POWER RESOURCES, INC.
SMITH RANCH – HIGHLAND URANIUM PROJECT

SOURCE MATERIAL LICENSE APPLICATION

NRC License No.: SUA-1548
Docket No.: 40-8964

Volume I

Chapters 1-10

March 12, 2003

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1.1 INTRODUCTION

The Smith Ranch-Highland Uranium Project (SR-HUP) is a commercial in situ leach (ISL) facility located in the South Powder River Basin, Converse County, Wyoming. The current (March 2003) U.S. Nuclear Regulatory Commission (NRC), License Number SUA-1548 for the Smith Ranch Project (SRP) was issued in conformance with the License Renewal process to Rio Algom Mining Corp. (RAMC) on May 8, 2001. The expiration date of this license is September 30, 2010. During July 2002 Power Resources, Inc. (PRI), the operator of the adjacent Highland Uranium Project (HUP), acquired the Smith Ranch Project from RAMC. License Amendment No. 3 dated July 11, 2002 transferred License Number SUA-1548 from RAMC to PRI.

Commercial ISL production of uranium is currently (March 2003) continuing at both the Smith Ranch and Highland sites. Commercial production began at the HUP in January 1988 and at the SRP in June 1997.

In concert with the transfer of the SRP NRC license to PRI, PRI consolidated operations with the adjacent HUP during September 2002. The HUP is currently (March 2003) operated under NRC License No. 1511. The consolidation of the SR and HUP mineral ownership and operations resulted in a more cost effective operation and allows the potential mining of ore bodies located near property boundaries and previously owned by both RAMC and PRI. The consolidation of operations involved the following major activities:

- Consolidation of workforces and resulting combined decrease in employees from approximately 100 to 80.
- Relocation of all HUP Main Office and Maintenance functions to the Smith Ranch Facility.
- Construction of approximately 3.5 miles of gravel road between Smith Ranch and HUP facilities.
- Movement of all resin transport, elution and yellowcake processing to the more modern and efficient Smith Ranch Central Processing Plant (CPP).
- Placement of the HUP Central Plant and associated facilities on "stand-by" status. The HUP Central Plant would be restarted in the case that the uranium market improves such that additional yellowcake processing capacity is needed, or if a major unanticipated shutdown condition occurred at the Smith Ranch CPP.

In concert with the consolidation of the SRP and HUP into the SR-HUP, PRI desires to combine both existing NRC licenses into one license to facilitate the transition to one operation and one accompanying radiation safety and environmental protection program. Through discussions with NRC Headquarters and Region IV staff, it was determined that the existing Smith Ranch Facility License (SUA-1548) and accompanying license application (which is the newest of the two licenses) would be revised to reflect the combined operation of the SR-HUP. It was also determined that it was advantageous to both PRI and NRC to combine the NRC License (No. SUA-1540) for the non-operating Ruth/North Butte Project to License SUA-1548 as well. Accordingly, the License Amendment Request submitted herein intends to accomplish these actions by revising Volume 1 of the existing Smith Ranch Facility license application.

PRI also controls other non-producing uranium properties in Wyoming, including the Gas Hills Project and the Ruth/North Butte Projects, that will potentially be used as Satellite production centers to SR-HUP in the future, in the event that the price of uranium increases to a level that supports their development. Uranium potentially produced from these ISL projects will be shipped via truck to the SR-HUP for yellowcake processing. Shipments will consist of either uranium loaded ion exchange (IX) resin (which is currently trucked between existing Satellites and the Smith Ranch CPP), or yellowcake slurry. Currently (March 2003), the Ruth/North Butte Project is licensed by NRC (No. SUA-1540) and permitted by the Wyoming Department of Environmental Quality (WDEQ) (Permit No. 631, Ruth Project, and Permit No. 632, North Butte Project). Currently (March 2003), the Gas Hills Project is permitted by the WDEQ (Permit No. 687) and the NRC licensing action to approve the Gas Hills Project as a Satellite to the SR-HUP is nearing approval as the Environmental Assessment (EA) is in the final stages of completion.

Reclamation Performance Bonds that cover aquifer and surface reclamation are held by the WDEQ. The amount of the Performance Bonds are updated annually via the Annual Surety Estimate Revision to account for new areas as they are disturbed and/or to reflect completion of decommissioning/reclamation. Both the NRC and WDEQ review and approve the annual revisions.

1.2 GENERAL SOLUTION MINING PROCESS

The mechanics of uranium ISL mining are relatively straightforward. A carbonate/bicarbonate leaching solution and oxidant are injected into the ore bearing sandstone formation through a series of wells that have been drilled, cased, cemented, and tested for mechanical integrity. As the leaching solution moves through the formation and contacts the ore, the uranium is oxidized, becomes soluble and dissolves into the leaching solution. The uranium bearing solution is drawn to a recovery well where it is pumped to the surface and transferred to the recovery plant. In the plant the uranium is recovered from the leach solution by ion exchange (IX) and the solution is re-injected to extract additional uranium.

1.3 ADVANTAGES OF ISL URANIUM MINING

ISL uranium mining is a proven technology that has been successfully demonstrated commercially in Texas and Nebraska, and at the SR-HUP, and other operations in Wyoming. ISL mining of uranium is environmentally superior to conventional open pit and underground uranium mining as evidenced by the following:

1. ISL mining results in significantly less surface disturbance as mine pits, waste dumps, haul roads, and tailings ponds are not needed.

2. ISL mining requires much less water demand as pit dewatering, conventional milling, and tailings transport are avoided.

3. The lack of heavy equipment, haul roads, waste dumps, etc. result in very little air quality degradation at ISL mines.

4. Fewer employees are needed at ISL mines, thereby reducing transportation and socioeconomic concerns.

5. Aquifers are not excavated, but remain intact during and after ISL mining.

6. Tailings ponds are not used, thereby eliminating a major ground water pollution concern.

7. ISL uranium mining results in leaving the majority of other contaminants where they naturally occur instead of moving them to waste dumps and tailings ponds where their presence is of more environmental concern.

1.4 ORE AMENABILITY TO ISL URANIUM MINING

Amenability of the uranium deposits in the SR-HUP area to ISL mining was demonstrated initially through core studies. Results of the core studies were confirmed in the two pilot R&D projects at the Smith Ranch site using bicarbonate/carbonate leaching solutions with hydrogen peroxide and oxygen. The pilots were authorized by Wyoming Department of Environmental Quality, Land Quality Division (WDEQ-LQD) Permits 5RD and 13RD and by NRC License SUA-13387. These tests, conducted in uranium deposits at depths of 500 feet and 750 feet, have demonstrated the feasibility of mining the uranium reserves in the project area using ISL methods.

The initial ISL pilot, the Q-Sand pilot, operated until May 1986. Uranium recovery from the pilot exceeded the forecast recovery and aquifer restoration, completed in May 1986, was deemed acceptable, as was the completion of a one-year aquifer stability demonstration period. The second ISL pilot, the O-Sand pilot, was initiated in July 1984 and performed as forecast, confirming the amenability of the ore to ISL mining.

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

The second pilot R&D Project (known as the "Expanded R&D"), which was operated from December 16, 1978 to September 1981, demonstrated the technical feasibility of in situ mining utilizing gaseous oxygen, sodium bicarbonate and gaseous carbon dioxide within the leach fluid, the ability to control leach fluids within the mining zone, and the restorability of the affected ground water to its original use suitability. Reports concerning the results of the pilot activities, including restoration of affected ground water, were previously submitted to NRC and WDEQ.

The information and experience gained during these pilot programs formed the basis for the commercial uranium ISL mining operations. PRI believes the pilots demonstrated that such a program can be implemented with only minimal short-term environmental impacts and with no significant risk to the public health or safety. The remainder of this application describes the Mining and Reclamation Plans for this project and the concurrent environmental monitoring programs employed to ensure that any impact to the environment or public is minimal.

CHAPTER 2
SITE CHARACTERIZATION

2.1 SITE LOCATION AND LAYOUT

The SR-HUP permit area for the uranium mining project is located in the southern Powder River Basin, Converse County, Wyoming. The Main Office and the Central Processing Plant (CPP) complex located at Smith Ranch is approximately 17 air miles (22 road miles) northeast of the town of Glenrock, Wyoming and 23 air miles (25 road miles) northwest of Douglas, Wyoming. Access to the site from the intersection of State Highway 93 and Highway 95 is by Ross Road, a paved county road. Figure 2-1 shows the general location and access to the project area.

Plate 1 shows the lands controlled by the SR-HUP and the locations of facilities, including; satellite buildings, wellfields, major roads, and the Main Office Central Processing Plant area. The SR-HUP mine permit area encompasses approximately 30,760 acres (approximately 14,560 acres in the former HUP area and 16,200 acres in the former SR area). The combined acreage of 30,760 acres for the SR-HUP mine permit area differs slightly from the historic acreage for the individual operations as the operations previously shared "over-lapping" mine permit areas.

The land surface ownership includes approximately 22,660 acres of private ownership, 3,300 acres of State of Wyoming ownership, 3,075 acres of U.S. Government ownership (administered by the Bureau of Land Management (BLM)), and 1,725 acres directly owned by PRI.

The Main Office and Central Processing Plant are located at the former Bill Smith underground mine site in the NW ¼ Section 36, T36N, R74W. The HUP Office/Central Plant complex, which went on "standby" status in late 2002, is located in the NW ¼ Section 29, T36N, R72W.

2.2 USES OF ADJACENT LANDS AND WATERS

2.2.1 General

Lands contained within the mine permit area have historically been used for sheep and cattle grazing. PRI controls mineral and surface rights in the areas scheduled for uranium mining and development. The only residential site within the mine permit area is the Vollman Ranch, which is located in the NW ¼ Section 27, T36N, R73W (see Plate 1). The ranch house is located approximately 2000 ft from the F-Wellfield and 2.1 and 1.5 miles from Satellite Nos. 2 and 3, respectively. The only other residential sites near the SR-HUP include the Sundquist (Smith) Ranch and Fowler Ranch, which are both located outside the mine permit area, distant from any current, or planned operations.

The proposed use of the land for the immediate future includes continued livestock grazing and in-situ uranium mining on a commercial scale. Currently (March 2003) approximately 1200 acres at the SR-HUP have been excluded from livestock by fencing. The majority of the excluded acreage results from fencing of wellfield and Satellite areas and the two land application (irrigation) facilities. A breakdown of the approximate acreage of fenced areas (as of January 2003) is as follows:

Area	Acres
Wellfields/Satellites	800
Satellite No. 1 Irrigation Facilities/Reservoir	125
Satellite No. 2 Irrigation Facilities/Reservoir	180
Smith Ranch Main Office/Central Plant Area	45
Highland Main Office/Central Plant Area	50

After mining activities are completed, the land will be returned to the pre-mining use of livestock grazing and wildlife use. The Reclamation Plan included in Chapter 6 of this application describes how affected areas will be decommissioned and reclaimed after the completion of mining activities.

2.2.2 Agricultural Activity

Livestock grazing is the main source of food production and agricultural activity on the permit area and the adjacent lands. Due to the short growing season, the forage provided by natural vegetation, although nutritious, is sparse. According to personnel from the U.S.D.A. Soil Conservation Service Office in Douglas (November 10, 1986) the stocking rate in the vicinity of the mine site averages one-fourth to one-third of an animal unit per acre, per month, on range that is in good condition. In the past, some isolated areas were homesteaded and dry farmed. Most of these dry farms ultimately were abandoned and left to re-vegetate by natural processes, or seeded with crested wheat grass or other grasses for grazing purpose.

