the Plant and Office;
- Plant Operator's computer;
- All ventilation systems;
- Tank agitators;
- Instrumentation;
- Any safety systems (i.e. safety showers, eyewash stations, etc); and
- Any installed security systems.

7.4.10 Overflow of Sumps or Berms

As described in **Section 4.2.5.5**, no liquids will be stored in the header houses, and the sumps in the header houses will be equipped with fluid detection sensors wired to automatic alarms and shutoffs in the event of a pipeline or pump failure. Also, as outlined above, the Plant will be equipped with concrete containment curbing and sumps to contain any releases within the Plant. The response to a failure of alarm/notification systems, resulting in failure of a sump or berm to contain all of a release within the fenced areas around the mine units or Plant, and the potential dose to workers and members of the public are described in **Section 5.7.6.6.**

7.5 Design of Chemical Processes

7.5.1 Design Criteria

The engineering design of all chemical process systems will consider, at a minimum, the issues listed below. The designing engineer will attempt to control hazards primarily through the implementation of engineering design and secondarily through administrative controls.

- Chemical Compatibility
  - Galvanic Corrosion
  - Microbial
  - Oxidation
  - Other Chemical Considerations such as Acid/Base and Oxidizer/Reductant
- Vibration
- Shock (Impact and Water Hammer)
- Normal Effects of Aging
- Wear of Moving Parts
- Structural Strength of Component(s) and Foundation (Mechanical Overload, Chemical Corrosion, Washout from Pipeline Breaks)
- Rupture Strength
- Thermal Shock
- Exposure to Elements
  - Sunlight
  - Cold
  - Heat
  - Wind Loading

- Fatigue
- Likely Human Errors (For example, if a valve can be mispositioned)
- Failure of pumps and valves
- Maintenance Issues

All of the above issues will be considered for: routine operations; cumulative impacts such as shock combined with cold temperatures; and in conjunction with credible risk scenarios such as a fire or failure of a safety or alarm system.

Prior to system commissioning, the designing engineer will inspect the system to insure it was constructed pursuant to the approved design. Any deviations from the approved design will be reviewed by the engineer to ensure they comply with all process and safety requirements.

7.5.2 Mitigation of Spills

7.5.2.1 Berms

All hazardous chemical tanks containing non-cryogenic liquids will be within secondary containment consisting of either a dual containment tank or a berm. Dual containment tanks and berms must be designed to be chemically compatible with the chemical they contain. Multiple chemical tanks may be within a common secondary confinement but only if they are compatible with each other. For example, bases will not be stored with acids, and oxidizers will not be stored with reductants. When multiple tanks are stored within common secondary containment, the secondary containment must be capable of holding a minimum of 110% of the largest vessel. In cases where multiple tanks are connected through common manifolds, the secondary containment must be able to hold the maximum volume that could be released as the result of a credible scenario accident.

7.5.2.2 Sumps

Sumps will be designed to safely collect and transfer the liquid hazardous chemicals that may be spilled within their collection area. The pumping and piping systems within and associated with the sump will be designed to be compatible with all bulk chemicals used within its collection area. Sumps will transfer liquids to a tank or holding pond that is compatible with all chemicals that may be in or transferred to them.

7.5.2.3 Alarms and Detectors

Sumps will be fitted with high level alarms so operators are notified when the sump pump cannot keep up with the fluids it is receiving. Likewise, all chemical tanks will be fitted with high level alarms, pressure alarms or gauges, as appropriate, to warn the operator when the tank has reached its safe capacity. When a non-alarming gauge is used, it will be placed in a location visible to the operator and the upper limit will be clearly posted.

Chemical detectors (portable and/or fixed) will be maintained to measure all types of hazardous volatile chemicals at the site including, but not limited, to an oxygen detector. All employees potentially exposed to volatile hazardous chemicals will be trained in the proper use of the detectors.

7.6 Assessment and Mitigation of Accidents Involving Chemicals

7.6.1 Hydrochloric Acid

7.6.1.1 Hazards of Hydrochloric Acid

Liquid hydrochloric acid (37% HCl) will be delivered in bulk quantities as a liquid and will be stored as a liquid. HCl will be used at the facility to decarbonate the uranyl carbonate during the precipitation process. The acid will be stored in two outdoor 10,151-gallon fiberglass tanks just southeast of the Plant building. The tanks will be either within dual containment tanks or within a bermed area meeting the requirements in **Section 7.5.2**. Hydrochloric acid is also known as hydrogen chloride and muriatic acid. The hydrochloric acid will retain its hazardous properties up until the point it is diluted in the precipitation cell.

Hydrochloric acid, a strong fuming acid, is considered a hazardous chemical due to the significant hazards it presents when inhaled and contacted. HCl has an NFPA hazard ranking of Health - 3, Flammability - 0, Reactivity – 2, and Other - Acid.

Inhalation – Hydrochloric acid has a significant vapor pressure of 166.991 mm of Hg at 21.1 degrees Celsius and exposure to the vapor is potentially hazardous. The NIOSH

Immediately Dangerous to Life and Health Limit (IDLH) is only 75 ppm. The OSHA permissible exposure limit is 5 ppm. Upon mixing hydrochloric acid with common oxidizing chemicals, such as sodium hypochlorite (bleach, NaClO) or potassium permanganate ($KMnO_4$), toxic chlorine gas is produced. Hydrochloric acid is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin. Inhalation may result in spasms, inflammation and edema of the larynx and bronchi, chemical pneumonitis, and pulmonary edema. Symptoms of exposure may include burning sensation.

Direct Contact – Hydrochloric acid has an appearance very similar to water which can result in inadvertent contact with spills. Hydrochloric acid is a very strong acid and can quickly cause damage when in contact with skin or the eyes.

Ingestion - Swallowing hydrochloric acid solutions is particularly dangerous because it is a very strong acid. Even small oral doses of 37% acid may cause significant damage to the mouth, throat, and stomach (abdominal pain, vomiting and diarrhea).

Explosion – Hydrochloric acid is a stable chemical and does not disassociate unless exposed to extreme heat. Even then the evolution of gas is not catastrophic enough to result in an explosion.

7.6.1.2 Accident Scenarios and Mitigation for Hydrochloric Acid

Credible accident scenarios involving HCl and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - LC ISR LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers. An eye wash station and wash down water will be available;
  - The HCl tank, secondary containment and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - An LC ISR, LLC employee will ensure the delivery driver is safely setup before the downloading process begins and will ensure the tank has sufficient capacity to accept the load. If the tank has insufficient capacity to hold the

entire contents of the load, the level gauge will be monitored to prevent overfilling;

- All delivery drivers and employees who may be exposed to HCl will wear appropriate PPE including but not limited to chemical resistant boots, face shield, chemical resistant suit, and chemical resistant gloves;
- All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving spills of HCl;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

• Rupture of Outdoor Tank due to Physical Impact (impact by mobile equipment)

Mitigations

- Bollards or a concrete berm will be placed around the HCL storage vessels to eliminate the potential for impact by a vehicle. The berm or bollards will be inspected daily to ensure they remain in good condition;
- A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
- LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
- All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving spills of HCl;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
- A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project; and
- Chemicals capable of neutralizing any spilled acid will be maintained on site.

• Rupture of Buried Pipeline between Storage Tanks and Plant due to Excavation or Frost Shift

Mitigations

- When buried, all hazardous chemical lines will be sufficiently deep to get below the frost line (minimum of four feet);
- The location of all buried hazardous chemical lines will be accurately surveyed and placed on all maps used to determine safe locations to dig; and

- A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

- Rupture of Exposed Pipeline (indoor and outdoor) due to Physical Impact

  Mitigations
  - All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area, the engineer will select impact resistant piping or provide shielding;
  - All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving spills of HCl;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

- Exposure to Employee while Breaking into a Line for Maintenance

  Mitigations
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - Pipelines conveying hazardous chemicals will be identified through labeling or color coding; and
  - All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving spills of HCl.

- Exposure to fumes during offloading and decarbonation during the precipitation process

  Mitigations
  - An acid fume scrubber will be installed with the HCl storage vessels. The primary purpose of the scrubber is to remove acid fumes during offloading when there is considerable turbulence and pressurized air moving through the vessels. Secondarily, the scrubber will remove acid fumes during storage;
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving spills of HCl;
  - The scrubber system will be inspected daily with the results of the inspection documented. This will ensure that the system is maintained in good working order; and
  - An interlock will be programmed into the precipitation process so acid cannot be added to the vessel unless the tank contains enough fluid to submerge the agitator and the agitator is in operation.

- Rupture of outdoor tank or outdoor piping due to a range fire

  Mitigation:
  - All vegetation will be removed within 15 feet of the tanks and piping;
  - The tank will be designed to relieve pressure in the event the acid decomposes due to heat; and
  - All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and emergency response involving fires and spills of HCl.

The implementation of these mitigations and the design criteria listed above, make the likelihood and consequence of such an accident acceptable.

7.6.2 Hydrogen Peroxide

7.6.2.1 Hazards of Hydrogen Peroxide

Hydrogen peroxide (50% H_2O_2, also known as peroxide) will be delivered to the facility in bulk quantities as a liquid and will be used to change the oxidation state of uranium compounds in the precipitation cell which will in turn cause precipitation of uranyl peroxide. Hydrogen peroxide will be stored in a 8,300-gallon aluminum tank in the indoor chemical storage area of the plant. Hydrogen peroxide is considered a hazardous chemical because it is a strong oxidizer, a weak acid and can rapidly evolve oxygen during exothermic decomposition due to heat or chemical reactions. Hydrogen peroxide maintains its hazardous properties until it is added to the precipitation cell.

Hydrogen peroxide has an NFPA hazard ranking of Health - 3, Flammability - 0, Reactivity – 1, and Other – oxidizer.

Hydrogen peroxide, either in 50% or diluted form, can pose several risks:

Inhalation - Hydrogen peroxide has a vapor pressure of 1.2 kPa at 50 °C and exposure to the vapor is potentially hazardous. Hydrogen peroxide vapor is a primary irritant, primarily affecting the eyes and respiratory system and the NIOSH Immediately Dangerous to Life and Health Limit (IDLH) is only 75 ppm. Long term exposure to low concentrations is also hazardous and can result in permanent lung damage. The OSHA permissible exposure limit of 1.0 ppm is calculated as an eight-hour time-weighted average (29 CFR 1910.1000, Table Z-1).

Vapors of peroxide have been known to cause sensitive contact explosions with strong reductants such as grease and oil. Above roughly 70% concentrations, hydrogen peroxide can give off vapor that can detonate above 70 °C (158 °F) at normal atmospheric pressure. Due to this hazard, LC ISR, LLC will not use concentrations of peroxide exceeding 50%.

Direct Contact – When hydrogen peroxide (50%) is spilled on organic material such as leather boots or cotton clothing, the water will evaporate until the concentration reaches a sufficient strength to spontaneously ignite. Spills of peroxide, which look very much like water, can unwittingly be contacted by employees and result in chemical burns to skin or ignition of clothing. Hydrogen peroxide (50%) is corrosive and causes significant irritation to the eyes, mucous membranes and skin. Upon contact with skin the peroxide causes a capillary embolism which manifests itself as painful whitening of the skin.

Ingestion - Swallowing hydrogen peroxide solutions is particularly dangerous, as decomposition in the stomach releases large quantities of gas (10 times the volume of a 3% solution) leading to internal bleeding. Even small oral doses of hydrogen peroxide (50%) may cause significant damage to the mouth, throat, and stomach (abdominal pain, vomiting and diarrhea).

Explosion – Hydrogen peroxide (50%) is unstable and decomposes exothermically to oxygen and water when exposed to transition metal catalysts, light, heat, or reductants. The evolution of oxygen can be violent (explosive) under the wrong conditions such as the addition of a strong reductant. The evolution of oxygen is not a direct chemical hazard but oxygen does significantly speed up combustion. Therefore, if the heat from a fire is causing accelerated decomposition, the resulting oxygen gas can intensify the fire.

7.6.2.2 Accident Scenarios and Mitigation for Hydrogen Peroxide

Credible accident scenarios involving H_2O_2 and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers. An eye wash station and wash down water will be available;
  - The H_2O_2 tank, secondary containment and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - An LC ISR, LLC employee will ensure the delivery driver is safely setup before the downloading process begins and will ensure the tank has sufficient capacity to accept the load. If the tank has insufficient capacity to hold the entire contents of the load, the level gauge will be monitored to prevent overfilling;
  - All delivery drivers and employees who may be exposed to H_2O_2 will wear appropriate PPE including but not limited to chemical resistant boots, face shield, chemical resistant suit, and chemical resistant gloves;
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2.

- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

- Rupture of Indoor Storage Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - The H_2O_2 storage vessels will be positioned in a manner to minimize the potential for impact by a vehicle;
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

- Rupture of Exposed Pipeline (indoor) due to Physical Impact

  Mitigations:
  - All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area the engineer will select impact resistant piping or provide shielding;
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project.

- Exposure to Employee while Breaking into a Line for Maintenance

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
  - A chemical detector capable of accurately measuring the Immediately Dangerous to Life and Health level and Permissible Exposure Level will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - Pipelines conveying hazardous chemicals will be identified through labeling or color coding; and
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2.

- Rupture of Valve, Tank, or Line due to Decomposition of H_2O_2

  Mitigations:
  - Valves used on H_2O_2 systems will be designed for the chemical (proper seals and drilled ball valves);
  - Valves on H_2O_2 lines will be labeled to warn users about the danger of trapping H_2O_2 between valves;
  - The storage tank will be sufficiently vented to allow the release of decomposition gases in the event the peroxide becomes unstable. The vent will be screened to prevent the introduction of contaminants into the vessel; and
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2.

- Rupture of Indoor Tank or Piping due to Fire

  Mitigation:
  - The chemical storage area will be constructed of fire resistant material. Additionally, a fire suppression system will be installed to prevent the spread of fires; and

- All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2 and fires.

- Explosion or Fire resulting from Contact with Strong Reductant

  Mitigation:
  - All potentially affected employees will be trained regarding the hazards of H_2O_2, how those hazards will be mitigated, and emergency response involving spills of H_2O_2. This training will specifically address the hazards of mixing peroxide and strong reductants such as grease or oil; and
  - Individuals constructing peroxide pipelines will be trained in proper materials to use and how the materials must be prepared (pickling and use of non-petroleum based pipe dopes).

The implementation of these mitigations and the design criteria listed above, make the likelihood and consequence of the listed credible accidents acceptable.

7.6.3 Soda Ash

7.6.3.1 Hazards of Soda Ash

Soda ash (Na_2CO_3) will be delivered to the facility in bulk quantities as a dry powder. It will be stored in a water solution. Soda ash solution will be used for two primary processes: injection into the mine unit to serve as a complexing agent that places oxidized uranium mineralization into solution; and elution of resin in the elution vessel. The facility will have up to two options for the storage of soda ash. First, a soda ash solution will be stored in a heated 16,900-gallon fiberglass tank in the indoor chemical storage area of the plant. Second, dry soda ash may be stored in a bin.

Soda ash has an NFPA hazard ranking of Health - 1, Flammability - 0, Reactivity – 1, and Other – None.

Inhalation - While soda ash does not present a hazard as a vapor, it does present a minor hazard as a dust irritant. Inhalation of dust may cause irritation to the respiratory tract. Symptoms from excessive inhalation of dust may include coughing and difficult breathing. Excessive contact is known to cause damage to the nasal septum.

Direct Contact – Contact with dry or solutions of soda ash can be very irritating to the skin due to the very high pH. Contact may be corrosive to eyes and cause conjuctival edema and corneal destruction. Risk of serious injury increases if eyes are kept tightly closed. Other symptoms may appear from absorption of sodium carbonate into the bloodstream via the eyes.

Ingestion - Sodium carbonate is only slightly toxic, but large doses may be corrosive to the gastro-intestinal tract where symptoms may include severe abdominal pain, vomiting, diarrhea, collapse and death.

Explosion – Sodium carbonate is non-combustible and does not present an explosion risk. However, sodium carbonate can generate large quantities of carbon dioxide when in contact with acids.

7.6.3.2 Accident Scenarios and Mitigation for Sodium Carbonate

Credible accident scenarios involving Na_2CO_3 and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - The soda ash tank and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - An LC ISR, LLC employee will ensure the delivery driver is safely setup before the downloading process begins and will ensure the tank has sufficient capacity to accept the load. If the tank has insufficient capacity to hold the entire contents of the load, the level gauge will be monitored to prevent overfilling;
  - An eye wash station and wash down water will be available;
  - All delivery drivers and employees who may be exposed to soda ash dust will wear appropriate PPE including but not limited to gloves and an appropriate respirator;
  - All potentially affected employees will be trained regarding the hazards of soda ash, how those hazards will be mitigated, and emergency response involving spills of soda ash; and
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

- Rupture of Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - All potentially affected employees will be trained regarding the hazards of Na_2CO_3, how those hazards will be mitigated, and response to spills of Na_2CO_3; and
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

- Rupture of Exposed Pipeline (indoor) due to Physical Impact

  Mitigations:
  - All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area the engineer will select impact resistant piping or provide shielding;
  - All potentially affected employees will be trained regarding the hazards of Na_2CO_3, how those hazards will be mitigated, and emergency response involving spills of Na_2CO_3;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;

- Exposure to Employee while Breaking into a Line for Maintenance (soda ash will be in a water solution during storage and processing).

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - All potentially affected employees will be trained regarding the hazards of Na_2CO_3, how those hazards will be mitigated, and emergency response involving spills of Na_2CO_3.

- Exposure to Dust during Offloading

  Mitigations:
  - A bag house will be installed with the Na_2CO_3 storage vessels. The primary purpose of the bag house is to capture dust during offloading when there is considerable turbulence and pressurized air moving through the vessels;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - All potentially affected employees will be trained regarding the hazards of Na_2CO_3, how those hazards will be mitigated, and responses to spills of Na_2CO_3; and
  - The bag house system will be function checked at least weekly. This will ensure that the system is maintained in good working order.

- Rupture of Indoor Tank or Piping due to Fire

  Mitigation:
  - The chemical storage area will be constructed of fire resistant material. Additionally, a fire suppression system will be installed to prevent the spread of fires; and
  - All potentially affected employees will be trained regarding the hazards of Na_2CO_3, how those hazards will be mitigated, and emergency response involving spills of Na_2CO_3 and fires.

The implementation of these mitigations and the design criteria listed above, as well as the minimal hazards presented by soda ash, make the likelihood and consequence of the considered accidents acceptable.

7.6.4 Oxygen

7.6.4.1 Hazards of Oxygen

Oxygen (O_2) will be delivered to the facility in bulk quantities as a cryogenic liquid and will also be stored as a cryogenic liquid in a steel pressure vessel near the mine unit(s) in which it is being used. The oxygen vessel will likely be rented from a supplier so the exact size is not known at this time. Oxygen will be injected into the mine unit to oxidize uranium mineralization.

Oxygen has an NFPA hazard ranking of Health - 3, Flammability - 0, Reactivity – 0, and Other – Oxidizer.

Inhalation – Oxygen is toxic when inhaled at high partial pressures. These types of scenarios are generally associated with scuba diving or self contained breathing apparatus. Such scenarios are not expected at the Lost Creek Project.

Direct Contact – Direct contact with cryogenic liquid oxygen will cause immediate freezing of the contacted skin. Direct contact with warmed gaseous oxygen does not present a contact hazard.

Ingestion – Swallowing of liquid oxygen is nearly impossible as the oxygen will cause immediate painful frostbite to the mouth.

Explosion – Oxygen can significantly speed the combustion process since it is a strong oxidizer. However, oxygen is not fuel in the oxidizing reaction. Oxygen is neither flammable nor combustible but can speed up other reactions to the point that they are explosive. Even steel will burn in an enriched oxygen atmosphere when a source of ignition is added. Oxygen can instantly and violently react with strong reductants such as oil or grease.

Warming of cryogenic liquid to a gaseous state does result in considerable expansion which results in pressure that can exceed tank capacity.

7.6.4.2 Accident Scenarios and Mitigation for Oxygen

Credible accident scenarios involving O_2 and mitigations to prevent or minimize the accident include the following:

- Spill during offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
  - The O_2 tank and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - The tank will be fitted with a level gauge that is visible to the delivery driver;
  - All delivery drivers and employees who may be exposed to O_2 will wear appropriate PPE including but not limited to boots, face shield, chemical suit, and thermal gloves;

- All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project.

- Rupture of Outdoor Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - Bollards will be placed around the O_2 storage vessels to eliminate the potential for impact by a vehicle. The bollards will be inspected daily to ensure they remain in good condition;
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
  - All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project.

- Rupture of Buried Pipeline between Storage Tank and Mine Unit due to Excavation or Frost Shift

  Mitigations:
  - When buried, all hazardous chemical lines will be sufficiently deep to get below the frost line (minimum of four feet);
  - The location of all buried hazardous chemical lines will be accurately surveyed and placed on all maps used to determine safe locations to dig. Locations of buried hazardous chemical lines will also be marked in the field;
  - A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project;
  - Emergency shut off valves, clearly labeled, will be located at the oxygen tank;

- All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project. Oxygen level readings will be collected before an employee enters a confined space such as a bell housing. Employees shall not enter a confined space that is enriched or deficient in oxygen.

• Rupture of Exposed Pipeline (indoor and outdoor) due to Physical Impact or Corrosion

Mitigations:
- All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area the engineer will select impact resistant piping or provide shielding. In the case of oxygen pipelines, the line will be composed of rugged carbon steel which is capable of withstanding a significant impact without failing. Carbon steel is also chemically compatible with oxygen;
- All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
- A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project; and
- Header houses will have a fan running at all times to prevent the buildup of radon and oxygen in the event of small leaks. Large oxygen leaks will not be sufficiently evacuated by the header house fans. However, since the oxygen is under considerable pressure, leaks are extremely loud and employees will be trained to not enter a header house if they hear an oxygen leak.

• Exposure to Employee while Breaking into a Line for Maintenance

Mitigations:
- A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety

Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
- A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
- Pipelines conveying hazardous chemicals will be identified through labeling or color coding;
- Oxygen lines will be purged with an inert gas before performing any hot work on the line; and
- All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2.

- Tank or Pipeline Rupture due to Improper Thermal Management

  Mitigations
  - A pressure vessel certified for storage of cryogenic oxygen will be used. The vessel will be fitted with required safety release valves or rupture discs capable of safely relieving pressure;
  - The evaporation and compressor system will be inspected on a daily basis with the inspection documented;
  - A chemical detector capable of accurately measuring oxygen enrichment will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2; and
  - All potentially affected employees will be trained about the hazards of trapping a cryogenic liquid within a vessel, pipeline, or valve.

- Rupture of Outdoor Tank or Outdoor Piping due to Range Fire

  Mitigation:
  - All vegetation will be removed within 15 feet of the tanks and piping; and
  - All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving fires and spills of O_2.

- Explosive Reaction due to Contact with a Strong Reductant

  Mitigation:
  - All potentially affected employees will be trained regarding the hazards of O_2, how those hazards will be mitigated, and emergency response involving spills of O_2. This training will specifically address the hazards of mixing oxygen and strong reductants such as grease or oil; and
  - Individuals constructing oxygen pipeline will be trained in proper methods for pickling pipelines for welding without the use of solvents and proper cleaning of oxygen pipelines.

The implementation of these mitigations and the design criteria listed above, make the likelihood and consequence of the evaluated accidents acceptable.

7.6.5 Carbon Dioxide

7.6.5.1 Hazards of Carbon Dioxide

Carbon dioxide (CO2) will be delivered to the facility in bulk quantities as a cryogenic liquid and will also be stored as a cryogenic liquid. Carbon dioxide will be mixed with the soda ash solution to control pH and thus convert the soda ash to sodium bicarbonate. Carbon dioxide may also be injected directly into the injection circuit without pre-mixing with soda ash. Carbon dioxide will be stored in a steel pressure vessel southeast of the Plant building. The size of the carbon dioxide vessel will depend on facility requirements which have not been finalized.

Carbon dioxide has an NFPA hazard ranking of Health - 1, Flammability - 0, Reactivity – 0, and Other – None

Inhalation – Carbon dioxide does not present a toxic hazard when inhaled. Rather, carbon dioxide is a simple asphyxiant that displaces oxygen which in turn leads to suffocation.

Direct Contact – Direct contact with cryogenic liquid carbon dioxide will cause immediate freezing of the contacted skin. Direct contact with warmed gaseous carbon dioxide does not present a contact hazard.

Ingestion - Swallowing of liquid carbon dioxide is nearly impossible as the it will cause immediate painful frostbite to the mouth.

Explosion – Carbon dioxide is chemically very stable and does not present a chemical explosion hazard. Warming of cryogenic liquid to a gaseous state does result in considerable expansion which can generate considerable pressure.

7.6.5.2 Accident Scenarios and Mitigation for Carbon Dioxide

Credible accident scenarios involving CO_2 and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
  - The CO_2 tank and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - The tank will be fitted with a level gauge that is visible to the delivery driver. Also, an LC ISR, LLC employee will ensure the delivery driver is safely setup before the downloading process begins;
  - All delivery drivers and employees who may be exposed to CO_2 will wear appropriate PPE including but not limited to boots, face shield, cryogenic suit, and thermal gloves;
  - All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving spills of CO_2;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
  - A chemical detector capable of accurately measuring oxygen deficiency will be maintained at the Project.

- Rupture of outdoor Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - Bollards will be placed around the CO_2 storage vessel to eliminate the potential for impact by a vehicle. The bollards will be inspected daily to ensure they remain in good condition;
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;

- LC ISR LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
- All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving spills of CO_2;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring oxygen deficiency will be maintained at the Project.

• Rupture of Buried Pipeline between Storage Tank and Plant due to Excavation or Frost Shift

Mitigations:
- When buried, all hazardous chemical lines will be sufficiently deep to get below the frost line; minimum of four feet;
- The location of all buried hazardous chemical lines will be accurately surveyed and placed on all maps used to determine safe locations to dig; and
- A chemical detector capable of accurately measuring oxygen deficiency will be maintained at the Project.