2.2.3 Recreation

Major recreational activities within a fifty mile radius of the proposed mine site are mostly outdoor activities, such as camping, hunting, picnicking, hiking, skiing and snowmobiling. Water sports, such as water skiing, boating, canoeing and fishing are popular in public use areas designated by the state and counties along the North Platte River and at Alcova Lake and the Glendo Reservoir. In addition to State and Community designated parks and recreation areas, a portion of the Medicine Bow National Forest, approximately forty miles south of the site provides additional area for recreational activities. Figure 2-2 shows the approximate location of these major facilities and points of interest in the general area.

2.2.4 Water Rights

Appendix D-6 (Hydrology) of the License Application lists surface and ground water rights for the SR-HUP area. Adjudicated surface water rights are limited to several stock ponds and ditches that retain surface water runoff on a limited basis. The majority of ground water rights in the SR-HUP area are associated with monitoring wells and the production areas at the ISL mining operations.

As is the case with many of the intermontane basins in Wyoming, water in the vicinity of the permit area is available primarily from groundwater sources as described in Appendix D-6 of this document. These groundwater sources may receive sporadic recharge due to runoff from the limited precipitation in the Powder River Basin. However, this quantity of this recharge is relatively insignificant since it can only occur at sandstone surface outcrops of the aquifers that constitute a very limited receiver relative to the entire Powder River Basin. None of the principle sources of groundwater outcrop or receive recharge within the permit area.

The permit area has several known stock ponds consisting of small earthen dams across dry stream channels that collect the small quantities of runoff. The locations of these ponds are shown on Figure D6-12. One of these ponds is supplemented by groundwater pumped from a well by a windmill. Some water also accumulates in small excavations or natural depressions at low points in the Sage Creek drainage. No other significant waterbodies are present in the permit area. During underground mining the local rancher constructed a small reservoir to collect water discharged from the Bill Smith Mine and used the water for irrigating approximately 160 acres of alfalfa and native grass. However, with the absence of pumping from the mine after it was reclaimed and abandoned, the reservoir is dry most of the time but is still used as a stock pond when there is runoff.

Wells in the vicinity of the permit area excluding those owned by PRI are rather uniformly distributed over the area, with the greatest density occurring south of Sage Creek. Most of these wells are associated with windmills used for livestock watering. As such, these wells are usually shallow, less than 180 feet in depth. Only three wells in the permit area and on adjacent lands are known to be used for domestic water supply.

As discussed in Appendix D-6, these wells include the water well at the Sundquist (Smith) Ranch located approximately 2.6 miles southwest of the Smith

Ranch Main Office/CPP site, the Vollman Ranch well located approximately 1.5 miles east of Satellite No. 3 and the Fowler Ranch well located just north of the permit area approximately 2.5 miles north of the Highland Central Plant. Plate 1 shows the locations of these dwellings. Water wells at the Satellite buildings, the Highland Central Plant, and the Smith Ranch Main Office/CPP site only supply water for plant operations and washing purposes. These water supplies are not used for drinking as bottled water is supplied for this purpose.

The three ranch wells in the area are all completed (screened) at depths stratigraphically above the zones planned for ISL mining and are also located distant from planned wellfield areas. The Sundquist (Smith) Ranch well is105 ft in depth, the Vollman Ranch well is 180 ft in depth, and the Fowler Ranch well, which is used very intermittently, as fulltime residents do not reside at the site, is 212 ft deep.

No mining is planned for the zones these wells are completed in as there is no uranium mineralization of economic significance in these zones. Since these wells are located laterally from proposed mine areas and are vertically separated from the ore zones by at least 300 to 400 ft of alternating layers of shale, siltstone, and sandstone, it is very unlikely that the wells will be affected by mining related activities. The intensive ground water monitoring program utilized during operation would detect any problems prior to these wells being adversely affected.

Maps showing the location of the known wells and springs in the permit area and on the adjacent lands is included in Appendix D-6.

2.3 POPULATION DISTRIBUTION

The population within fifty miles of the Smith Ranch Main Office/CPP site is centered within the communities of Casper, Douglas and Glenrock, Wyoming as shown on Figure 2-2. These urban areas are significant in that they provide the major locations of public services such as schools, churches, medical care facilities, and public parks. These communities also provide the majority of the cultural and scenic attractions for the residents of Converse and Natrona Counties.

Casper, Wyoming is the County Seat of Natrona County. In 1986 Casper claimed to be the largest city in the state. Casper has developed into a regional retail trade center serving a 150 mile radius which includes all or part of seven counties. Its regional prominence as a retail center is supported by the Eastridge Mall, which opened in the Fall of 1982. The Casper labor force and population peaked in Spring of 1982 and has declined since that time.

Casper has doubled its acre size during the ten years between 1975 and 1985. This growth can be contributed to the energy boom in the late 1970s and early 1980s. From 1970 to 1980 the city experienced a 30% increase in its population. Decreases in the price and demand for both oil and uranium have contributed to a population loss between 1980 and 1990. As can be seen on Table 2-1, the population in Casper fell from 51,016 in 1980 to 46,742 by 1990 – a loss of 4274 people. After 1990, the Casper area began to recover from the energy-related population decline. Between 1990 and 1995, the population increased by 2041, bringing the population total to 48,783 (see Table 2-1). However, referring to Table 2-1 again, will show that another population decline has occurred between 1995 and 1999. During this period, the population fell by 500, resulting in the 1999 total of 48,283.

Douglas is the County Seat of Converse County. Glenrock, also in Converse County, is the closest town to the SR-HUP site with the site being approximately 22 road miles northeast of the town. Between 1970 and 1980 both Glenrock and Douglas experienced phenomenal growth, 80.6% and 136.9%, respectively. However, with the change in energy demand, through 1984 Glenrock lost 27% of its population and Douglas lost 17% of its population. Although Glenrock and Douglas experienced population changes similar to those in Casper between the years 1970 and 1995, population growth continued in Glenrock and Douglas between 1995 and 1999 (see Table 2-1).

The reduction in employment in the area uranium operations illustrates the loss of jobs to the area. In March 1980, uranium producers reported 1,264 people directly employed in the uranium mining and milling operations in Converse County. In September 1987 the same uranium producers reported less than 100 employees in Converse County with many of these employees working on reclamation projects that were completed within 2 years. Startup of this uranium mining project has increased company employment in the area to about 80 people and provided jobs for 20 to 40 contractor employees. Most of the new positions were filled from the local population.

The only occupied dwelling within the permit area is the Vollman Ranch which is located approximately 1.5 miles east of Satellite No. 3 and 4.2 miles east-northeast of the Smith Ranch Main Office/CPP site. The nearest dwelling to the Smith Ranch Main Office/CPP Site is the Sundquist (Smith) Ranch located 2.6 miles to the southwest. A total of seven people normally reside at these ranch homes for an occupational density of 0.09 persons per square mile for the area within a five mile radius of the plant.

2.4 HISTORIC, SCENIC AND CULTURAL RESOURCES

Six Cultural Resource Surveys have been conducted on lands comprising the SR-HUP. These surveys are included in Appendix D-3 of the application and are summarized as follows:

2.4.1 Smith Ranch Area

A Class III Cultural Resource Inventory for the proposed permit area was completed in November 1985 by Frontier Archaeology of Worland, Wyoming. These data are presented in Appendix D-3. Eighteen sites were located. Ten of the sites are historic and eight are prehistoric. Following review of these sites by the BLM and the Wyoming State Archives, Museums and Historical Department during the Spring 1986, it was determined that only two sites could be potentially affected by the project. The mitigation and protection of these sites are discussed in Chapter 5. Appendix D-3 contains the Cultural Resource Class III Survey plus the appropriate letters from the SHPO, etc. The report also includes a listing of cultural resource (i.e. The Bozeman Trail) sites known in the vicinity of the permit area. This list was compiled through review of the State Archives, WSHPO and Casper BLM office.

Another Cultural Resource Class III Survey was conducted in December 1998 by Pronghorn Archeological Services of Mills, Wyoming. The scope of the survey covered the areas within the permit area not previously surveyed in the 1985 survey. The 1998 survey identified three new historic sites, thirteen prehistoric sites, and twenty-two isolated artifacts. Of those, twelve of the prehistoric sites were considered to be eligible for inclusion to the National Register of Historic Places, and none of those sites are located where mining activities are planned. The BLM and WSHPO have reviewed the report. Appendix D-3 contains this report and supporting correspondence. A significant portion of Appendix D-3 contains information that falls under the confidentiality requirement for archeological resources under 43 CFR 7.18, "Confidentiality of archaeological resource information". Therefore, PRI requests that all portions of Appendix D-3 remain "CONFIDENTIAL" for the purpose of Public Disclosure of this application.

2.4.2 Highland Uranium Project Area

Several detailed archeological surveys have been conducted on lands comprising the Highland Uranium Project and adjacent areas. Surveys for the original permit area (1985 Everest Minerals permit application), the Section 14 Amendment area and the West Highland Amendment area are included as Addenda D3-1, D3-2 and D3-3A respectively.

The North Morton Ranch property was acquired from the Tennessee Valley Authority in September, 1985. Much of the northern portion of the Highland area lies within the former North Morton Ranch permit area. The cultural resource inventory performed as a part of the North Morton application (Permit No. 230C) is provided as Addendum D3-3B.

The extreme western portion of the Highland area was previously surveyed by Kerr McGee Nuclear in 1985 as a part of the South Powder River Basin Solution Mining Project application submitted to WDEQ in April, 1988. Appropriate portions of this cultural resources inventory are provided as Addendum D3-3C.

All addenda are included in a separate binder in order that the information can be kept confidential. It is concluded in all surveys within the Highland area that the sites mapped are of no significant historical or archeological value.

2.5 METEOROLOGY

2.5.1 General

The project permit area is located in eastern Wyoming, where climate can generally be classified under the Koppen System (C. R. Itchfield, 1974) as semiarid and cool. The climate in the area is rather dry due to the effective barrier to moisture from the Pacific Ocean offered by the Cascades, Sierra Nevada, and the Rocky Mountains when winds are from the west and northwest. The mountain ranges in the west-central portion of the state, which are oriented in a general north-south direction, are perpendicular to the prevailing winds. These ranges also tend to restrict the passage of storms and thus restrict precipitation in the eastern part of Wyoming.

The official weather station closest to the permit area is located at the Natrona County International Airport near Casper, Wyoming. Meteorological data (wind speed, wind direction, and temperature) for the project area are taken from the Natrona County International Airport.

2.5.2 Precipitation

Mean annual precipitation for the area is approximately 12 inches (Normals, Means & Extremes, NOAA, Casper, WY, 2000) and the average yearly total evaporation is reported as 44 inches (U.S. Weather Bureau, NOAA, 1985). The net evaporation for the area is taken as the difference between these numbers and is calculated to be 32 inches per year.

The bulk of the annual precipitation is received from moisture laden easterly winds, particularly during spring months. Most of this precipitation is in the form of rain although occasional heavy wet snowfalls in spring months are not uncommon, but these snows are short-lived. Summer precipitation is almost exclusively from thundershower activity and under normal conditions provides sufficient moisture to maintain growth of rangeland grasses. Seasonal snowfall averages about 72 inches, but the water content of winter snow is low owing to the cold temperatures at which it usually occurs. The very dry strong west and southwest winds following these winter snows tend to clear the snow from the rangelands thereby permitting winter grazing of livestock.

The average number of days throughout the year with one hundredth of an inch of precipitation is near 90, most of which occur during the spring and summer. Consequently the absence of rain clouds or clouds usually associated with precipitation results in bright days with considerable sunshine throughout the winter season.

2.5.3 Temperature

The dryness of the air has a considerable modifying effect in preventing discomfort during the warm summer months as well as during periods of subzero temperatures in the winter. The average maximum temperature during summer months of June, July and August is 83° F, while during the winter, the average minimum temperature is 15° F. The average temperature is 67° F (19° C) in the summer and 26° F (-3° C) in the winter. Extreme temperatures in these respective seasons have reached as high as 104° F (40° C) and as low as -40° F (-40° C), between 1961 and 1990. The average length of the growing season is 129 days, with the average date of the last freezing temperature in spring May 22, and the first freezing temperature in fall September 28.