• Rupture of Exposed Pipeline (indoor and outdoor) due to Physical Impact

Mitigations:
- All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area the engineer will select impact resistant piping or provide shielding. CO_2 pipelines are generally constructed out of steel which is highly impact resistant and is chemically compatible with the gas;
- All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving spills of CO_2;
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and
- A chemical detector capable of accurately measuring oxygen deficiency will be maintained at the Project.

- Exposure to Employee while Breaking into a Line for Maintenance

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
  - A chemical detector capable of accurately measuring oxygen deficiency will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - Pipelines conveying hazardous chemicals will be identified through labeling or color coding; and
  - All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving spills of CO_2.

- Tank or Pipeline Rupture due to Improper Thermal Management.

  Mitigations
  - A pressure vessel certified for storage of cryogenic CO_2 will be used. The vessel will be fitted with required safety release valves or rupture discs capable of safely relieving pressure;
  - The evaporation and compressor system will be inspected on a daily basis with the inspection documented;
  - A chemical detector capable of accurately measuring CO_2 deficiency will be maintained at the Project;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving spills of CO_2; and
  - All potentially affected employees will be trained about the hazards of trapping a cryogenic liquid within a vessel, pipeline, or valve.

- Rupture of Outdoor Tank or Outdoor Piping due to a Range Fire

  Mitigation:
  - All vegetation will be removed within 15 feet of the tanks and piping; and

- All potentially affected employees will be trained regarding the hazards of CO_2, how those hazards will be mitigated, and emergency response involving fires and spills of CO_2.

The implementation of these mitigations and the design criteria listed above, make the likelihood and consequence of the evaluated accidents acceptable.

7.6.6 Caustic Soda

7.6.6.1 Hazards of Caustic Soda

Caustic soda (50% NaOH – sodium hydroxide or lye) will be delivered to the facility in bulk quantities as a liquid. Caustic soda is used to control the pH of the precipitation process during the addition of hydrogen peroxide. Controlling the pH allows for optimum growth of uranyl peroxide crystals while excluding trace elements such as vanadium from the crystal structure. The caustic will be stored in a heated 16,900-gallon fiberglass tank in the indoor chemical storage area of the Plant.

Caustic soda has an NFPA hazard ranking of Health - 3, Flammability - 0, Reactivity – 0, and Other – None.

Inhalation – Caustic soda is delivered, stored, and used in a liquid state so inhalation is not a credible concern.

Direct Contact – Caustic is a highly corrosive strong base that will cause significant chemical burns to exposed skin. Contact with eyes can result in blindness if not washed out immediately.

Ingestion – Ingestion of such a caustic chemical is unlikely. However, if ingested, caustic may cause severe and permanent damage to the digestive tract including gastrointestinal tract burns, perforation of the digestive tract, severe pain, nausea, vomiting, diarrhea, and shock.

Explosion – Caustic is a stable chemical and does not present an explosion risk.

7.6.6.2 Accident Scenarios and Mitigation for Caustic Soda

Credible accident scenarios involving NaOH and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - LC ISR, LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
  - The NaOH tank, secondary containment and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - An LC ISR, LLC employee will ensure the delivery driver is safely setup before the downloading process begins and will ensure the tank has sufficient capacity to accept the load. If the tank has insufficient capacity to hold the entire contents of the load, the level gauge will be monitored to prevent overfilling;
  - All delivery drivers and employees who may be exposed to NaOH will wear appropriate PPE including but not limited to chemical resistant boots, face shield, chemical resistant suit, and chemical resistant gloves. An eye wash station and wash down water will be available;
  - All potentially affected employees will be trained regarding the hazards of NaOH, how those hazards will be mitigated, and emergency response involving spills of NaOH.
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented; and

- Rupture of Indoor Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - LC ISR LLC will only hire qualified delivery companies. This means that the delivery company must only use DOT HazMat certified drivers;
  - All potentially affected employees will be trained regarding the hazards of NaOH, how those hazards will be mitigated, and emergency response involving spills of NaOH; and
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

- Rupture of Exposed Pipeline (indoor and outdoor) due to Physical Impact

  Mitigations:
  - All exposed (non-buried) pipelines conveying hazardous chemicals will be located, to the extent possible, in locations that minimize the likelihood of being struck. For example, lines will generally be located overhead out of the work area. In instances where hazardous chemical lines must be located within a work area the engineer will select impact resistant piping or provide shielding;
  - All potentially affected employees will be trained regarding the hazards of NaOH, how those hazards will be mitigated, and emergency response involving spills of NaOH; and
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

- Exposure to Employee while Breaking into a Line for Maintenance

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired. The LOTO procedure will include a requirement that all hazardous chemical lines be drained before breaking into them. In circumstances where the line cannot be drained first, the Safety Department will be consulted before breaking into the line to ensure all appropriate safety measures are taken;
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented;
  - Pipelines conveying hazardous chemicals will be identified through labeling or color coding; and
  - All potentially affected employees will be trained regarding the hazards of NaOH, how those hazards will be mitigated, and emergency response involving spills of NaOH.

- Rupture of Indoor Tank or Piping due to Fire

  Mitigation:
  - The chemical storage area will be constructed of fire resistant material. Additionally, a fire suppression system will be installed to prevent the spread of fires; and
  - All potentially affected employees will be trained regarding the hazards of NaOH, how those hazards will be mitigated, and emergency response involving spills of NaOH and fires.

The implementation of these mitigations and the design criteria listed above, make the likelihood and consequence of the evaluated accidents acceptable.

7.6.7 Salt

7.6.7.1 Hazards of Salt

Sodium chloride (NaCl) will be delivered to the facility in bulk quantities as a granular solid but will be stored in a water solution. Salt will be used to elute the ion exchange resin in the elution vessels. The salt will be stored in a 16,900-gallon fiberglass tank in the indoor chemical storage area of the plant.

Salt has an NFPA hazard ranking of Health - 1, Flammability - 0, Reactivity – 2, and Other – None

Inhalation – Inhalation of large quantities of salt dust is irritating to the lungs and upper respiratory tract.

Direct Contact – May cause skin irritation with prolonged contact.

Ingestion - Ingestion of large quantities can irritate the stomach (as in overuse of salt tablets) with nausea and vomiting. May affect behavior (muscle spasticity/contraction, somnolence), sense organs, metabolism, and cardiovascular system. Continued exposure may produce dehydration, internal organ congestion, and coma.

Explosion – No hazard as salt is very stable.

7.6.7.2 Accident Scenarios and Mitigation for Salt

Credible accident scenarios involving NaCl and mitigations to prevent or minimize the accident include the following:

- Spill during Offloading (leaking connection or fill line, overfill of tank)

  Mitigations:
  - The NaCl tank and fill line will be inspected daily with the results of the inspection documented. This will ensure that systems are maintained in good working order;
  - A Lock Out/Tag Out (LOTO) system will be implemented that will require all unsafe systems be taken out of service until repaired;

- An LC ISR LLC employee will ensure the delivery driver is safely setup before the downloading process begins and will ensure the tank has sufficient capacity to accept the load. If the tank has insufficient capacity to hold the entire contents of the load, the level gauge will be monitored to prevent overfilling;
- All delivery drivers and employees who may be exposed to NaCl will wear appropriate PPE including but not limited to safety glasses and gloves;
- All potentially affected employees will be trained regarding the hazards of NaCl, how those hazards will be mitigated, and response to spills of NaCl; and
- The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

• Rupture of Tank due to Physical Impact (impact by mobile equipment)

  Mitigations:
  - A LOTO system will be implemented that will require all unsafe systems be taken out of service until repaired;
  - All potentially affected employees will be trained regarding the hazards of HCl, how those hazards will be mitigated, and response to spills of salt.
  - The EHS Department will perform inspections each week day to ensure safety measures are being consistently and properly implemented.

• Rupture of Indoor Tank or Piping due to Fire

  Mitigation:
  - The chemical storage area will be constructed of fire resistant material. Additionally, a fire suppression system will be installed to prevent the spread of fires; and
  - All potentially affected employees will be trained regarding the hazards of NaCl, how those hazards will be mitigated, and emergency response involving spills of NaCl and fires.

The implementation of these mitigations and the design criteria listed above, as well as the minimal hazards presented by salt, make the likelihood and consequence of the considered accidents acceptable.

7.7 Training

It is critical for all potentially affected individuals to be familiar with the physical and chemical hazards present in the work place and how to successfully mitigate these hazards. Toward that end, a comprehensive training program will be developed and implemented prior to the initiation of operations. The training program will include, as a minimum, the following items:

- Methods and observations that are in place or may be used to detect the presence or release of a hazardous chemical in the work area;
- The physical and health hazards of the chemicals in the work area;
- The measures employees can take to protect themselves from the hazards, such as in place work practices, emergency procedures (including evacuation and notification of public emergency response personnel), and personal protective equipment to be used;
- Details of the hazard communication program, including the labeling system;
- Material safety data sheets and how employees can obtain and use the appropriate hazard information;
- The distribution of chemicals throughout the processing plant and field in pipes.
- If an employee is instructed to use a hazardous material for which he/she has not been trained, it will be their responsibility to inform their supervisor prior to handling such material, so proper training can be given;
- Physical hazards presented by process tankage, piping, and equipment and how individuals may mitigate these hazards (lockout/tagout, confined space, moving parts, cryogenic fluids, etc.); and
- The potential for upset conditions and how to safely mitigate these conditions.

The EHS Supervisor will ensure that all new individuals who may be exposed to processing hazards receive initial training before exposure. The EHS Supervisor will also ensure that each potentially affected employee and contractor receive annual refresher training. When an employee or contractor is given a new task, the supervisor will assess if additional training is needed and provide any necessary training before the individual is exposed to the hazard. On the job training is only acceptable if an experienced operator is on hand to immediately oversee all activities. All training will be documented by the trainer with records maintained until license termination.

7.8 Economic and Social Effects of Construction and Operation

A summary on the socioeconomic effects of the Project is presented in **Section 7.1.11** of this report. The costs and benefits for the construction and operation of the Project are discussed in **Section 9.0** of this report. Details on the economic and social effects of the Project are presented in **Section 4.10** of the ER.

Attachment 7.2-1

Estimated Radiation Doses from the Lost Creek ISR, LLC Lost Creek In Situ Recovery Facility

March 2008

INTRODUCTION

Lost Creek ISR, LLC (a wholly owned subsidiary of Ur–Energy) is planning to construct and operate an in situ facility for recovery of uranium at a location in central Wyoming (Lost Creek Project). The permit area is 38 miles northwest of Rawlins, Wyoming in the Great Divide Basin. In order to estimate the potential impact to members of the public residing near the facility, radiation doses were modeled using the MILDOS-AREA code. MILDOS-AREA has been approved for this use by the U. S. Nuclear Regulatory Commission.

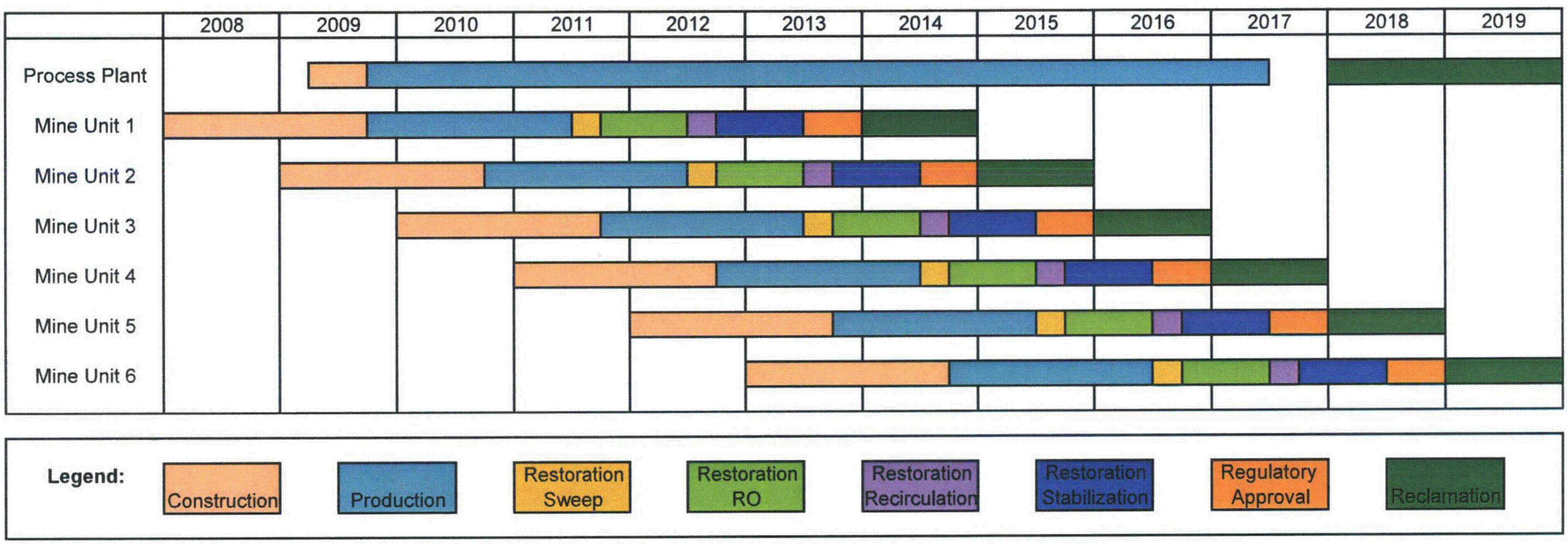
PROJECT DESCRIPTION

The Lost Creek Project will consist of six mine units that will be developed for injection and recovery of uranium leaching solutions over an eight year period. The leaching solution or lixiviant, which consists of groundwater augmented with oxygen and carbon dioxide, is pumped into the underground ore body to mobilize the uranium. Extraction wells remove the lixiviant containing uranium (pregnant solution) from the ore body. The uranium is then extracted from the pregnant solution by passing through ion exchange columns.