2.5.4 Wind

Wind speed data from the Natrona County International Airport is used to estimate wind speed and direction for the project site. The mean annual wind speed at the airport for the years 1961-1990 is 13 miles per hour from the southwest. The highest mean monthly wind speed occurs in January and is 16.4 miles per hour from a west-southwesterly direction. The lowest mean monthly wind speed occurs in July and is reported as 10.1 miles per hour from the west-southwesterly direction. The maximum observed wind speed maintained for longer than one minute was 81 mph from the southeast during March, 1956. Figure 2-3 is a wind rose diagram for the Casper area indicating that the prevailing winds are from the southwest. See Appendix D-4 for more detailed climatology data.

2.6 GEOLOGY AND SEISMOLOGY

2.6.1 Regional Geology

The permit area is located in the southern portion of the Powder River Basin, which is in the unglaciated Missouri Plateau section of the Great Plains physiographic province (Thornbury, 1969). The Missouri Plateau includes the part of the Great Plains north of the northern boundary of Nebraska, with the exception of the Black Hills. It is bounded by the Pine Ridge Encarpment to the south, the Bighorn and Laramie mountains to the west, the Missouri Escarpment to the east, and the glacial moraine plains north of the Missouri River to the north. The Missouri Plateau has often been mistakenly classified as a plain; in fact, it comprises a number of basins separated by uplifts.

The Powder River Basin, named after the north-flowing Powder River, covers approximately 2000 square miles. It is bounded on the west by the Bighorn Mountains and the Casper Arch and on the south by the Laramie Range-Hartville Uplift. The northern and eastern margins of the basin are less distinct. The broad Black Hills Uplift forms the eastern demarcation, the Miles City Arch forms the northern boundary.

The Powder River Basin is synclinal, with the synclinal axis oriented in a general northwest-southeast direction along the western margin of the basin. East of the axis, the sedimentary rock strata exposed at the surface dip gently (about 1° to 2°) to the west. West of the axis, the strata dip more steeply (as much as 20°) to the east.

The basin incorporates a sedimentary rock sequence that has a maximum thickness of about 15,000 feet along the synclinal axis. The sediments range in age from Recent (Holocene) to early Paleozoic (Cambrian) (500 million to 600 million years ago) and overlie a basement complex of Precambrian-age (more than a billion years old) igneous and metamorphic rocks (see Figure D-5.3 of Appendix D-5). Of particular interest in the permit area are the Tertiary-age formations:

Formation	Age (Years)
White River (Oligocene)	25-40 million
Wasatch (Eocene)	40-60 million
Fort Union (Paleocene)	60-70 million

The uranium-bearing sandstones to be mined lie within the Fort Union and Wasatch formations. With the exception of the Quaternary sediments in the drainage valleys, these are the only formations that crop out in the permit area.

The Powder River Basin represents a localized depression in what was, for long geologic time, a large basin extending from the Arctic to the Gulf of Mexico. During Paleozoic and Mesozoic time, the configuration of this expansive basin changed as the result of uplifts on its margins. The northern and southern connections of the basin to the open ocean also changed position several times before they both finally closed. By the end of the Cretaceous, many intrusive uplifts had occurred and the remaining portions of the large basin were well removed from connections to the sea.

In the late Paleocene marked uplift, inland masses surrounding the Powder River Basin and accelerated subsidence in the southern portion of the basin resulted in thick sequences of arkosic sediments being deposited. Arkosic sediments were derived from the granitic cores of the Laramie and Granite Mountains exposed to weathering and erosion by the Laramide uplift. Uranium mineralization contained in these arkosic facies constitute the oldest ore zones in the permit area.

Continued acceleration of uplift in the Laramie and Granite Mountains in central Wyoming resulted in further deposits of coarse clastic sediments. Since drainage was generally northward, the finer sediments were carried north toward the center of the basin.

Rapidly flowing streams cut channels through the accumulating sediments near the basin margins. These streams eventually filled with coarse clastic sediments, providing zones of high transmissivity for mineralizing solutions that entered the area later. During that time, and well into the Eocene, the Powder River Basin remained largely flat and portions of it were intermittently cut off from the main channels of surface water flows. However, ample water, provided by runoff from the mountainous uplifts, produced substantial swamps that eventually became large coal deposits.

The Eocene deposits (Wasatch Formation) in the Powder River Basin characteristically consist of nearly 1000 feet of clays and siltstones containing widespread discontinuous lenses of coarse, cross-bedded arkosic sandstones. The coarsest of these are to be found in the southwestern portion of the basin and are the host rock for the uranium deposits to be mined. These sediments gradually diminish in size northward. North of Pumpkin Buttes, the Wasatch sediments become markedly finer-grained and similar in appearance to the Fort Union Formation.

Near the end of the Eocene, northward tilting and deep weathering with minor erosion took place in the basin. Uranium migration and concentrations occurred at that time. Subsidence resumed in the late Oligocene and continued through the Miocene and Pliocene. A great thickness of tuffaceous sediments was deposited in the basin during at least a part of this period of subsidence. By the late Pliocene, regional uplift was taking place, leading to a general rise in elevation of several thousand feet. The massive erosional pattern that characterizes much of the Powder River Basin began with this Pliocene uplift and continues to the present.

The tectonic change at the end of the Paleocene is reflected in some locations by either a depositional or an erosional disconformity between the Fort Union Formation and the overlying Wasatch Formation. As uplift of the highlands continued into the Eocene epoch, the Fort Union Formation was eroded at the margins of the basin and the material redeposited toward the center. The rapidly accumulating sediments of the Wasatch Formation were deposited increasingly farther out into the basin.

2.6.2 Site Geology

The Wasatch Formation is the youngest bedrock unit throughout most of the permit area. It consists of interbedded claystones, silty sandstones, and relatively clean sandstones. In the vicinity of the Pumpkin Buttes, approximately 40 miles north of the permit area, the Wasatch Formation is known to be 1575 feet thick (Sharp and Gibbons, 1964). However, active stream erosion has left only about 500 feet of the formation in the central and east-central portions of the permit area, and none of the formation in the southwestern portion of the area. The surface contact between the Wasatch Formation and the underlying Fort Union Formation, roughly parallels the axis of the Powder River Basin, through the southwestern portion of the permit area. The interbedded claystones, siltstones, and relatively clean sandstones in the Wasatch vary in degree of lithification from uncemented to moderately well cemented sandstones, and from weakly compacted and cemented claystones to fissile shales.

The Fort Union Formation in the Powder River Basin is lithologically similar to the Wasatch Formation. Throughout the permit area, the Fort Union includes interbedded silty claystones, sandy siltstones, relatively clean sandstones, and claystones, with a few thin coal seams occurring locally. The degree of lithification is quite variable, ranging from virtually uncemented sands to moderately well cemented siltstones and sandstones. The total thickness of the Fort Union in the area is approximately 3000 feet.

Both the Wasatch and Fort Union strata are highly lenticular, with numerous facies changes within short lateral distances. In some cases it is essentially impossible to trace even relatively thick stratigraphic units more than a few thousand feet. On the other hand, some units can be traced for miles.

One shale, marking the top of the Fort Union Formation, is believed to persist throughout the permit area. This shale, designated locally as the "P" shale, averages over 60 feet thick. Approximately 500 feet of alternating sandstones and shales of the Wasatch Formation overlie the "P" shale in the vicinity of the Smith Ranch Main Office/CPP. The sandstone beds generally are 40 to 100 feet thick and alternate with shales that range from 20 to 50 feet thick. Some of the lower sands in the Wasatch are mineralized. Below the "P" shale are about 400 feet of sediments, largely sandstone, that include the mineralized zones to be mined. See Appendix D-5 for additional regional and site geological data.

2.6.3 Seismology

The area of east central Wyoming where the project site is situated lies in a seismically relatively quiet region of the United States. Although distant earthquakes may produce shocks strong enough to be felt on the Powder River Basin, the region is ranked to be one of minor seismic risk, as shown on Figure 2-4. Few earthquakes capable of producing damage have originated in this region as indicated on the Regional Seismicity Map provided on Figure 2-5. The seismically active region closest to the site is the Intermountain Seismic Belt of the Western United States which extends in a northerly direction between Arizona and British Columbia. It is characterized by shallow earthquake foci between 10 and 25 miles in depth, and normal faulting. Part of this seismic belt extends along the Wyoming-Idaho border, more than 250 miles west of the permit area and would be the most probable source of earthquakes affecting the project site.

Table 2-3 lists the largest recorded earthquakes that have occurred within 300 miles of the SR-HUP site and gives the maximum ground acceleration that would be realized at the site as a result of these disturbances from a period of 1870 through 1995 (Source USGS, 2000). The earthquake of highest intensity that occurred nearest the site is presumed to be the Casper, Wyoming earthquake of 1897. This earthquake has been assigned a probably maximum intensity of VII, based on damage incurred. Figure 2-6 provides a means for estimating the intensity of earth tremors at the Smith Ranch site originating from such an epicentral intensity 47 miles away. The small figure insert shows that the probable magnitude for an earthquake with an epicentral intensity of VII is 5.67 on the Richter Scale. Assuming that the distance from the CPP to the epicenter is approximately 47 miles, then the acceleration of the ground at the site would be 0.04 g, or slightly greater than intensity V.

No faulting in the project area has been reported, nor is any faulting evident from geophysical log interpretations. The ground accelerations reported in Table 2-2 (.01 g to .04 g) are not considered to be of a magnitude that would disturb the operations or facilities in the unlikely event that an earthquake occurred during the life of the mine.

2.7 HYDROLOGY

2.7.1 Surface Waters

The permit area is located in the southern part of the Powder River Basin in the Sage Creek drainage of North Platte River drainage system and the Box Creek drainage of the Cheyenne River drainage system. The only natural surface water in the permit area is ephemeral runoff in response to limited rainfall and snowmelt. Surface runoff is very limited, as reflected by a 1957-1958, USGS survey of the Box Creek drainage system which starts near the center of the permit area and flows east. The recorded mean flow from the 109 square mile drainage for 1957 and the first half of 1958 was 1.79 CFS (Table 2-3). Stock ponds collect some runoff for watering livestock, however these ponds are dry much of the time.

2.7.2 Groundwater

Descriptions of the geologic formations of the Powder River Basin and their hydrologic properties have been discussed in numerous publications (Hodson, et al., 1973; Hodson, 1971; Whitcomb, et al., 1958; Huntoon, 1976; Davis, 1976) and summarized in Appendix D-5 (Geology). The primary hydrologic units beneath the permit area include alluvial deposits, the Wasatch Formation, the Fort Union Formation, and the Cretaceous-age Lance and Fox Hills formations (see Table D-6.1 of Appendix D-6). Some of these units are classified as aquifers and can yield groundwater to wells and springs. The locations of water sources in this area are shown in Appendix D-6.

Alluvium. The alluvial deposits within the permit area consist of thin, unconsolidated, poorly stratified clays, silts, sands, and gravels. The total thickness of these deposits is estimated to range from less than 1 foot to 30 feet. There are no known wells within the permit area less than 30 feet deep and only three wells less than 100 feet deep, therefore very little information on water in the alluvial deposits, if any, is available.

Small amounts of precipitation infiltrate the alluvium during part of the year and the intermittent flow in drainage channels across the alluvium may provide some recharge to localized perched water tables in the alluvium. However, since the water table is typically more than 100 feet below the land surface throughout the permit area, most of the recharge flows through the alluvium to the Wasatch formation. In a drainage in the southwest portion of the area, a shallow water table appears to be the source of water for a small water hole but the potential for the development of the alluvium as a groundwater supply is not promising.