Mine units and processes are staged as shown in Figure 1. The plan calls for installation of new wells in Mine Unit 1 (MU-1) to begin in 2009 and be completed in 2010. The underground ore will be lixiviated (termed "Uranium Production" on the figure) beginning approximately eight months following the initiation of new well installation. Production in MU-1 will continue into the first quarter (Q1) of 2011. Restoration of MU-1 will begin in the fourth quarter (Q4) of 2011 and continue for approximately the first half of 2012 (Q1-2). Mine Units 2-6 will follow the same pattern with initiation of each subsequent unit in the year following the previous mine unit installation. Restoration of the planned mine units should be completed by the end of 2017.

The Ion Exchange facility, located at the main plant, will be operational beginning in the fourth quarter (Q4) of 2009 and will continue more or less constantly through the first half of 2016. Lixiviant will be pumped from each active mine unit to the Ion Exchange facility for elution.

Lost Creek Project Development, Production and Restoration Schedule



POTENTIAL RADIOACTIVE EFFLUENTS

Uranium-238 in the ore body ultimately decays to ^{226}Ra and then ^{222}Rn. Uranium (including ^{238}U, ^{234}U, and ^{235}U) and radon are soluble in the leach solution and may be released during operations. Because the facility will not have a dryer, there is no potential for release of radionuclides in airborne particulates. Thus, radon gas is the only potential radioactive effluent. The MILDOS code was used to estimate potential doses to members of the public and workers from radon released during the following operations:

- *New wells:* When drilling new wells into the ore body, drill cuttings, including ore, are transported to the surface in drilling mud. Cuttings are stored in mud pits where ^{222}Rn may be released to the atmosphere.
- *Producing mine units*: Radon dissolved in the lixiviant may be released in two ways, either from purge water or from gas venting at the wellhead.
- *Ion Exchange columns:* Radon gas may be released from the columns as a function of the volume of the columns, the porosity of the resin and the unloading rate of the column.
- *Restoration activities*: During the restoration of the mine units, water is circulated within and discharged from the wells in release rates similar to those from producing mine units.

MILDOS MODELING

The computer code MILDOS-AREA was used to estimate potential radiation doses from planned Lost Creek ISR operations. MILDOS (ANL, 1989) was originally developed to estimate doses from conventional uranium milling operations, including large area releases such as ore storage pads and tailings beaches. Inputs to the dose are limited to uranium decay chain radionuclides. MILDOS was subsequently updated in 1998 to address potential impacts of uranium *in situ* leaching operations. In situ leach specific types of source terms, such as production wells and restoration wells are included in the updated version. Modeling assumptions and parameters are addressed below.

METEOROLOGY

Meteorological conditions greatly influence dispersion of radionuclides from estimated releases during the year. The proposed Lost Creek plant has a meteorological station that records wind speed, wind direction, and stability class simultaneously. However, an entire year of data is not yet available, so data from the Lost Soldier site were used. Lost Soldier is located about 12 miles northeast of the Lost Creek site. Data for the Lost Soldier site for the period April 2006 through April 2007 were converted to the site-specific joint frequency distribution (STAR file) required as input by MILDOS. These calculations were performed using the STARMD program which is based on the Sigma-Theta method in EPA 454/R-99-005 (EPA, 1987). STAR data represent percentages of time for each wind direction (16 compass points) in particular wind speed and stability classes.

As shown in Table 1, winds at the Lost Soldier site come from the west (W), west northwest (WNW) and northwest (NW) nearly 60% of the time.

Table 1. Wind Direction Frequency (April 2006 – April 2007).

Direction from	Frequency
N	0.02022
NNE	0.00981
NE	0.01118
ENE	0.01887
E	0.02035
ESE	0.01815
SE	0.03502
SSE	0.05787
S	0.05513
SSW	0.05364
SW	0.03563
WSW	0.03789
W	0.15696
WNW	0.30398
NW	0.11932
NNW	0.04596
Total	1.00000

EQUATIONS USED TO CREATE RADON RELEASE ESTIMATES

Equations used by MILDOS to estimate releases are those detailed in NUREG-1569, Appendix D. Therefore, releases from a new mine unit are given by the following:

$Rn_{new} = 10^{-12} * E * L * [Ra] * T * M * N$, where

Rn_{new} = ^{222}Rn release rate from new mine unit (Ci/yr),

10^{-12} = Ci/pCi,

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

T = storage time in mudpit (d),

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

N = number of mudpits generate per year.

The radon source term, S in pCi/d, can be expressed as:

$S = 10^6 * E * L * [Ra] * A * D * \rho$, where

$10^6 = cm^3/m^3$,

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

A = active area of ore zone (m^3),

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

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

The water discharge rate from ion exchange column resin unloading, F_i (L/day), is calculated by:

$F_i = N_i * V_i * P_i$, where

N_i = number of ion exchange column unloadings per day

V_i = Volume of ion exchange column (L) and

P_i = porosity of resin material (unitless).

The ^{222}Rn concentration in process water at equilibrium, C_{Rn} (pCi/L), is described by:

$C_{Rn} = (10^6 * [Ra] * A * D * \rho * E * L * f) / [(L + v) * V + F_p + F_i]$, where

$10^6 = cm^3/m^3$,

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

A = active area of ore zone (m^3),

D = average thickness of ore zone (m),

ρ = bulk density of ore material (g/cm^3),

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

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

v = rate of radon venting during circulation (per day),

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

F_i = water discharge rate from ion exchange column resin unloading (L/d).

The rate of ^{222}Rn release from purge water, Rn_w (Ci/y), is given by:

$Rn_w = 3.65E\text{-}10 * C_{Rn} * F_{p,}$, where

3.65E-10 = day-Ci/pCi-yr,

C_{Rn} = concentration of radon in process water (pCi/L), and

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

Likewise, the rate of ^{222}Rn release from venting, Rn_v (Ci/y), is given by:

$Rn_v = 3.65E\text{-}10 * v * C_{Rn} * V_{,}$, where

3.65E-10 = day-Ci/pCi-yr,

v = rate of radon venting during circulation (per day),

C_{Rn} = concentration of radon in process water (pCi/L, and

V= volume of water in circulation (L).

The annual ^{222}Rn discharge from unloading of ion exchange columns, Rn_x, Ci/y, is given by:

$Rn_x = 3.65E\text{-}10 * F_i * C_{Rn}$, where

3.65E-10 = day-Ci/pCi-yr,

F_i = water discharge rate from ion exchange column resin unloading (L/d) and

C_{Rn} = concentration of radon in process water (pCi/L).

INPUT PARAMETERS

Important parameters for various source types are shown in Table 2. Size and mine unit- dependent parameters are given in Table 3. The specific mine unit parameters include location relative to the Central Plant or Ion Exchange Facility.

Table 2 Important input parameters.

All sources	Thickness of ore body	3.7 m
	Density of ore body	1.94 g/cm^3
New Well sources	Number of mud pits/yr	935
	Ore material added to mudpit	2.5E5 g/y
	Duration of storage in mudpit	4 days
	% U_3O_8	0.055%
Production Mine Unit sources	Emanation fraction	0.25
	Fraction of radon in solution	0.80
	Rate of radon venting	0.01/day
	Treated water purge rate	3.3E5 L/d
	% U_3O_8	0.055%
	Volume in circulation	Varies with size of unit
Ion Exchange columns	Column volume	1.41E5 L
	Column unloading rate	0.68/day
	Porosity of resin	0.4
	% U_3O_8	0.055%
Restoration Mine Unit sources	Emanation fraction	0.25
	Volume in circulation	Varies with size of unit
	Operating days	365/yr
	Treated water purge rate	7.63E5 L

Table 3 **Mine unit-specific parameters.**

Mine Unit	**MU-1**	**MU-2**	**MU-3**	**MU-4**	**MU-5**	**MU-6**
X (km)*	0.29	0.96	-0.51	1.02	-1.27	1.90
Y (km)*	-0,80	-0.83	-1.14	-0.55	-1.32	-0.77
Z (m)*	-13.4	-11.3	-10.7	-5.8	-14.9	-4.6
Area of active drilling (m^2)	1.66E5	1.62E5	1.55E5	1.69E5	1.88E5	1.88E5
Volume in circulation (L)	1.52E8	1.48E8	1.42E8	1.54E8	1.72E8	1.72E8
* Relative to plant (0,0,0)						

RECEPTOR LOCATIONS

There are no nearby permanent residents near the facility, so receptors were placed at the property boundary as listed in Table 4.

Table 4 Receptor locations.

Receptor	**X (km)**	**Y (km)**
NB	0.00	0.33
NEB	0.66	0.66
EB1	3.80	0.92
EB2	3.81	0.11
EB3	3.81	-0.69
SEB1	2.26	-0.71
SEB2	2.26	-1.16
SEB3	0.73	-1.18
SB	0	-2.41
ALT 1	0.74	-1.77
ALT 2	0.75	-2.40
SWB1	-0.66	-2.42
SWB2	-0.64	-4.06
SWB3	-2.57	-4.07
SWB4	-2.58	-2.58
WB	-2.61	0
NWB	-0.33	0.33
IX plant	0	0

Locations of the proposed plant and centroids of the various mine units, as well as specific receptor locations are also shown Figure 2.

POPULATION DISTRIBUTION

There are no towns of any size within 30 km of the proposed site. However, towns within 80 km from the proposed Lost Creek Project include Rawlins, Jeffrey City, Wamsutter and Bairoil. Directions, distances and census data are listed in Table 5.

Table 5 Population distribution surrounding the Lost Creek site.

Town	Direction	Distance (km)	Population
Rawlins	SE	75	8500
Jeffrey City	NNE	40	110
Wamsutter	S	50	275
Bairoil	ENE	35	100

SOURCE STRENGTH

The QADJUST factor in MILDOS was used to adjust the timing and fraction of a year that various sources operate in keeping with the pattern shown in Figure 1. The annual rate of release from a specific mine unit was varied depending timing of the release. For example, if a source operated for only ¾ year, QADJUST was set at 0.75 to account for that diminished output on a yearly basis. By varying QADJUST in this way, it was possible to plot the variation in dose as the project progresses.

MODELING ASSUMPTIONS

The proposed plant is situated in the NW ¼ of the SE ¼ of Section 18, Township 25 north, Range 92 west and is the 0,0 point for the MILDOS modeling. An alternate plant location, Plant 2, is situated in the SE ¼ of the NE ¼ of Section 19, Township 25 north, Range 92 west. Hence, Site 2 is located -1.736 km (to the south), 0.478 km (to the east) from the Site 1 location.