Wasatch Formation. The Wasatch Formation typically is lenticular fine- to coarse-grained sandstones with interbedded claystones and siltstones. This formation ranges from 0 to approximately 500 feet thick in the permit area and includes some of the more important shallow aquifers in the Powder River Basin.

Most properly constructed wells completed in a Wasatch aquifer yield from 5 to 15 gallons per minute (gpm). However, the water supply well (WW-103) for the SR-HUP located at the Smith Ranch Main Office/CPP can produce 140 gpm from a completion interval of approximately 120 feet containing four separate lenses. This well is 474 feet deep.

For the most part, the upper Wasatch aquifers occur under water table (unconfined) conditions. Artesian (confined) aquifers near the base of the formation are separated from overlying formations and from each other by impermeable claystone or mudstone layers.

The Wasatch formation is considered a good water supply for limited development, however the formation does crop out in the permit area and the amount of groundwater available is difficult to assess. Hydrologic characteristics calculated from the Q-Sand pump test are believed representative of the deeper Wasatch aquifers (Appendix D-6).

Fort Union Formation. The Fort Union Formation underlies the Wasatch Formation beneath most of the permit area but in the southwestern portion of the area, the Fort Union lies directly beneath the surface. Typically, it is comprised of lenticular sandstones with interbedded claystones and siltstones. The Fort Union is as much as 3000 feet thick beneath the Smith Ranch Main Office/CPP site.

The Fort Union Formation also include important aquifers in the Powder River Basin, and most of the wells in the vicinity of the plant site penetrate this formation. While most wells tap these aquifers for small (5 to 20 gpm) water volumes, test wells completed in the Fort Union have produced as much as 560 gpm (see Table D-6.3 of Appendix D-6).

The Wasatch and Fort Union aquifers are separated by a relatively thick impermeable shale (locally designated the "P" shale). Similar separation of aquifers within the Fort Union are common, and wells completed in these layers are often found to be under artesian pressure.

Substantial volumes of water can be produced from the Fort Union in the Southern Powder River Basin as demonstrated by the Bill Smith Mine. The mine produced 1500 to 1700 gpm from initial development until the mine was allowed to flood, a period of several years. Hydrologic characteristics of the Fort Union are illustrated by the O-Sand pilot pump test and the Section 25 and Section 35 pump tests summarized in Appendix D-6

Lance and Fox Hills Formations. These formations underlie the Fort Union Formation beginning at depths of about 3000 feet in the permit area. Data from other areas indicate well yields seldom exceed 100 gpm from these aquifers, and the groundwater reserves may not be large. Little is known of their hydrologic characteristics, as no water wells are known to tap these aquifers in the vicinity of the permit area, it appears unlikely that these formations will be tapped for water supply in the near future because of depth and availability of water from the Wasatch and Fort Union Formation.

The Wasatch and the Fort Union aquifers are of the greatest importance to the proposed mining activities since they contain all the mineralized zones currently proposed for development. Results of the initial pump tests conducted in these formations are included in Appendix D-6.

2.8 ECOLOGY

Topography in the permit area has a general gradient from northwest to the southeast. The northern and southwestern portions of the permit area contain the higher ground. The ephemeral channel of Sage Creek runs to the southeast while the ephemeral channel of Box Creek drains to the east.

Soils on the hilltops and higher areas are shallow and sometimes associated with materials from rock outcrops. The soils become deeper on the side slopes of the hills and in the lower areas and drainages. Soils in the permit area generally pose no special problems and are rated as good for reclamation purposes. A low intensity soil survey, as well as detailed soils information, is contained in Appendix D-7.

Vegetation is a typical northern plains short grass prairie forage characteristic of areas of low annual precipitation. Dominant plant species present are Sage brush, Western Wheatgrass, Needlegrasses, Blue Gramma and Threadleaf Sedge. A vegetation study presented in Appendix D-8 provides details including productivity and cover information.

The wildlife in the area is typical for the region. Studies and observations of wildlife on the permit area and in the surrounding vicinity are presented in Appendix D-9. Important game species include the Pronghorn Antelope, Cottontail Rabbit, Sage Grouse, Mourning Dove and Mule Deer. Non-game species are typical of the sage brush grassland habitat in the region. No rare or endangered species were observed.

2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS

A background pre-mining radiological survey of the O-Sand pilot area was conducted and is summarized in Table 2-4. Background radiation for the surface were normal and no anomalies were found. Background gamma surveys were conducted on a 200 foot grid pattern for Wellfield Nos. 1 through 4. The results of these surveys show that the average background gamma radiation levels range from 10 to 17 μR/hr. Comparison of these data with historic background data collected from the Smith Ranch and HUP Air Monitoring Stations shows that the gamma levels are in close agreement.

A description of air particulate, radon-222, and gamma radiation background data from the Air Monitoring Stations is provided in Chapter 5. Radiological data concerning groundwater in the vicinity are reported in the baseline water quality data in Appendix D-6.

2.10 BACKGROUND NON-RADIOLOGICAL CHARACTERISTICS

Background non-radiological characteristics of the site are discussed in the applicable sections of Appendix D. Groundwater background concentrations of substances that could potentially be mobilized by leaching such as trace metals are presented with other baseline values as part of the groundwater quality data in Appendix D-6.

Because of the relatively low surface disturbance necessary to construct the wellfield and recovery facilities, no additional atmospheric pollution in the form of dust is anticipated resulting in significant change to the existing air quality.

TABLE 2-1

POPULATION TRENDS IN

CONVERSE AND NATRONA COUNTIES

1970- 1999

Place	1970	1980	1990	1995	1999
Casper	39,361	51,016	46,742	48,783	48,283
Glenrock	1,515	2,736	2,153	2,291	2,357
Douglas	2,677	6,030	5,076	5,435	5,655
Converse Co.	5,938	14,069	11,128	11,937	12,396
Natrona Co.	51,264	71,856	61,226	63,801	63,151

Sources: Population Estimates for Places, Annual Time Series, July 1, 1990 to July 1, 1998. U.S. Census Bureau, Washington, DC.

Population Estimates Program Population Division, U.S. Census Bureau, Washington, DC. March 2000.

Wyoming Data Handbook 1985, Department of Administration and Fiscal Planning Control, Division of Research and Statistics.

Table 2-2

MAXIMUM EXPECTED EARTHQUAKE INTENSITIES AND GROUND ACCELERATIONS AT THE SMITH RANCH SITE

	Maximum Epicentral Intensity of Record	Distance from Epicenter to Smith Ranch Site	Maximum Probable Intensity at Smith Ranch Site	Maximum Ground Acceleration at Smith Ranch Site
Hebgen Lake, Montant (1959)	X	285 miles	III-IV	Less than 0.01 g
Northeastern Nebraska (1934)	VI	121 miles	IV	Approximately 0.02 g
Black Hills, South Dakota (1928)	V	100 miles	III-IV	Less than 0.02 g
Powder River Basin (1967)	VI	36 miles	IV	Approximately 0.02 g
Casper, Wyoming (1897)	VII	47 miles	V-VI	Approximately 0.04 g

Table 2-3

Geological Survey Water Supply Paper 1509
Extracted From
Surface Water Supply of the United States - 1957
Part 6-A Missouri River Basin
above Sioux City, Iowa

Cheyenne River Basin
Box Creek near Bill, Wyoming

<u>Location</u> - Lat 43°06', long 105°15', in SE¼ sec. 9, T36N, R70W, on left bank 12 ft below bridge on State Highway 59 and 9.7 miles south of Bill.
<u>Drainage area</u> - 109 sq mi
<u>Records available</u> - July 1956 to September 1957
<u>Gage</u> - Water-stage recorder. Datum of gage is 4,694.12 ft above mean seal level (State Highway benchmark).
<u>Extremes</u> - 1956: No flow during period July to September.
1956-57: Maximum discharge during water year, 1,190 cfs June 9 (gage height, 7.25 ft), from rating curve extended above 70 cfs on basis of slope-area determination of peak flow; no flow at times.
<u>Remarks</u> - Records good except those above 70 cfs, which are fair, and those for period of ice effect or no gage-height record, which are poor. No flow July 14 (first day of record) to Dec. 7, 1956. Many small stock reservoirs above station.

Rating table, water year 1956-57 (gage height, in feet, and discharge, in cubic feet per second)
(Shifting-control method used May 16-18, 20, 21, 25-27, July 29 to Aug. 9)

2.4	0	2.8	1.6	4.0	45
2.5	.1	3.0	4.2	4.5	92
2.6	.4	3.3	11	5.0	175
2.7	.8	3.6	22	6.0	470

Discharge, in cubic feet per second, water year October 1956 to September 1957

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1			0		0	0	0	0	5.7	22	0	0.1
2			0		0	0	0	.1	3.1	*7.2	0	.1
3	(*)		0		0	0	0	.1	1.8	3.8	0	.1
4			0		0	0	0	.1	1.4	2.1	0	.2
5			0		0	0	0	.1	*1.2	1.4	*0	.2
6			0		b.1	0	0	.1	1.0	.9	0	.2
7			0		b.1	0	0	.1	1.0	.5	0	.2
8		(*)	.2		b.1	0	0	.2	1.2	.4	.1	.2
9			.4		b.2	.1	0	.2	*51	.3	.1	.2
10			.4		b.2	.1	0	.2	182	.2	.1	.2
11			.1		b.2	.1	0	.1	11	.1	0	.2
12			.1		*b.2	.1	0	.3	5.0	*.1	0	.2
13			.1		b.2	*.1	0	.4	*3.4	1.3	0	*.6
14			*.1		b.2	.1	0	1.1	3.2	.6	0	.2
15			.1		.1	.1	0	.9	2.3	.2	.1	.2
16			0		.1	.1	0	1.4	2.3	.1	.1	.2
17			0		0	.1	0	*7.7	2.6	.1	*.1	.2
18			0		0	.1	0	3.6	4.2	.1	.1	.2
19			0		0	.1	0	2.9	2.6	.1	.1	.2
20			0		0	.1	.4	3.9	*1.6	.1	.1	.2
21			0		0	.1	.3	28	*29	.2	.1	.2
22			0		0	.1	.1	6.8	*22	.1	.1	.2
23			0	(*)	0	.1	0	3.9	9.2	.1	.1	.2
24			0		.1	.1	.3	4.6	4.4	.1	.1	.2
25			0		0	.1	.5	*67	2.7	.1	.1	.2
26			0		0	.1	.4	13	2.1	.1	.1	.1
27			0		0	.1	.2	*8.9	2.1	.1	.1	.1
28			0		0	.1	.1	6.3	2.0	.1	.1	.1
29			0		-	.1	*0	*3.4	1.4	.1	.2	.1
30			0		------	.1	0	37	208	.1	.2	.1
31		------	0		------	.1	------	35	------	.1	.1	------
Total	0	0	1.5	0	1.8	2.3	2.3	237.5	570.5	42.8	2.2	5.6
Mean	0	0	0.05	0	0.06	0.07	0.08	7.66	19.0	1.38	0.07	0.19
Ac-ft	0	0	3.0	0	3.6	4.6	4.6	471	1,130	85	4.4	11

Calendar year 1956: Max - Min - Mean - Ac-ft -
Water year 1956-57: Max 208 Min 0 Mean 2.37 Ac-ft 1,720

<u>Peak discharge (base, 100 cfs)</u>. - May 21 (4 a.m.) 118 cfs (4.69 ft); May 25 (11 a.m.) 190 cfs (4.95 ft); May 30 (9 a.m.) 141 cfs (4.83 ft); June 9 (11:30 p.m.) 1,190 cfs (7.25 ft); June 21 (5 p.m.) 121 cfs (4.76 ft); June 30 (6 a.m.) 840 cfs (6.7 ft).
*Discharge measurement or observation of no flow made on this day.
b Stage-discharge relation affected by ice.
<u>Note</u> - No gage-height record Sept. 14-30; discharge estimated on basis of recorded range in stage.