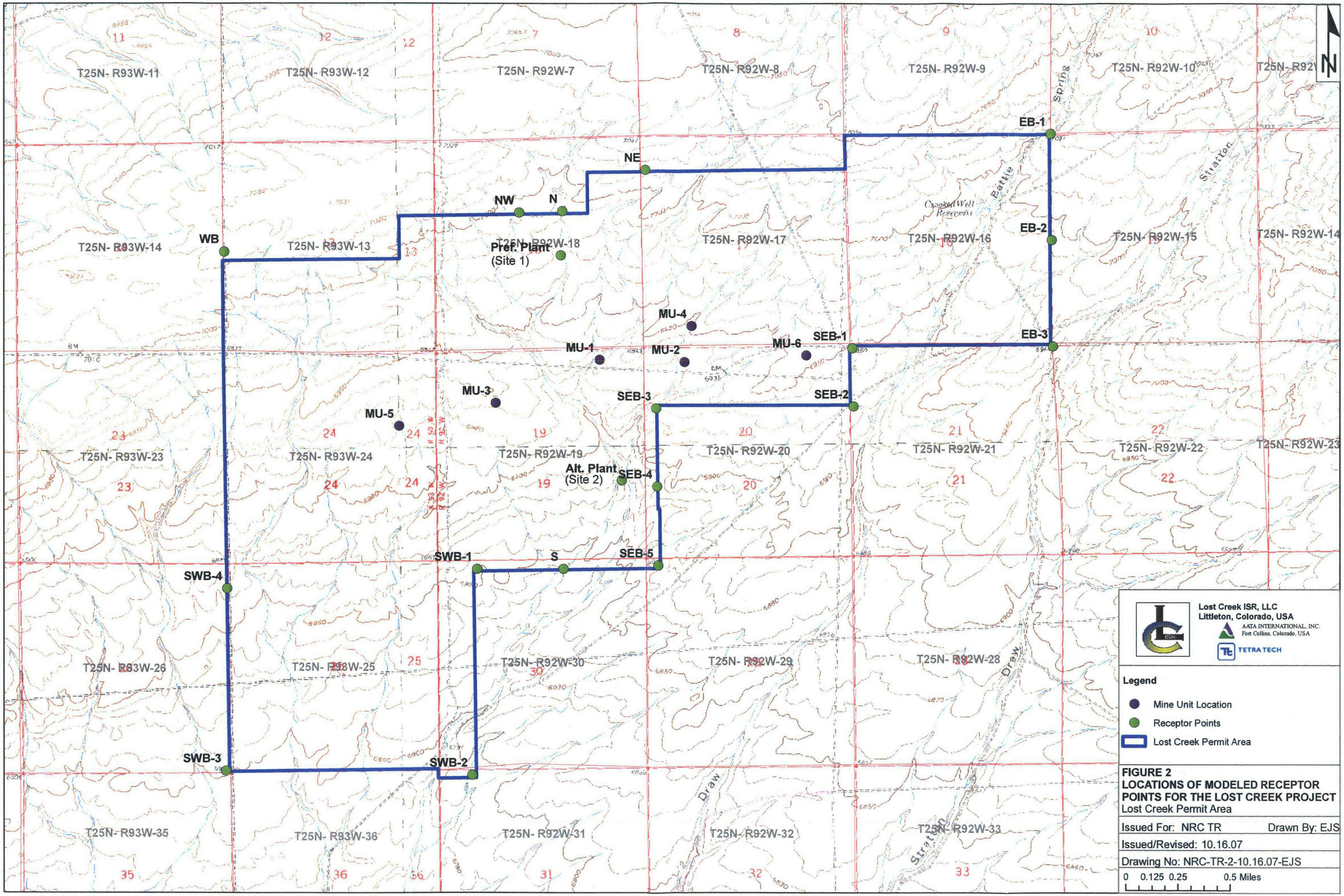


FIGURE 2
LOCATIONS OF MODELED RECEPTOR POINTS FOR THE LOST CREEK PROJECT
Lost Creek Permit Area

For both plant locations, sources were modeled according to the staging shown in Figure 1. New mine units, producing mine units, and restoration were modeled using the MILDOS-prescribed format and inputs for that type of source. Releases from the Ion Exchange columns were modeled in conjunction with purge water releases from the producing mine units at the location of the plant (0,0). Radon releases from restoration purge were also assumed to occur at the centroid of the plant. Venting from producing mine units and restoration wells was calculated assuming that the venting occurred at the centroid of the mine unit under consideration. Because the facility does not have a dryer, no particulates are released. So, all calculated doses come solely from radon releases.

Results are summarized below, and the output printouts are included as Appendix A.

MODEL RUNS

Dose modeling was conducted in several MILDOS Code runs as follows:

- New Wells were modeled for each of the six proposed mine units over a total period of seven annual time steps beginning in 2009.
- Production Wells were modeled for each mine unit over a total period of eight annual time steps from 2009 through 2016. Venting and purge were modeled separately, but with the same staging, because they are assumed to occur at different release locations.
- Ion Exchange Facility operation and releases were modeled over a series of eight annual time steps from 2009 – 2016, corresponding with production purges.
- Restoration purges and venting were modeled separately for each mine unit with the same time staging over a total period of seven annual time steps from 2011 – 2017.

As described above, the period of each year in which dose was calculated was varied using the QADJUST factor. So, for some time steps, certain mine units would be turned on or off depending on the staging shown in Figure 1 above.

MODELING RESULTS

CALCULATED RADON RELEASE RATES

Total estimated radon releases summed over the different source types are shown by year in Table 6. Operational year 2015 is the year of maximum radon release. The results are also shown in Figure 3.

Table 6. Calculated annual radon releases by source type.

	Total Estimated Radon Releases (Ci)								
	2009	2010	2011	2012	2013	2014	2015	2016	2017
New Wellfields	5.11E-03	5.72E-03	5.72E-03	5.72E-03	5.72E-03	5.72E-03	6.10E-04	0.00E+00	0.00E+00
Production Venting	4.17E+00	1.20E+02	1.48E+02	1.42E+02	1.51E+02	1.54E+02	1.62E+02	3.38E+01	0.00E+00
IX+Prod Purge	9.49E-01	2.74E+01	3.42E+01	3.41E+01	3.42E+01	3.42E+01	3.32E+01	6.78E+00	0.00E+00
Restoration Venting	0.00E+00	0.00E+00	3.73E+01	1.11E+02	1.08E+02	1.08E+02	1.18E+02	1.27E+02	8.45E+01
Restoration Purge	0.00E+00	0.00E+00	1.92E+01	5.77E+01	5.77E+01	5.77E+01	5.80E+01	5.79E+01	3.86E+01
Total	5.13E+00	1.48E+02	2.38E+02	3.45E+02	3.50E+02	3.53E+02	3.72E+02	2.25E+02	1.23E+02

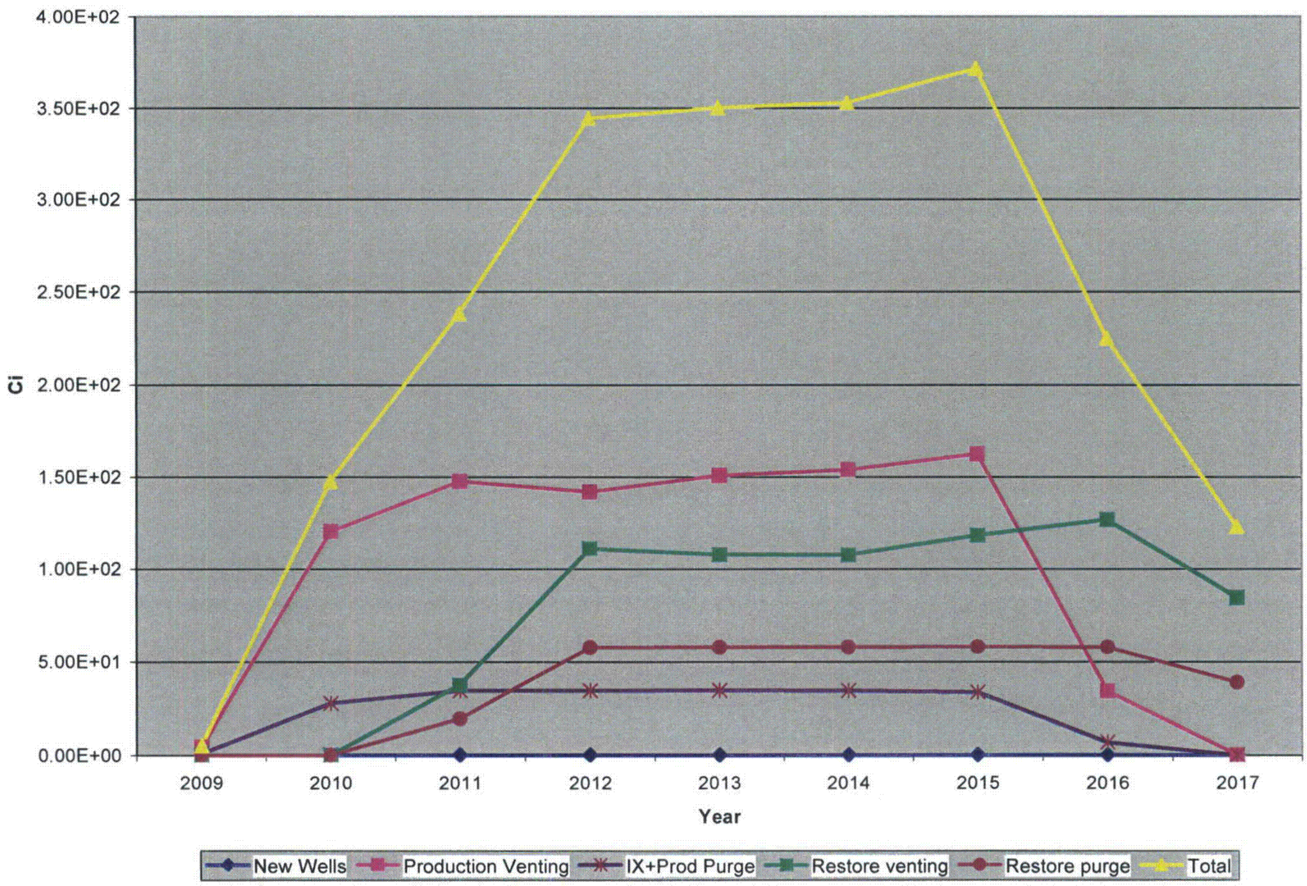


Figure 3. Calculated radon releases by source by year.

MAXIMUM DOSES TO INDIVIDUAL RECEPTOR LOCATIONS

Preferred Location (Plant 1)

For releases from the preferred location, estimated maximum annual total effective dose equivalents (TEDE) at individual receptor locations are shown below in Table 7 and Figure 4. The maximum dose for any receptor point occurs in 2015 at the SEB1 receptor location. This dose results exclusively from exposure to radon decay products, since there are no particulate releases from the facility. For this reason, the 40 CFR 190 annual dose commitments are zero in all cases. The shape of estimated doses through time reflects both the staging in different processes and their locations. For example, the centroid of mine unit 6 is located nearby to and upwind from receptor location SEB1.

Table 7. Total Effective Dose Equivalent to Maximum Individual by Location from Preferred Plant Location (mrem/yr).

	Total Effective Dose Equivalent to Maximum Individual (mrem/yr)								
Receptor location	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
NB	2.19E-02	6.22E-01	8.51E-01	1.40E+00	1.23E+00	1.25E+00	1.12E+00	7.61E-01	4.11E-01
NEB	1.41E-02	4.07E-01	6.43E-01	8.78E-01	9.58E-01	7.80E-01	7.68E-01	4.19E-01	2.40E-01
EB1	1.62E-03	4.73E-02	9.39E-02	1.13E-01	1.36E-01	1.04E-01	1.92E-01	1.02E-01	8.62E-02
SB	1.48E-03	4.24E-02	5.78E-02	1.30E-01	1.01E-01	2.82E-01	1.70E-01	1.67E-01	1.67E-02
SWB4	5.81E-04	1.66E-02	2.31E-02	4.10E-02	3.50E-02	5.68E-02	4.06E-02	3.22E-02	7.97E-03
WB	1.57E-03	4.48E-02	6.32E-02	1.17E-01	1.00E-01	1.55E-01	1.11E-01	8.71E-02	2.38E-02
NWB	1.33E-02	3.78E-01	5.09E-01	9.46E-01	8.01E-01	8.92E-01	7.12E-01	4.98E-01	2.39E-01
EB2	2.37E-03	6.85E-02	1.17E-01	1.52E-01	1.86E-01	1.49E-01	2.15E-01	1.12E-01	8.34E-02
EB3	3.36E-03	9.75E-02	1.81E-01	2.19E-01	2.75E-01	2.09E-01	3.82E-01	1.98E-01	1.66E-01
SEB1	8.02E-03	2.36E-01	5.23E-01	5.49E-01	9.01E-01	6.30E-01	3.01E+00	1.58E+00	1.66E+00
SEB2	9.96E-03	2.96E-01	6.96E-01	6.70E-01	9.61E-01	5.67E-01	1.56E+00	7.67E-01	7.54E-01
SEB3	6.28E-02	1.77E+00	1.60E+00	1.92E+00	8.35E-01	6.24E-01	4.08E-01	2.48E-01	1.01E-01
SWB3	3.94E-04	1.13E-02	1.65E-02	2.68E-02	2.38E-02	3.14E-02	2.56E-02	1.82E-02	6.41E-03
SWB2	5.70E-04	1.64E-02	2.33E-02	3.89E-02	3.35E-02	5.62E-02	4.25E-02	3.37E-02	8.90E-03
SWB1	1.11E-03	3.19E-02	4.44E-02	8.23E-02	6.94E-02	2.02E-01	1.31E-01	1.26E-01	1.38E-02
SEB4	5.02E-03	1.42E-01	1.56E-01	4.54E-01	2.81E-01	4.53E-01	2.08E-01	1.84E-01	3.22E-02
SEB5	2.57E-03	7.30E-02	9.03E-02	2.22E-01	1.54E-01	3.11E-01	1.73E-01	1.60E-01	2.23E-02