Table 2-3 (Cont.)

U.S. Geological Survey Water Supply Paper 1559
Extracted From
Surface Water Supply of the United States - 1958
Part 6-A Missouri River Basin
above Sioux City, Iowa

Cheyenne River Basin
3796. Box Creek near Bill, Wyoming

Location - Lat 43°06', long 105°15', in SE¼ sec. 9, T36N, R70W, on left bank 12 ft downstream from bridge on State Highway 59 and 9.7 miles south of Bill.
Drainage area - 109 sq mi.
Records available - July 1956 to June 1958 (discontinued).
Gage - Water-stage recorder. Datum of gage is 4,694.12 ft above mean sea level (State Highway bench mark).
Extremes - Maximum discharge during period, 15 cfs May 7 (gage height, 3.37 ft); no flow at times.
1956-58: Maximum discharge, 1,190 cfs June 9, 1957 (gage height, 7.26 ft), from rating curve extended above 70 cfs on basis of slope-area measurement of peak flow; no flow at times each year.
Remarks - Records fair. Many stock reservoirs above station.

Rating table, Oct. 1 to June 30, 1958 (gage height, in feet, and discharge, in cubic feet per second)

2.4	0
2.5	.5
2.6	1.6
2.7	2.9
3.0	8.2

Discharge, in cubic feet per second, October 1957 to June 1958

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1		0.1	0.1	0.1	0.1	0.2	3.4	1.4	0.6			
2		.1	.1	.1	.1	.1	*3.4	1.1	.6			
3		.1	*.1	.1	.1	.1	*2.4	.6	.6			
4		.1	0	.1	*.1	.1	2.8	.5	.6			
5		.1	0	0	.1	.1	5.9	.4	.7			
6		.1	.1	0	.1	*.1	5.9	.3	.7			
7	0.1	.1	0	0	.1	.1	4.4	2.6	.7			
8		0	0	0	.1	.2	3.0	6.0	.6			
9		0	0	*0	.1	.2	2.5	2.2	.6			
10		.1	0	0	.1	.1	2.2	1.5	.6			
11		.1	.1	0	.1	.1	*2.2	1.1	*.8			
12		.1	0	.1	.1	.1	2.0	.8				
13		.1	0	0	.1	.1	1.9	.6				
14		.1	.1	.1	.1	.1	1.6	*.5				
15	*.1	.1	.1	.1	.1	.1	1.2	1.2				
16	.1	.1	.1	.1	.1	.1	1.1	1.9	.6			
17	.1	.1	.1	.1	.1	.1	1.0	1.6				
18	.1	.1	.1	.1	.1	.1	.7	1.4				
19	.1	.1	.1	.1	.2	.4	.8	1.0				
20	.1	.1	.1	.1	.2	1.4	.7	.8				
21	.1	.1	.1	.1	.2	2.0	.8	.6				
22	.1	.1	0	.1	.2	1.9	1.2	.6				
23	.1	.1	.1	.1	.2	1.7	1.6	.6				
24	.1	0	.1	.1	.2	1.9	2.0	.7				
25	.1	0	.1	.1	.2	1.4	2.6	.8	.3			
26	.1	0	.1	.1	.2	1.6	3.5	.5				
27	.1	0	0	.1	.1	2.2	2.8	.4				
28	.1	0	0	.1	.3	2.1	2.0	.4				
29	.1	.1	0	.1	-	2.1	1.7	.4				
30	.1	.1	0	.1		4.0	1.7	.5				
31	.1	------	0	.1	------	6.7	------	.6	------			------
Total	3.1	2.3	1.7	2.3	3.8	31.5	69.0	33.8	15.2			
Mean	0.10	0.06	0.05	0.07	0.14	1.02	2.30	1.09	0.51			
Ac-ft	6.1	4.6	3.4	4.6	7.5	62	137	67	30			

Calendar year 1957: Max 208 Min 0 Mean 2.39 Ac-ft 1,730
Water year 1957-58: Max - Min - Mean - Ac-ft -

Peak discharge (base, 100 cfs). - No peak above base.

* Discharge measurement made on this day.
Note - No gage-height record Oct. 1-14, June 12-30; discharge estimated on basis of weather records, recorded range in stage, and normal recession.

TABLE 2-4

O-SAND BASELINE SURFACE RADIOLOGICAL ENVIRONMENTAL MONITORING

Sample Type	Sample ID	Sample Location	Depth cm	Ra 226 pci/g	Th 230 pci/g	u mg/g	Date
Vegetation	OI-7	Wellfield	NA	0.33		.002	4/17/84
	OI-9	Wellfield	NA	3.22	-	.100	4/17/84
	D-4	Down Drainage	NA	1.69	0.04	.006	8/13/84
	F-2	Wellfield	NA	0.76	0.02	.002	8/13/34
Soil	OI-9	Wellfield	5	2.15	1.18	.006	4/17/84
	OI-9	Wellfield	15	1.57	0.99	.005	4/17/84
	OI-7	Wellfield	5	2.35	1.36	.006	4/17/84
	OI-7	Wellfield	15	1.14	0.87	.006	4/17/84
	U-1	Up Drainage	5	0.74	0.40	.002	8/13/84
	u-1	Up Drainage	15	0.61	0.35	.002	8/13/84
	F-2	Wellfield	5	1.34	0.57	.007	8/13/84
	F-2	Wellfield	5	1.20	0.70	.008	8/13/84
	F-2	Wellfield	15	0.95	0.80	.002	8/13/84
	F-2	Wellfield	15	0.90	1.10	.001	8/13/84
	F-3	Wellfield	5	1.34	0.30	.001	8/13/84
	F-3	Wellfield	15	0.90	0.50	.002	8/13/84
	F-7	Wellfield	5	5.10	4.00	.017	8/13/84
	F-7	Wellfield	15	2.45	2.00	.006	8/13/84
	F-8	Wellfield	5	1.84	0.70	.003	8/13/84
	F-8	Wellfield	15	1.58	1.52	.002	8/13/84
	F-9	Wellfield	5	1.40	0.80	.002	8/13/84
	F-9	Wellfield	15	1.46	0.90	.002	8/13/84
	D-4	Down Drainage	5	15.00	3.80	.029	8/13/84
	D-4	Down Drainage	5	18.00	8.10	.033	8/13/84
	D-4	Down Drainage	15	3.60	0.90	.006	8/13/84
	D-4	Down Drainage	15	4.60	1.80	.006	8/13/84
	D-5	Down Drainage	5	7.40	3.40	.015	8/13/84
	D-5	Down Drainage	15	1.25	1.40	.002	8/13/84
	D-6	Down Drainage	5	1.05	1.60	.002	8/13/84
	D-6	Down Drainage	15	0.80	0.50	.001	8/13/84

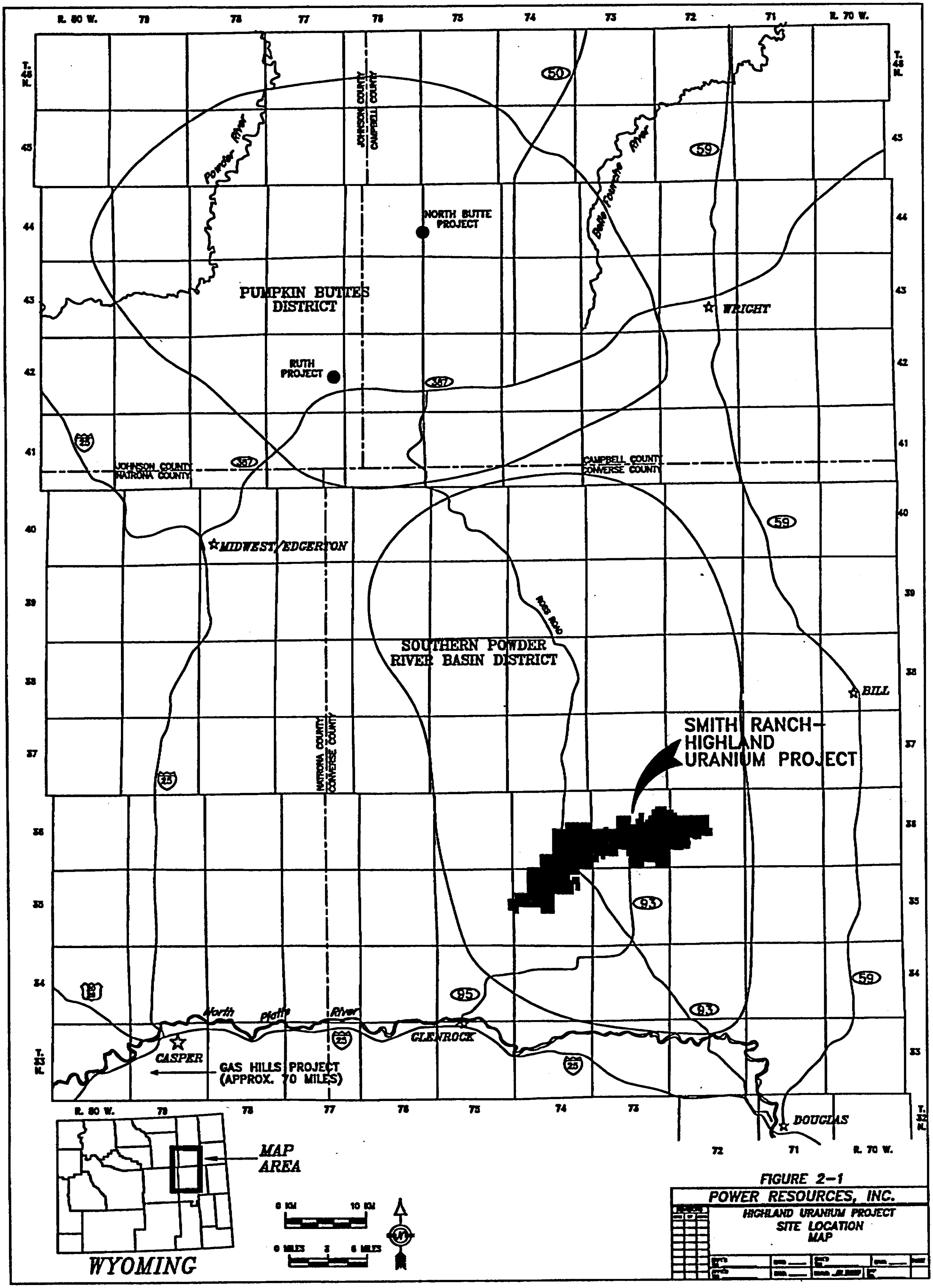
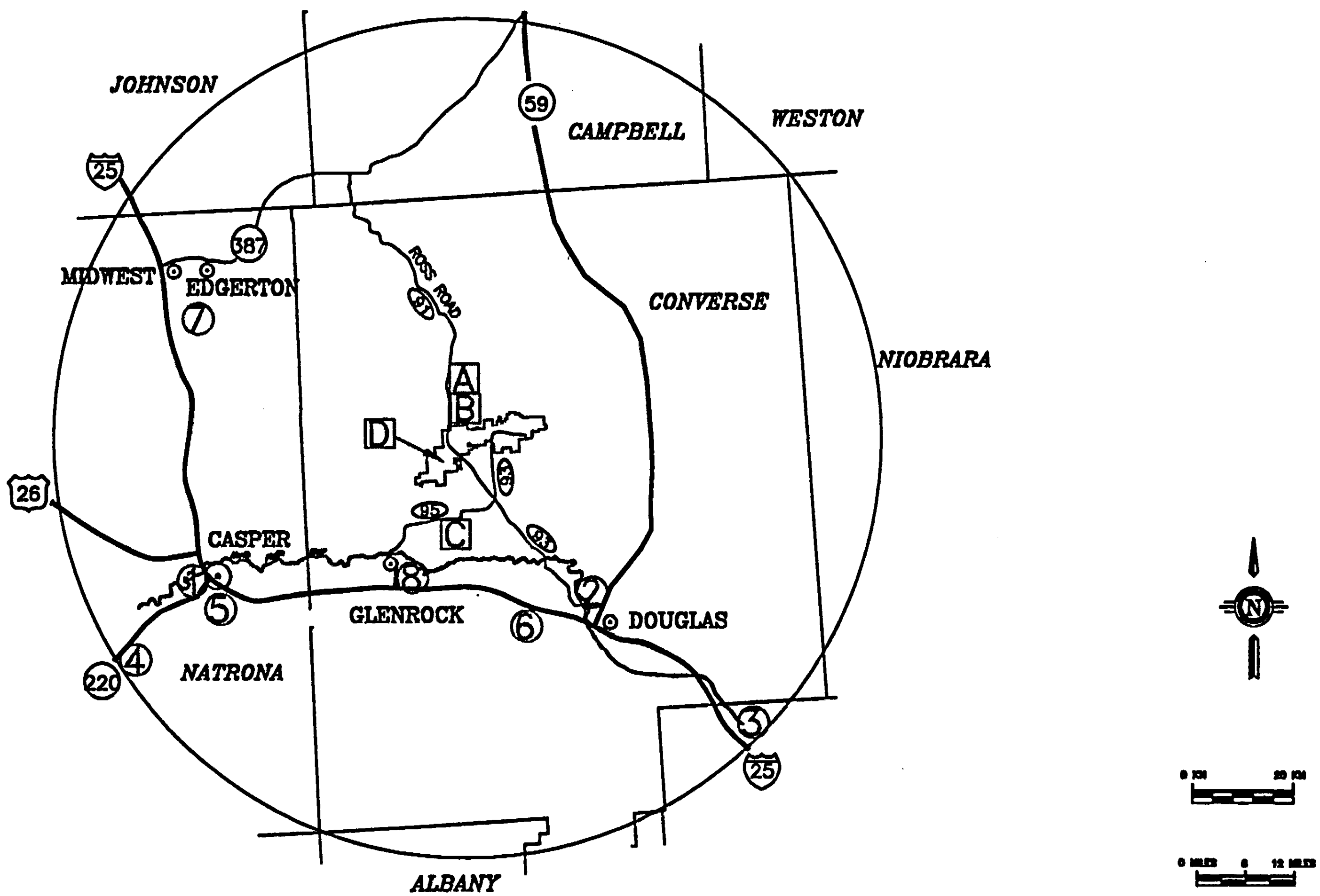


FIGURE 2-1
POWER RESOURCES, INC.
HIGHLAND URANIUM PROJECT
SITE LOCATION MAP



A URANIUM MINING AREAS

A BEAR CREEK URANIUM CO. (RECLAIMED)
B PIONEER NUCLEAR (RECLAIMED)
C LEUENBERGER SITE (RECLAIMED)
D SMITH RANCH – HIGHLAND URANIUM PROJECT

① LOCATION OF POINTS OF INTEREST

1 FORT CASPER
2 FORT FETTERMAN
3 GLENDO STATE PARK
4 ALCOVA RECREATION AREA
5 CASPER MTN. RECREATION AREA
6 AYRES NATURAL BRIDGE
7 SALT CREEK OILFIELD – TEAPOT DOME
8 DAVE JOHNSTON COAL POWER PLANT

\DRAW\NRC_PERMIT_02_03\FIG_2_2_NRC_LIC.DWG

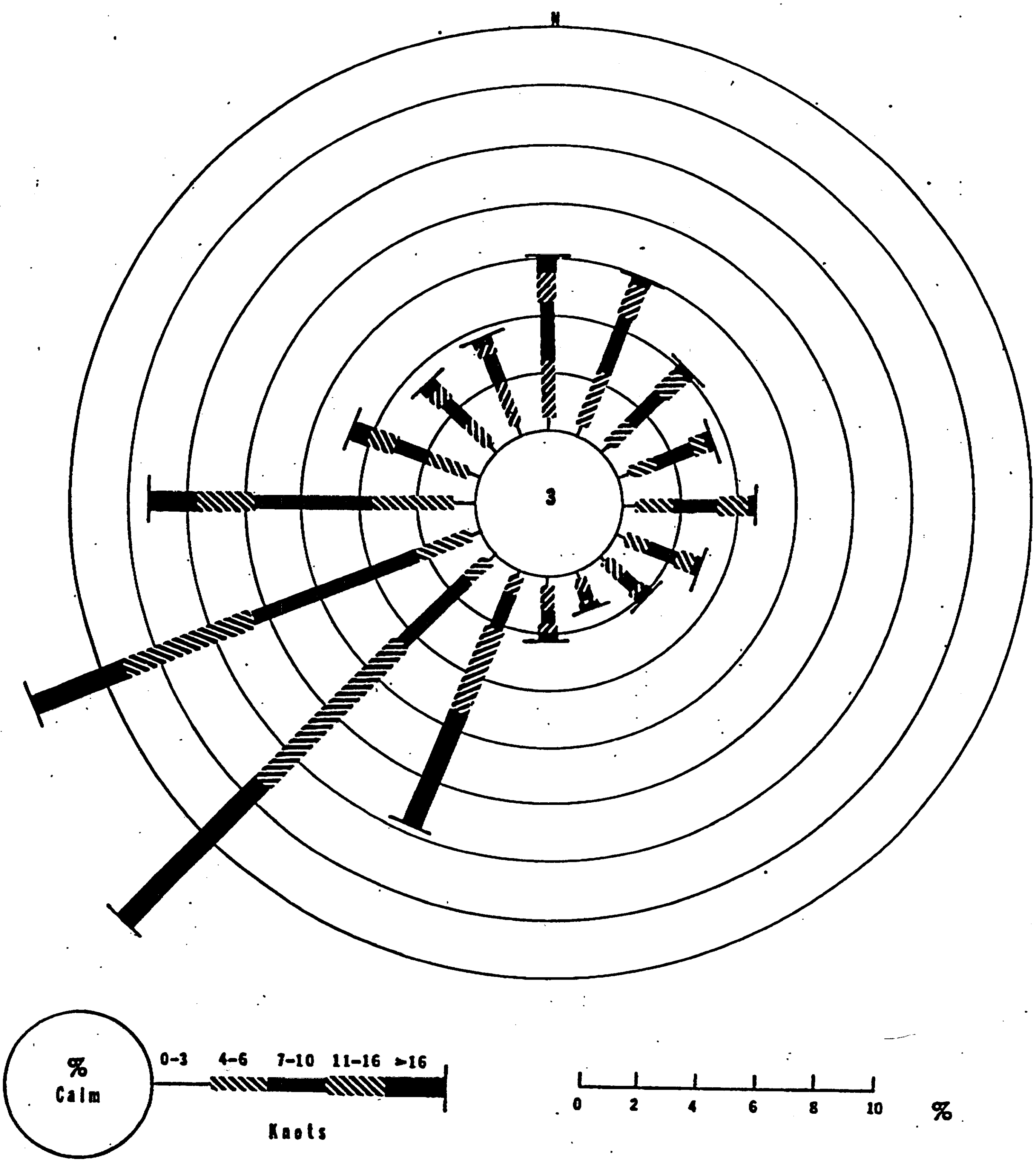
FIGURE 2-2

POWER RESOURCES, INC.

SMITH RANCH-HIGHLAND URANIUM PROJECT
POPULATION & ACTIVITY CENTERS WITHIN 60 MILES OF THE SMITH RANCH-HIGHLAND URANIUM PROJECT OFFICE & CENTRAL PROCESSING PLANT SITE

REVISIONS		
NO.	DATE	BY

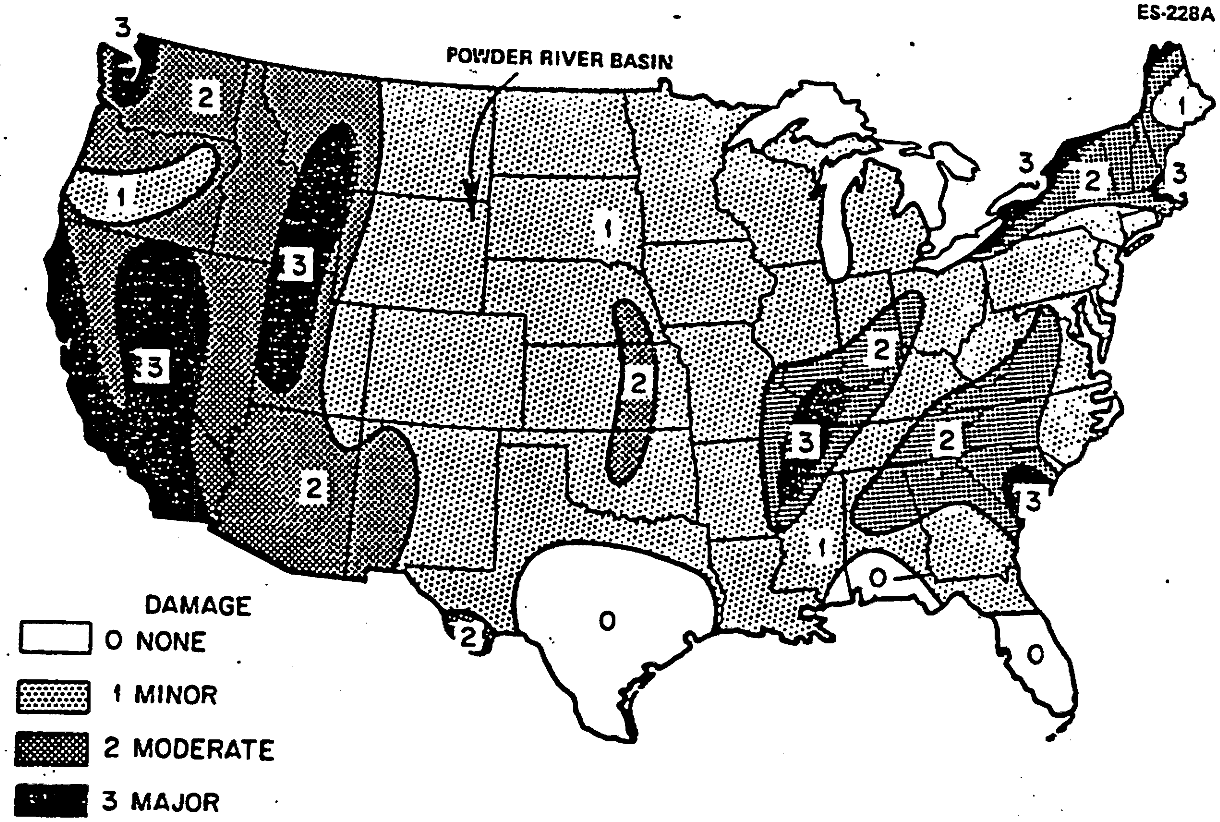
FIGURE 2-3



SOURCE: Based on the National Climatic Center's STAR program calculation for Casper (U.S. Department of Commerce, 1973).

Figure 2-3 – ANNUAL WIND ROSE FOR CASPER, WYOMING
(Period of Record, 1967 – 1971)

FIGURE 2-4



Seismic risk map of the United States. <u>Source:</u> S. T. Algermissen, *United States Earthquakes*, Fig. 2.4, U.S. Government Printing Office, Washington, D.C., 1968.