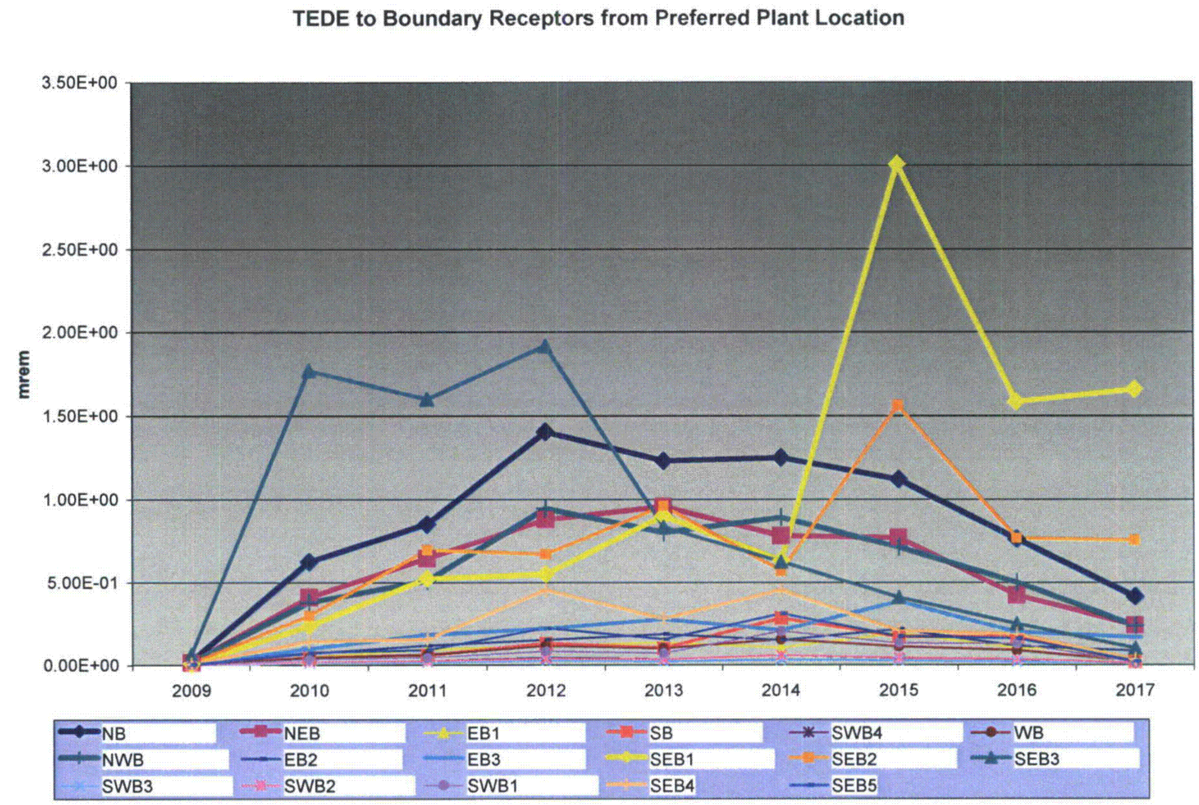


Figure 4. Total effective dose equivalent to maximum receptor from preferred plant location.

As shown in Figure 5, the vast majority of the dose to the SEB1 receptor location results from venting releases during production and restoration phases. These releases are modeled as occurring at the centroid of the mine unit. Most mine units are to the west of SEB1 and predominant winds have a westerly component nearly 60% of the time.

Doses to the north boundary (NB) receptor location, which is the closest point to the ion exchange columns have a maximum value of approximately 1.4 mrem in 2012 (Figure 6). Doses at NB are dominated by restoration purge, releases from the IX columns and production purge, which seems reasonable, given the close proximity (330m) to the plant centroid.

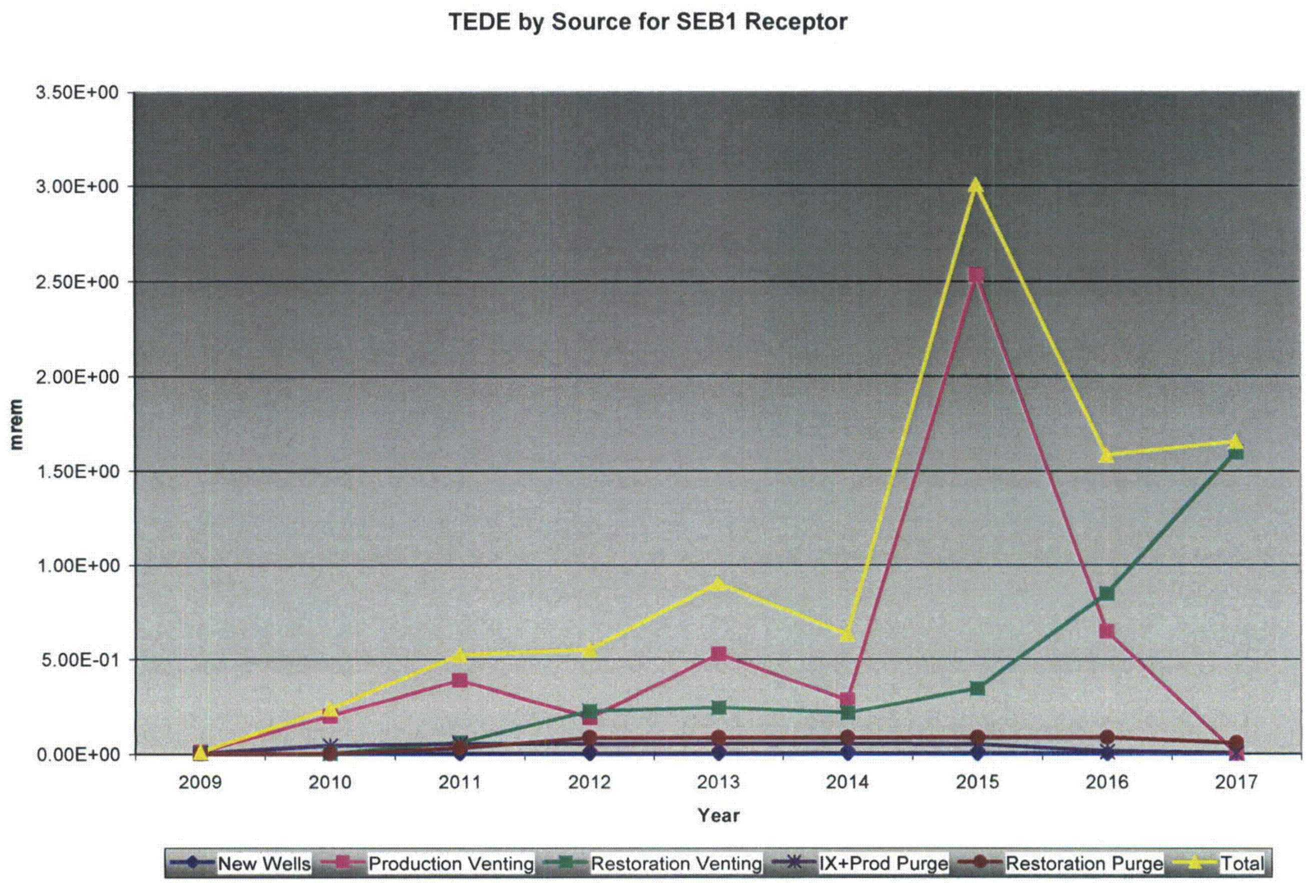


Figure 5. Total effective dose equivalent by source for SEB1 receptor location.

TEDE by Source for NB Receptor Location

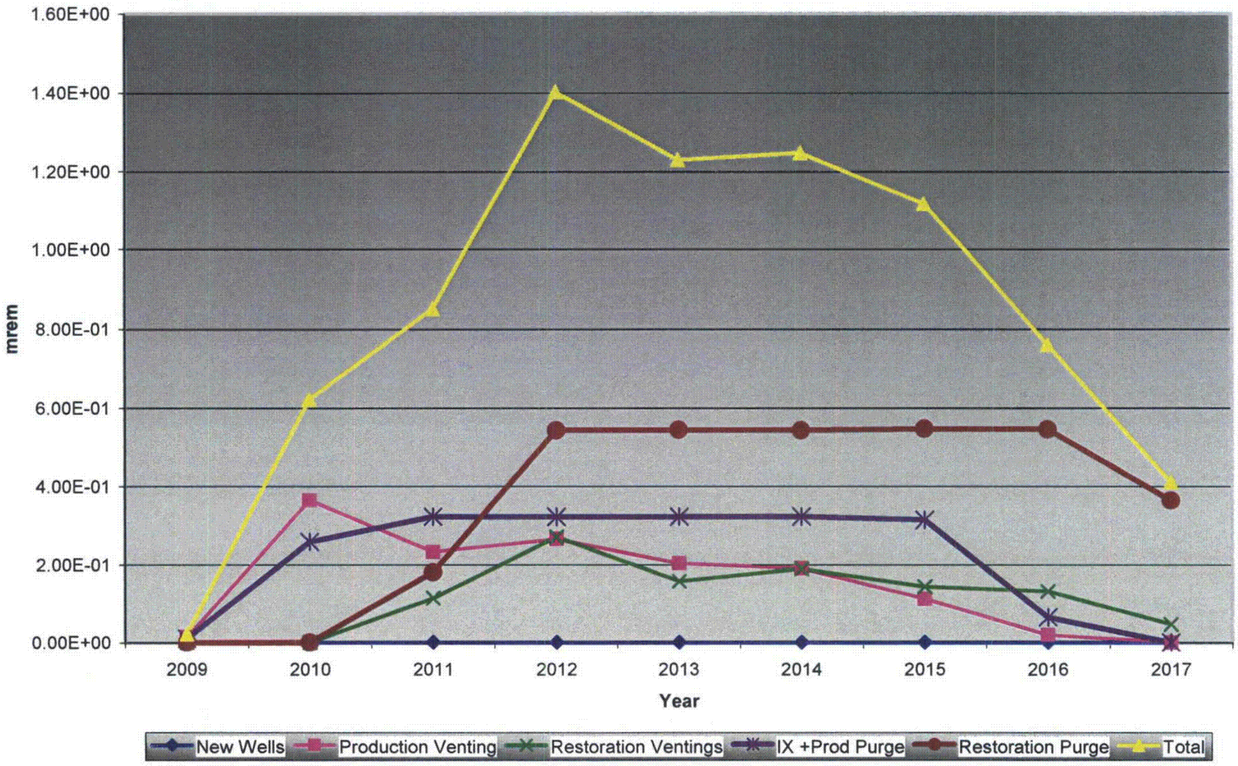


Figure 6. Total effective dose equivalent by source at the north boundary (NB) receptor location.

Alternate Location (Plant 2)

For releases from the alternate location (Plant 2), estimated maximum annual total effective dose equivalents (TEDE) at individual receptor locations are shown below in Table 8 and Figure 7. The maximum dose, 2.96 mrem, for any receptor point occurs in 2015 at the SEB1 receptor location. The shape of estimated doses through time reflects both the staging in different processes and their locations. By moving the plant to the alternative location, doses to the SEB3 location increase slightly from 1.92 mrem/yr to 2.47 mrem/y in the maximum year relative to doses if the plant is at the preferred location. It is important to note that moving the plant affects only releases from the ion exchange columns and the purge water, because we assume that all other releases occur at the centroid of the mine unit.

Table 8. Total Effective Dose Equivalent to Maximum Individual by Location from Alternate Plant Location (mrem/yr).

TEDE To Maximum Individual By Year and Location (mrem)									
Receptor	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
NB	1.40E-02	3.97E-01	4.11E-01	6.46E-01	4.72E-01	4.91E-01	3.65E-01	2.28E-01	9.26E-02
NEB	1.09E-02	3.13E-01	4.59E-01	5.63E-01	6.43E-01	4.65E-01	4.55E-01	1.97E-01	1.07E-01
EB1	1.62E-03	4.75E-02	9.43E-02	1.14E-01	1.37E-01	1.04E-01	1.93E-01	1.03E-01	8.65E-02
SB	1.78E-03	5.11E-02	7.47E-02	1.60E-01	1.30E-01	3.12E-01	1.99E-01	1.87E-01	2.90E-02
SWB4	6.51E-04	1.87E-02	2.71E-02	4.78E-02	4.18E-02	6.36E-02	4.73E-02	3.70E-02	1.08E-02
WB	1.54E-03	4.40E-02	6.18E-02	1.15E-01	9.75E-02	1.52E-01	1.08E-01	8.55E-02	2.28E-02
NWB	9.21E-03	2.61E-01	2.79E-01	5.52E-01	4.06E-01	4.97E-01	3.20E-01	2.20E-01	7.23E-02
EB2	2.17E-03	6.28E-02	1.05E-01	1.33E-01	1.67E-01	1.30E-01	1.96E-01	9.87E-02	7.54E-02
EB3	3.10E-03	9.01E-02	1.67E-01	1.94E-01	2.50E-01	1.84E-01	3.57E-01	1.80E-01	1.56E-01
SEB1	7.47E-03	2.21E-01	4.92E-01	4.97E-01	8.48E-01	5.78E-01	2.96E+00	1.55E+00	1.63E+00
SEB2	9.71E-03	2.89E-01	6.82E-01	6.45E-01	9.36E-01	5.42E-01	1.54E+00	7.50E-01	7.43E-01
SEB3	6.85E-02	1.94E+00	1.92E+00	2.47E+00	1.39E+00	1.18E+00	9.63E-01	6.42E-01	3.36E-01
SWB3	4.38E-04	1.26E-02	1.90E-02	3.10E-02	2.80E-02	3.57E-02	2.98E-02	2.11E-02	8.19E-03
SWB2	6.34E-04	1.82E-02	2.69E-02	4.51E-02	3.97E-02	6.24E-02	4.86E-02	3.81E-02	1.15E-02
SWB1	1.38E-03	3.98E-02	5.98E-02	1.09E-01	9.59E-02	2.28E-01	1.57E-01	1.44E-01	2.50E-02
SEB4	5.99E-03	1.70E-01	2.10E-01	5.47E-01	3.74E-01	5.46E-01	3.00E-01	2.50E-01	7.13E-02
SEB5	3.33E-03	9.49E-02	1.33E-01	2.96E-01	2.28E-01	3.84E-01	2.46E-01	2.12E-01	5.32E-02