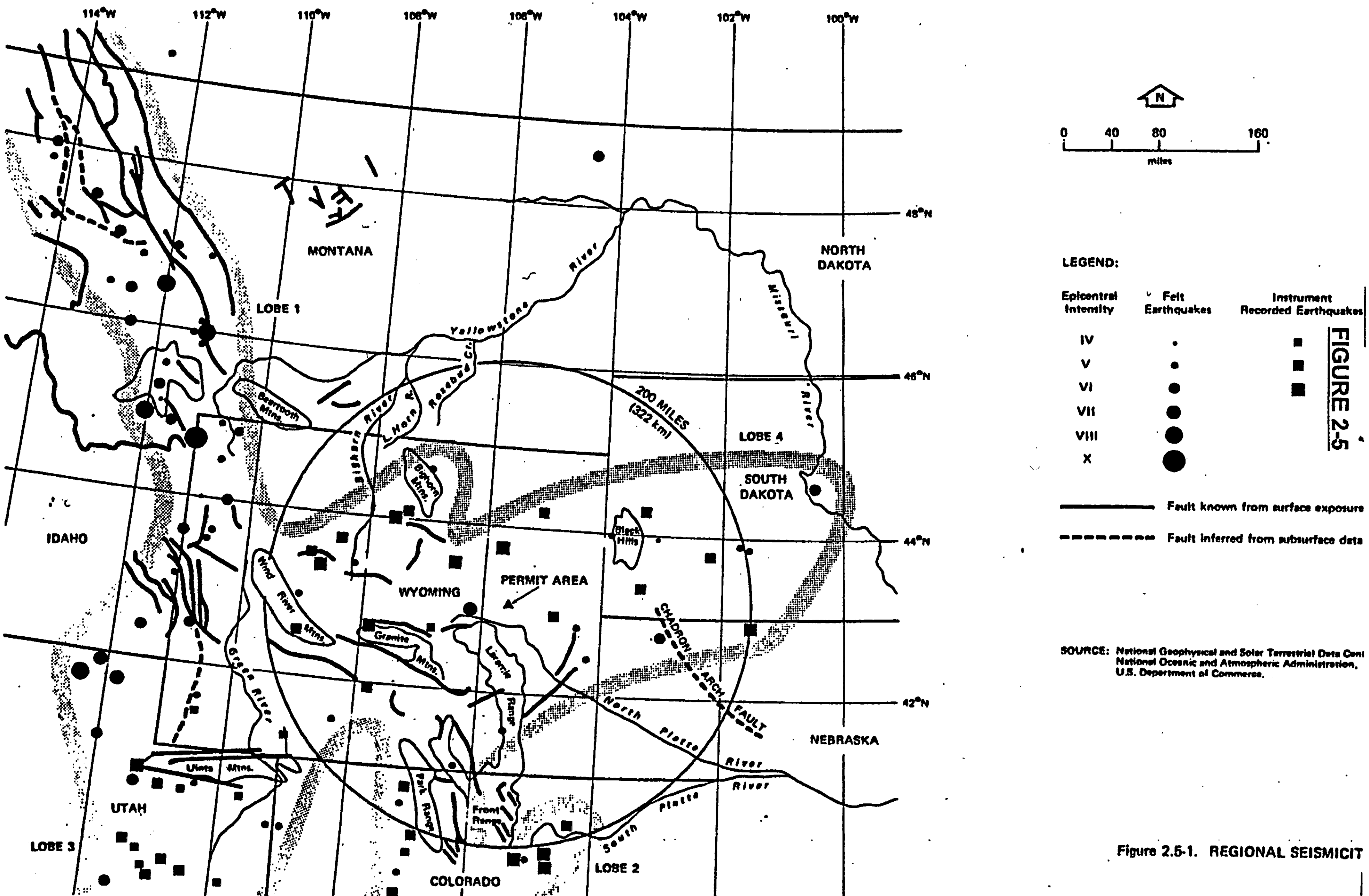
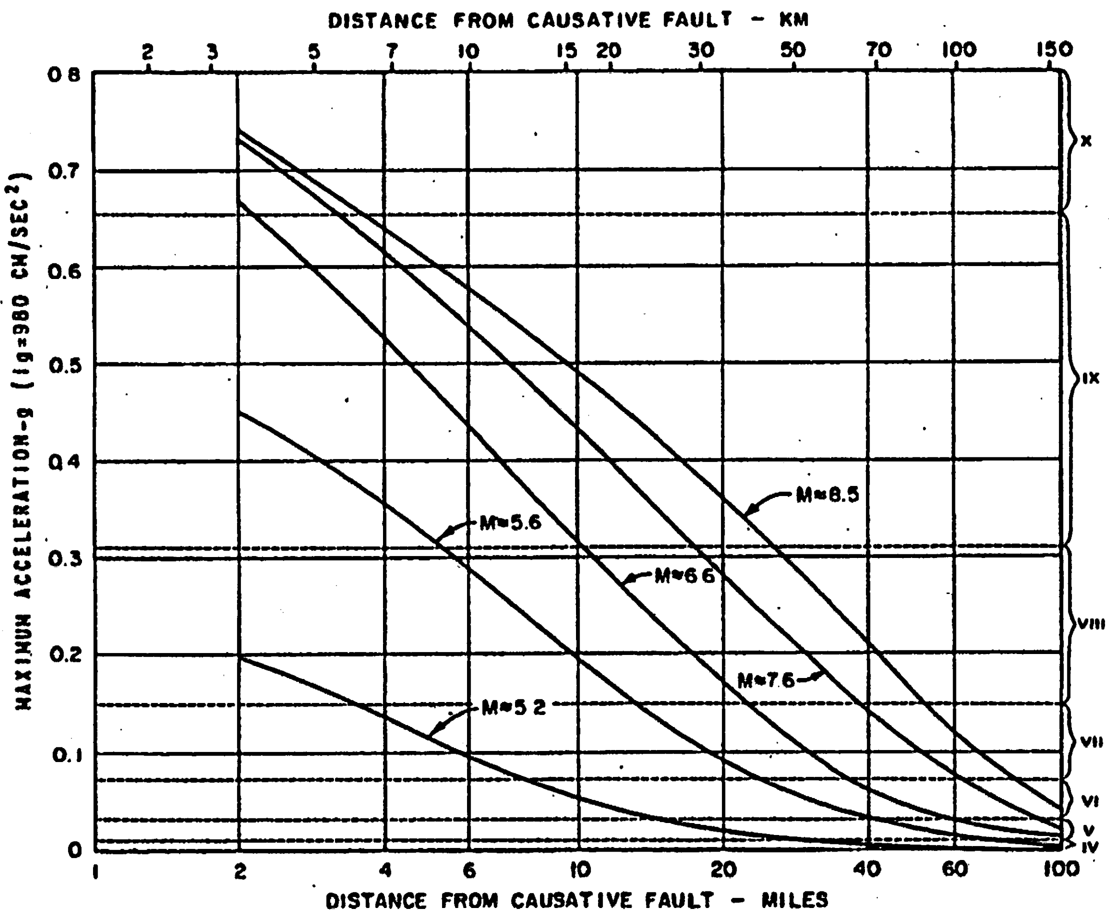
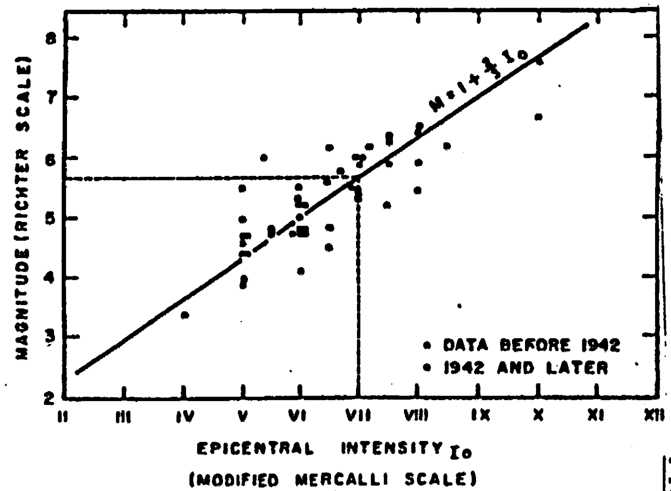


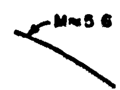
FIGURE 2-5

Figure 2.5-1. REGIONAL SEISMICIT



Source: Schnabel and Seed, 1972.
Woodward-Clyde Consultants, 1977.





MAXIMUM ACCELERATION vs. DISTANCE CURVE : CURVE REPRESENTS THE RELATIONSHIP BETWEEN DISTANCE FROM THE CAUSATIVE FAULT AND THE MAXIMUM AVERAGE ANTICIPATED ACCELERATION FOR AN EARTHQUAKE OF GIVEN RICHTER MAGNITUDE (M) WHICH RANGES FROM 1 TO 9 TO DATE.

FIGURE 2-6

Figure 2.5-2. CORRELATING FACTORS FOR ESTIMATING EARTHQUAKES

CHAPTER 3
DESCRIPTION OF THE FACILITIES

The permit area for the combined SR-HUP properties contains 30,760 acres. The total surface area to be affected by the proposed operation is within the permit area and will total approximately 1,800 acres.

The wellfields, two purge storage reservoirs and two irrigators, the two Office/Processing Plant areas, four Satellite facilities, and evaporation ponds are the significant surface features associated with the uranium in-situ leaching mining operation.

The total wellfield area to be used for the injection and recovery of leaching solution over the twenty year mine life will be approximately 800 acres. The areas fenced to limit access by livestock to wellfield areas will be slightly greater than that encompassed by the areas to be mined. The main facilities at the SR-HUP, besides the wellfields, include the two yellowcake processing plant sites and related facilities that are located within the former Bill Smith Mine Site (Smith Ranch Main Office CPP Complex) and the former Exxon Highland Mine Site (HUP Central Plant/Office Complex). Currently (March 2003) the HUP facilities remain on stand-by status, with all yellowcake processing, office and related activities occurring at Smith Ranch.

In association with the Smith Ranch CPP is a lined, two-celled evaporation pond to assist with wastewater disposal. Additional lined evaporation ponds consisting of 5 to 15 acre cells will be constructed as needed. Wastewater is also disposed at two deep disposal wells at Smith Ranch and one deep disposal well at Highland.

Currently (March 2003), there are four Satellite IX facilities constructed and in operation. Satellite Nos. 1, 2 and 3 are located at Highland. Satellite No. SR-1 is located at Smith Ranch. It is likely that one additional Satellite facility will require construction in order that existing uranium reserves can be recovered.

3.1 IN SITU LEACHING PROCESS AND EQUIPMENT

The SR-HUP uses processes and technology developed and demonstrated during Q-sand and O-sand R&D programs conducted at Smith Ranch, R&D Programs conducted at Highland, as well as techniques and processes developed at other ISL facilities that utilize best practices and industry experience.

3.1.1 Uranium Dissolution

In Situ Leach (ISL) mining of uranium requires the circulation of a solution that will oxidize the uranium to a soluble state and form stable uranium complexes that can easily be recovered from the ore body. The project uses a carbonate leaching solution consisting of varying concentrations and combinations of sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), oxygen, hydrogen peroxide (H_2O_2), and carbon dioxide (CO_2)

added to the native groundwater. The carbonate/bicarbonate leaching solution is used because of its selectivity for uranium and minor reaction with the gangue minerals. The pilot tests were conducted using sodium bicarbonate, carbon dioxide, hydrogen peroxide, and oxygen in the leaching solutions. When the leaching solution is injected into the ore zone, the dissolved oxidant reacts with the uranium mineral and brings the uranium to the U^{+6} oxidation state.