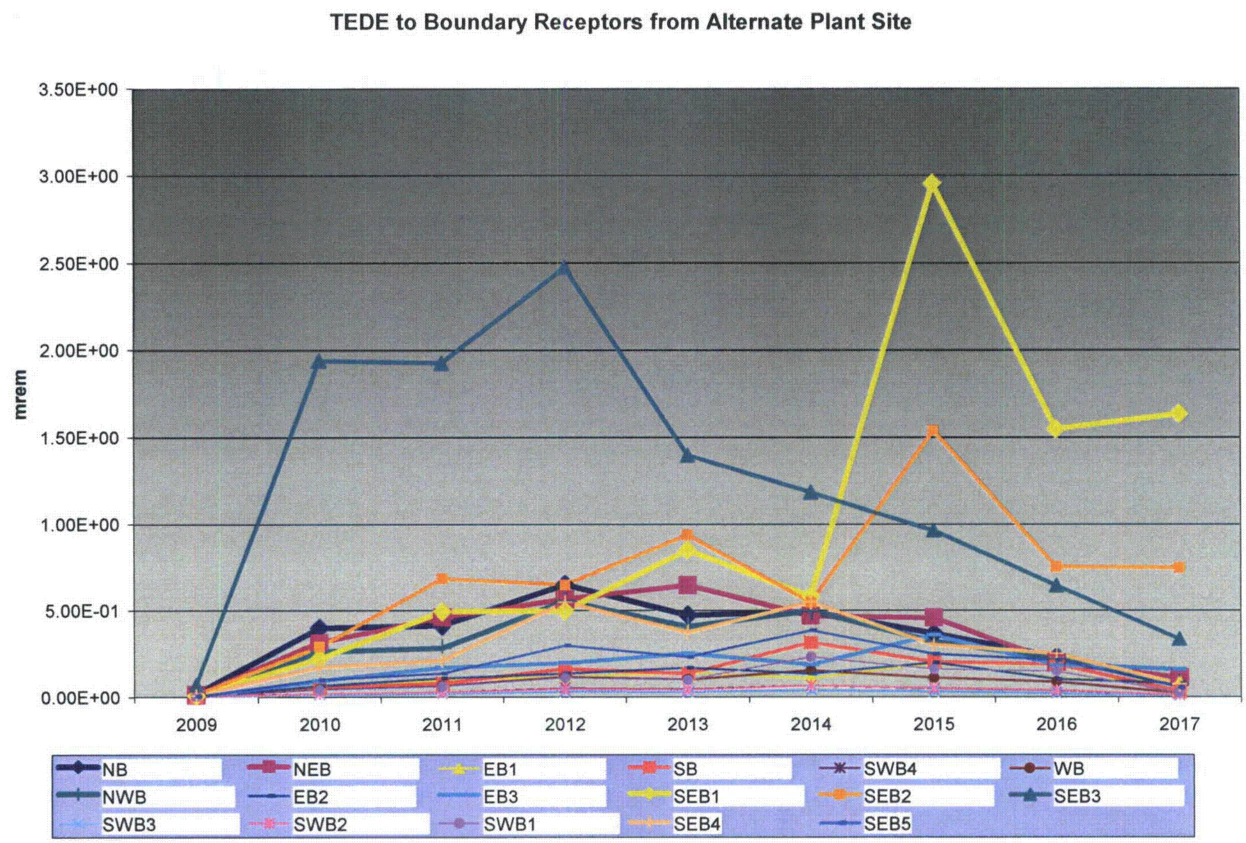


Figure 7. Total effective dose equivalent to maximum receptor from alternate plant location.

As shown in Figure 8, the major source of dose for the SEB1 receptor location is venting during production and restoration. This is to be expected because of the proximity of the mine units to the SEB1 receptor as shown in Figure 2.

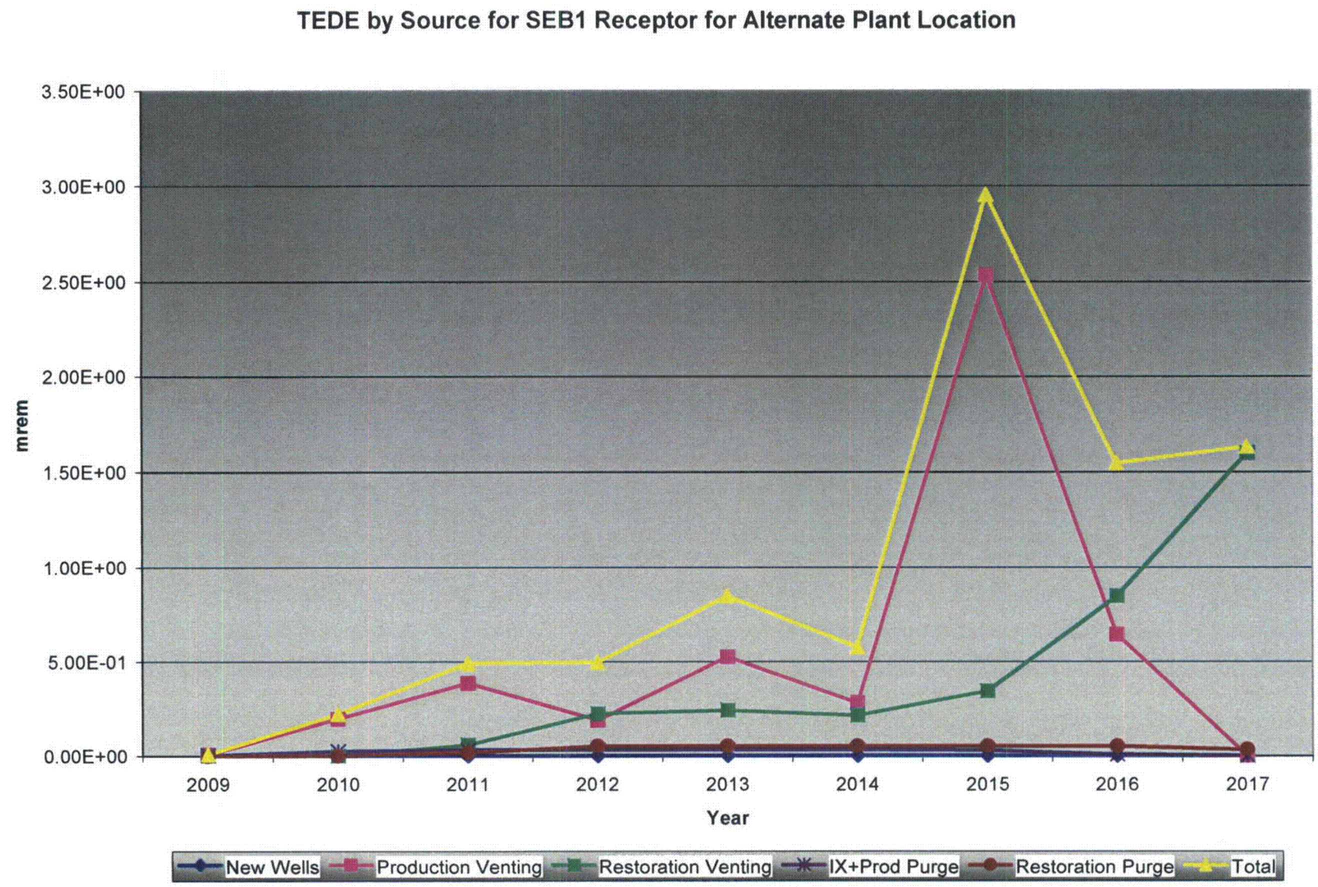


Figure 8. Total effective dose equivalent by type of release for SEB1 receptor location for releases using alternate plant location.

The effect of moving the plant to the alternate plant location can be seen by comparing Figure 9 to Figure 6. Calculated doses to the north boundary (NB) receptor location drop from 1.4 mrem/yr to approximately 0.7 mrem/yr if the ion exchange and purge water releases at the plant occur at the alternate plant location.

In summary, moving the plant to the alternate plant location has very little effect on dose to boundary receptor locations. For either plant location, the doses were far less than the standard of 100 mrem/yr. For actual receptors, doses would be even smaller because of the relatively large distances involved.

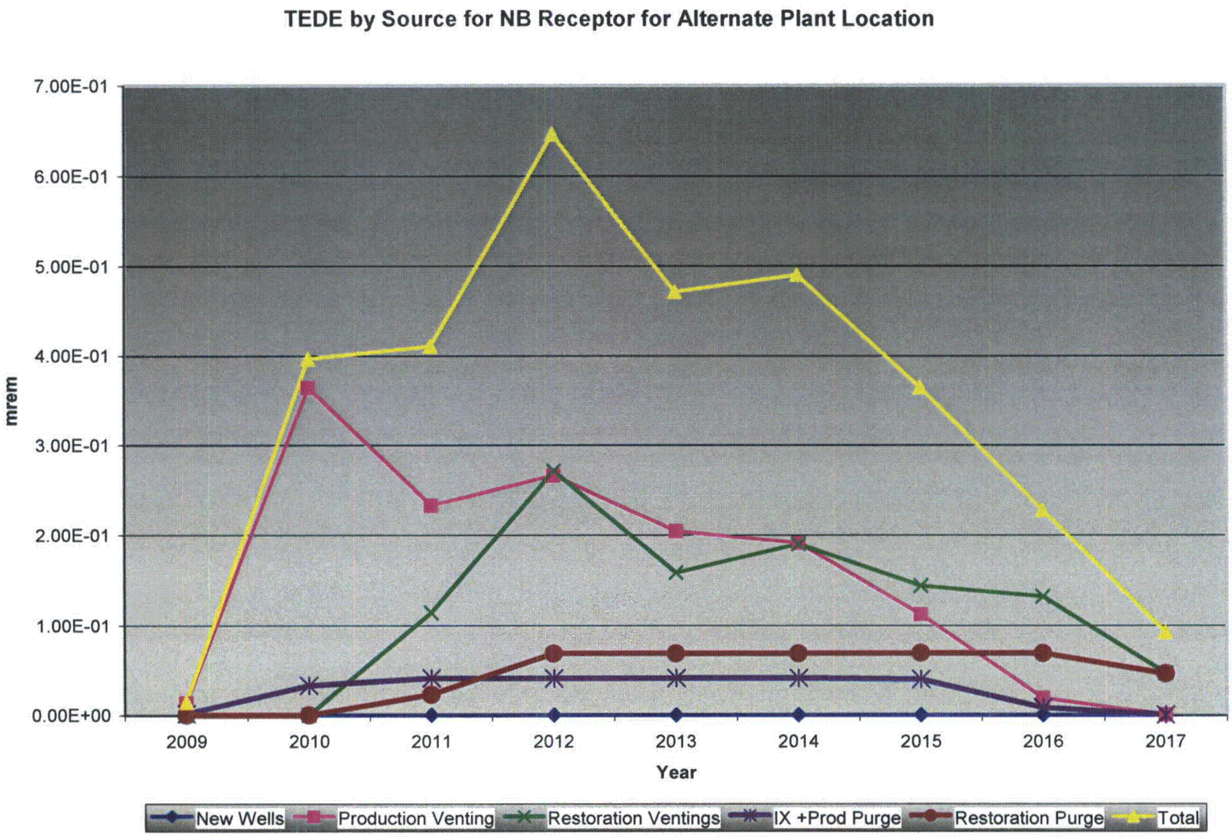


Figure 9. Total effective dose equivalent by source for NB receptor location from alternate plant location.

POPULATION DOSES

Using populations as shown in Table 5 above, population doses (person-rem/yr) from site releases were calculated for both total effective dose equivalent (TEDE) and the dose to the bronchial epithelium of receptors. Population dose results are summarized in Table 9. The maximum estimated annual population dose is 1.87E-2 person-rem to the population within 80 km and 6.39 person-rem to all populations. While there is no regulatory limit for population dose, it is interesting to compare results in Table 6 to exposures from natural background. Again using the population data in Table 5, and assuming 350 mrem/yr from natural background, the natural background population dose would be approximately 3.1E3 person-rem/yr, or approximately 160,000 times higher than the maximum year of the Lost Creek project. The location of the plant at either the preferred location of the alternate location would not influence population exposures because of the large distances involved and the relatively small distance between the preferred and the alternate plant locations.

Table 9. Dose to populations surrounding the proposed site.

	2009	2010	2011	2012	2013	2014	2015	2016	2017
	Total Effective Dose Equivalent (person-rem)								
Population within 80 km	1.29E-03	1.16E-02	1.45E-02	1.78E-02	1.80E-02	1.80E-02	1.87E-02	1.07E-02	3.87E-03
Population outside 80 km	4.38E-01	3.98E+00	4.94E+00	6.08E+00	6.14E+00	6.18E+00	6.37E+00	3.62E+00	1.32E+00
All populations	4.40E-01	3.99E+00	4.95E+00	6.10E+00	6.16E+00	6.19E+00	6.39E+00	3.63E+00	1.32E+00
	Bronchial Dose (person-rem)								
Population within 80 km	5.51E-03	1.59E-01	2.58E-01	3.68E-01	3.77E-01	3.73E-01	3.99E-01	2.39E-01	1.33E-01
Population outside 80 km	2.29E-01	6.60E+00	1.06E+01	1.54E+01	1.56E+01	1.58E+01	1.66E+01	1.01E+01	5.50E+00
All populations	2.35E-01	6.76E+00	1.09E+01	1.58E+01	1.60E+01	1.62E+01	1.70E+01	1.03E+01	5.64E+00

OCCUPATIONAL DOSES

Although it is outside the scope of the model, potential annual doses to a worker at the facility were modeled using MILDOS by creating hypothetical receptors nearby the plant. Four locations of the worker were defined by varying the (x,y) coordinates in km as (0,0.1), (0.1, 0), (0, -0.1), and (-0.1, 0). That places the hypothetical worker 100 meters N, E, S, and W from the plant. Annual doses were calculated to each worker location, multiplied by 0.22 (2000/8760) and averaged (Table 10, Figure 10). Calculated doses are well below occupational limits at less than 1 mrem annually. While this is an exceedingly low number it reflects the design of the facility which has radon releases occurring through a vent above the roof of the plant. Actual workers will be monitored and experience with other facilities of this type lead to the expectation that occupational doses will be very low.

Table 10 **Dose to "Worker" Locations Calculated by MILDOS.**

	Dose (mrem/y*)								
Location	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
100 m N	4.70E-03	1.33E-01	1.43E-01	2.37E-01	1.84E-01	1.89E-01	1.52E-01	9.81E-02	4.79E-02
100 m E	6.53E-03	1.85E-01	1.91E-01	3.00E-01	2.26E-01	2.23E-01	1.87E-01	1.18E-01	6.07E-02
100 m S	5.81E-03	1.63E-01	1.56E-01	2.52E-01	1.71E-01	1.74E-01	1.26E-01	7.93E-02	3.53E-02
100 m W	5.94E-03	1.69E-01	2.21E-01	3.81E-01	3.23E-01	3.34E-01	2.86E-01	1.96E-01	1.04E-01
Average	5.75E-03	1.63E-01	1.78E-01	2.93E-01	2.26E-01	2.30E-01	1.87E-01	1.23E-01	6.20E-02

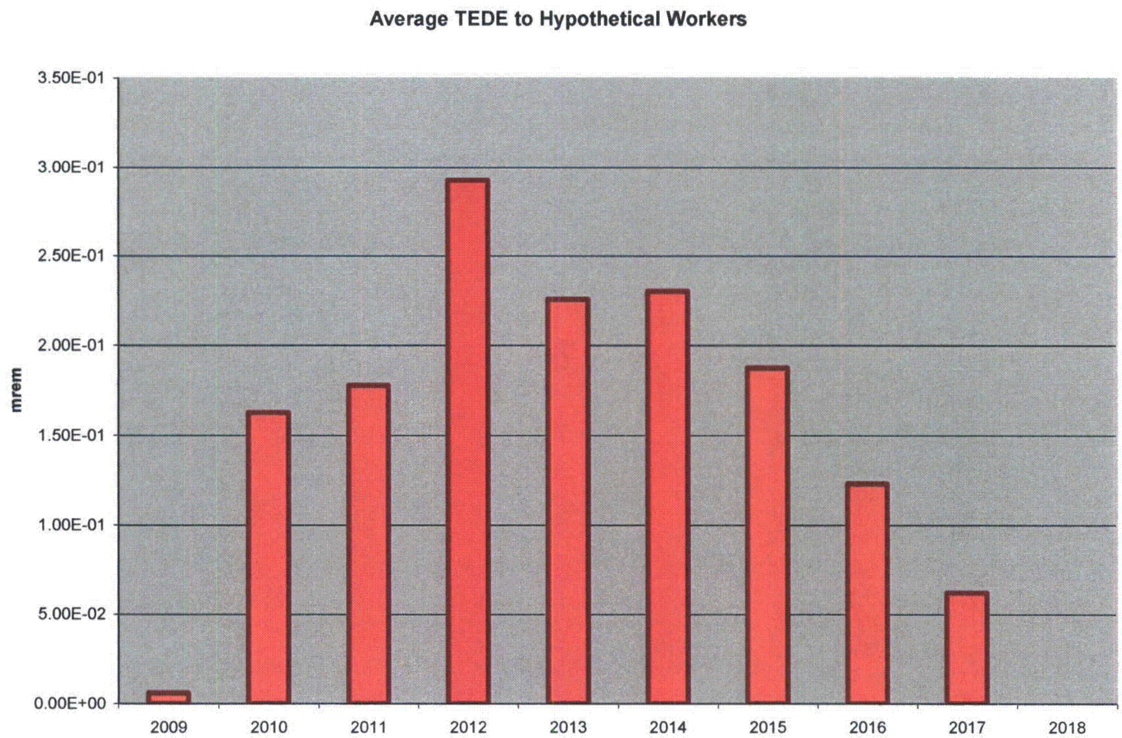


Figure 10 **MILDOS-calculated doses to a hypothetical average worker located 100 m N, E, S and W from the plant.**

SUMMARY

Results of MILDOS modeling show that boundary receptors receive only about 3% of the 10 CFR 20 limit of 100 mrem per year total effective dose equivalent (TEDE), whether the plant is located at either the preferred location or the alternative location. The major source of dose varies with receptor location and depends on staging of the releases through time at the various source locations. Releases from new mine units venting during production and restoration are assumed to occur at the centroid of the mine unit, so the location of the "plant" has no impact on those releases. Actual receptors are far removed from the permit area and would have even lower doses.

Because of the region's sparse population, very little population dose (person-rem/yr) occurs from the plant. Background exposures to surrounding populations are more than 1.6E5 times higher than contributions from the proposed facility. Doses to workers from releases at the facility are expected to be far below occupational dose limits and will be monitored during operations as required to provide documentation of actual exposures.

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Argonne National Laboratory (ANL), 1989. MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources, June. ANL/ES-161.

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U.S. Environmental Protection Agency (EPA), 1987. On-Site Meteorological Program Guidance for Regulatory Modeling Applications. EPA-450/4-87-013. U.S. EPA, Office of Air and Radiation, Research Triangle Park, NC 27711.

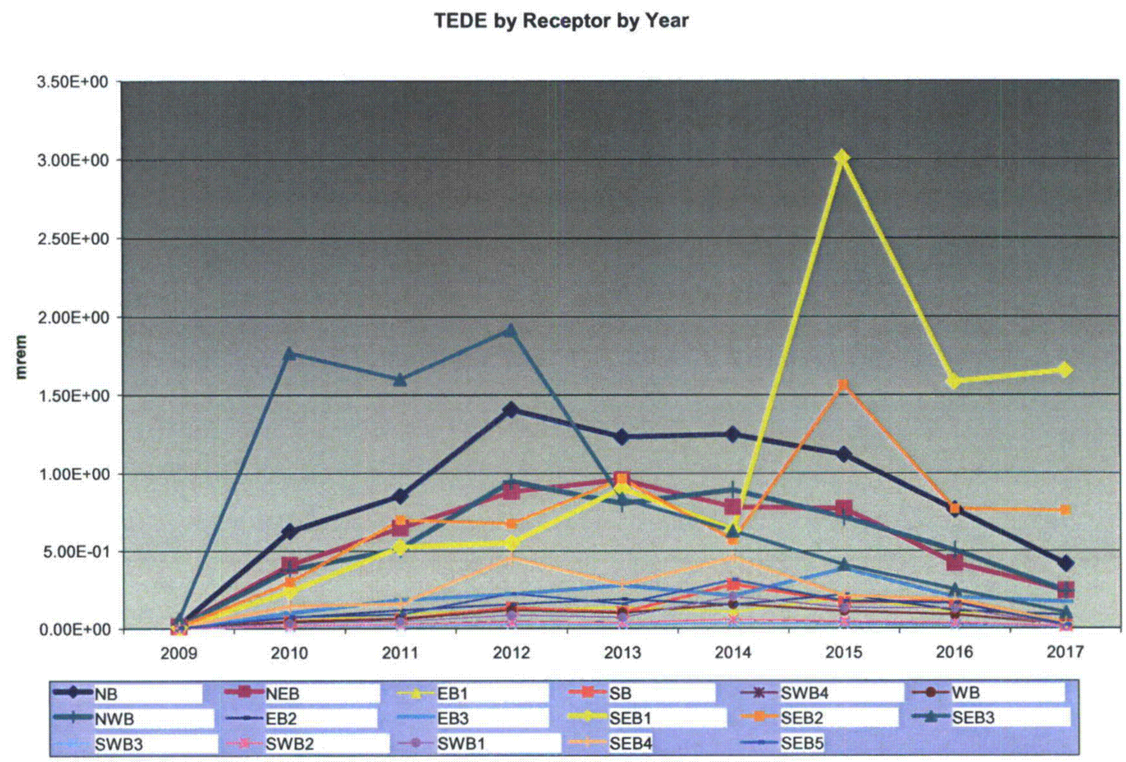
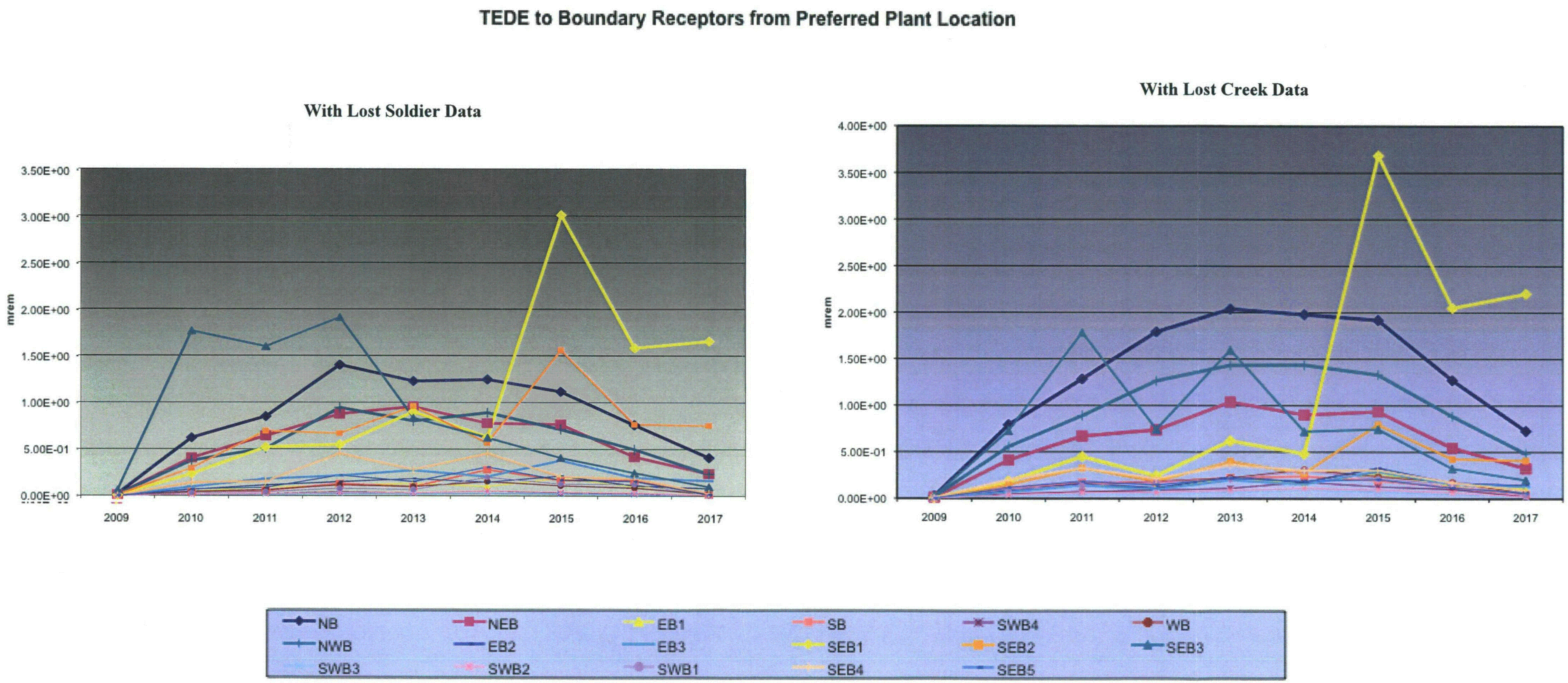


Figure 7.2-3a Total Effective Dose Equivalent at Boundary Receptor Points - Preferred Plant Site

Figure 7.2-3b Comparison of MILDOS Results using Meteorological Data from LS and LC Stations



See Figure 7.2-2 for boundary receptor locations.