The U^{+6} species form complexes with some of the carbonates in the leaching solution to create uranyldicarbonate ions $(UO_2(CO_3)_2)^{-2}$ and/or an uranyltricarbonate ion $(UO_2(CO_3)_3)^{-4}$, both of which are soluble and stable species in solution. When the uranium is removed by leaching, a small portion of the radium content also is mobilized. Depending on site conditions, contaminants such as arsenic, selenium, and/or vanadium, may also be oxidized and mobilized in low concentrations. Results from the ISL pilot operations in the project area and operating wellfields have shown elevated selenium values but no evidence of other trace elements being significantly mobilized during leaching. Figure 3-1 shows the primary chemical reactions expected to occur in the Production Zone.

The dissolution and complexing of uranium occur as the leaching solution flows through the ore body from the injection wells to the production wells. Leaching solutions will continue to be circulated through a given area of the production zone as long as uranium recovery from that area is economically attractive.

3.1.2 Resin Loading/Elution Circuit

The uranium-bearing solution or pregnant leaching solution pumped from the wellfield is piped to the ion exchange plant for extraction of the uranium by use of ion exchange units. As the solution passes through the IX resin in the IX columns the uranyldicarbonate and uranyltricarbonate are preferentially removed from the solution. The barren solutions leaving the ion exchange units normally contain less than 2 ppm of uranium. After the resin in a column is "loaded" with uranium, the vessel is isolated from the normal process flow and the resin is from the column for elution. For Satellite IX facilities, this transfer is performed by moving the uranium loaded resin from the Satellite to the CPP using truck transport. In the elution process the resin is contacted with a strong sodium-chloride salt solution which regenerates the resin in a process very similar to regenerating a conventional home water softener. The eluted resin is then placed back in service for additional uranium recovery. For Satellite facilities, freshly eluted resin is transferred from the Central Processing Plant to the IX facility using truck transport.

After the barren solution leaves the ion exchange columns, carbon dioxide and/or carbonate/bicarbonate is added as necessary to return the carbonate/bicarbonate concentration to the desired operating level. The solution is then pumped back to the wellfield, with the oxidant (O_2 gas and/or H_2O_2) added either as it leaves the CPP or Satellite, or just before the solution is re-injected into the Production Zone.

The piping and metering system for production and injection leaching solutions consists of buried trunk lines between the recovery plant and the operating wellfield areas with metering and flow distribution headers in the wellfield header buildings. The individual well flows and pressures are adjusted and controlled within the header buildings.

3.1.3 Precipitation Circuit

In the elution circuit, the uranyldicarbonate and uranyltricarbonate ions are removed from the loaded resin by a relatively small volume of strong chloride solution providing a solution (rich eluate) from which the uranium can be precipitated.

The rich eluate containing the uranium is routed to tankage for temporary storage in front of the batch or small continuous precipitation circuit. To initiate the precipitation cycle hydrochloric or sulfuric acid is added to the uranium bearing solution to breakdown the uranyl carbonate present in the solution. Hydrogen peroxide or ammonia then is added to the acidified eluate to effect precipitation of the uranium as uranyl peroxide or ammonium diuranate. The addition of hydrogen peroxide drives the pH of the solution down, and to optimize crystal growth and settling, a base, (e.g. sodium hydroxide or ammonia), is added as a pH adjustment. The uranium precipitate is allowed to settle. The uranium depleted supernate solution is removed and stored for re-use in future elutions or disposed. Sodium chloride and sodium carbonate are added to the lean eluate as needed for reconstitution.

Deep injection wells and/or lined evaporation ponds are used to collect and dispose process wastewaters such as the excess eluate. The evaporation ponds may have multiple cells and each cell will be lined with a hypalon or similar membrane liner. A system of perforated pipes will be installed in a sand bed under the pond liner and will be monitored to ensure that if a leak were to occur, it would be quickly detected.

The precipitation cycle procedures and methods to be employed for this project have been used extensively in ISL programs and in conventional uranium milling operations.

3.1.4 Product Filtering, Drying and Packaging

After precipitation, the settled yellowcake is prepared for drying and product packaging. The yellowcake from the elution/precipitation circuit is washed with fresh water to remove excess chlorides and other soluble contaminants and then de-watered. This slurry may be routed to holding tanks in the precipitation area prior to filtering and drying. The yellowcake is dried and packaged in 55 gallon steel drums for storage and shipment.

Currently (March 2003) the yellowcake is dried in a vacuum dryer at the SR CPP. With this type of dryer, the off-gases generated during drying are filtered and scrubbed to remove entrained particulates. The water sealed vacuum system provides ventilation while the dryer is being loaded and unloaded into drums. This type of dryer minimizes air borne effluents. The drying system is described in more detail in Chapter 4.

An enclosed warehouse, adjacent to the yellowcake drying area, is provided for the storage of yellowcake. Onsite inventory of drummed yellowcake typically is less than 200,000 lbs. However, in periods of inclement weather or other interruptions in product shipments, all production will be stored on-site in designated storage areas.

The drummed yellowcake is shipped by exclusive use transport to another licensed facility for further processing. All yellowcake shipments are made in compliance with applicable regulations. A flow diagram showing the major process components of the uranium recovery plant is included as Figure 3-2.

3.1.5 Major Process Equipment

Principal equipment used in the process consists of surge tanks (optional), ion exchange vessels, elution/precipitation tanks, vacuum drying systems, and the piping, pumps and valves required to control and move the solutions among the various process components. The continuous flow portion of the circuit (the ion exchange circuit) has instrumentation designed to monitor key fluid levels, flow rates and pressures. The elution/precipitation portion of the recovery plant circuit is designed for batch and semi-continuous operations. The number of batch cycles are increased as uranium production increases. The elution circuit operates under automated controls.

3.2 SITE FACILITIES LAYOUT

Major existing surface facilities at the SR-HUP are shown on Plate 1 and include the Smith Ranch Main Office-Central Processing Plant (CPP) and associated facilities, the Highland Office-Central Processing Facility Complex (on stand-by status as of March 2003), operating wellfields, Satellite Building Nos. 1, 2, 3 and SR-1, the Boner Storage Building, three deep disposal well facilities, the Satellite No. 1 Radium Settling Basin, Purge Storage Reservoir Nos. 1 and 2, and Irrigation Area Nos. 1 and 2.

3.2.1 Smith Ranch Main Office-Central Processing Plant

The Smith Ranch Main Office-Central Processing Plant (CPP) is located within the 30 acre fenced area in the NE¼ , NW¼, Section 36, T36N, R74W (see Plate 1). The northern end of the CPP houses IX facilities while the remainder of the building contains the resin elution and yellowcake processing and drying/packaging areas. The yellowcake drying/packaging area may process 9,750 pounds U_3O_8 per day (3.5 million pounds per year). However, normal operations are expected to be about 1 to 2 million pounds per year. The CPP IX facilities currently (March 2003) serve Wellfield 1, Wellfield 2, and portions of Wellfield 4. This area also contains the Evaporation Ponds, Pilot Plant Building, Construction and Maintenance Shops, and Warehouse facilities. Figure 3-3 shows the plan view of these facilities. Figure 3-4 shows the general layout of the process equipment in the CPP.

In concert with the acquisition of the Smith Ranch operation by PRI in July 2002, all resin and yellowcake processing operations were moved to the Smith Ranch CPP in September 2002, with the Highland Central Plant and associated facilities being placed on stand-by status at that time. It is anticipated that all resin and yellowcake processing will continue to be conducted only at the Smith Ranch CPP until the uranium market improves such that additional yellowcake processing capacity is needed, or if a major shutdown condition occurred at the Smith Ranch CPP.

3.2.2 Highland Central Processing Facility

The Highland Central Processing Facility (CPF) is located within the 40 acre fenced area in the NE¼ NW¼, Section 29, T36N, R72W (see Plate 1). Currently (March 2003), the Highland CPF remains on stand-by status. The Central Plant building houses the majority of the process equipment, such as the uranium extraction circuit, yellowcake precipitation, dewatering, drying and packaging equipment. All buildings at the CPF were obtained from the previous Exxon open pit uranium mine/mill operation. The yellowcake drying/packaging area at the Highland CPF may process up to 2 million pounds U_3O_8 per year. However, when operational, production has typically been less than 1.5 million pounds per year. The general layout of the CPF area is shown on Figure 3-5. The process equipment layout is shown on Figure 3-6.

3.2.3 Satellite Buildings

The Satellite buildings house the ion exchange (IX) columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, a small laboratory and an employee break room. Bulk carbon dioxide and oxygen are stored in compressed form adjacent to each Satellite building or in the wellfield. Gaseous carbon dioxide is added to the lixiviant as the fluid leaves the Satellite building for the wellfield and headerhouses.

The locations of Satellite buildings and associated structures are shown on Plate 1. There are four Satellite buildings in operation at the combined SR-HUP. Satellite No. 1 is located in the NW ¼ Section 21, T36N, R72W. The building occupies approximately 8,000 ft^2. The layout of Satellite No. 1 is shown on Figure 3-7. Satellite No. 1 serves the A and B-Wellfields (Section 21, 20-Sand and Section 21, 30-Sand Wellfields, respectively). Since July 1991 Satellite No. 1 has only been used for ground water restoration activities at the A and B-Wellfields. During production operations this facility had a capacity of approximately 1800 gpm.

Satellite No. 2 is located in the NE ¼ Section 14, T36N, R73W (see Plate 1). The building occupies approximately 13,000 ft^2. Satellite No. 2 serves the C-Wellfield (Section 14, 50-Sand Wellfield), D-Wellfield (Section 22/23, 40-Sand Wellfield), E-Wellfield, and the H-Wellfield. Satellite No. 2 will also potentially be used to produce the planned I-Wellfield. The Satellite No. 2 facility is designed to operate with a maximum through-flow of 3200 gpm during production operations. As of March 2003 the A, B, and C-Wellfields are undergoing ground water restoration while the D, D-Extension, E, F, and H-Wellfields are still in production. The layout of Satellite No. 2 is shown on Figure 3-8.

Satellite No. 3 is located in the SE ¼, Section 20, T36N, R73W (see Plate1). Satellite No. 3 and associated facilities serve the D-Extension and F-Wellfields and additional wellfields proposed for western portions of the permit area. The building occupies approximately 13,000 ft^2. The Satellite No. 3 facility is designed to operate with a maximum through-flow of 4,000 gpm during production operations. The layout of Satellite No. 3 is shown on Figure 3-9.

Satellite No. SR-1 is located in the SE ¼ Section 27, T36N, R74W (see Plate 1). The building occupies approximately 13,000 ft^2. Currently (March 2003), this facility serves Wellfield 3, portions of Wellfield No. 4 and planned future wellfield areas. The Satellite No. SR-1 facility is designed to operate with a maximum through-flow of 4500 gpm during production operations. The layout of Satellite No. SR-1 is shown on Figure 3-10.

The Boner storage building, which covers approximately 5,000 ft^2 is located just east of Satellite No. 2 (see Plate 1) and is used for wellfield equipment and materials storage and fabrication of various structures predominately used in the construction of wellfields.

3.2.4 Wellfields

3.2.4.1 Ore Deposits

The ore deposits in the SR-HUP area generally occur at depths of 450 feet to 1,000 feet below the surface in long narrow trends varying from a few hundred to several thousand feet long and 20 to 300 feet wide. The depth depends on the local topography, the dip of the formation and stratigraphic horizon. At Smith Ranch, the shallower ore deposits are contained within the Q-sand and the mineable ore in this sand occurs at depths of 450 to 500 feet. Most of the remaining uranium mineralization at the Smith Ranch occurs in the O-sand formation at a depth of 700 to 900 feet. The Q-sand pilot and O-sand pilot were conducted at depths of approximately 500 feet and 750 feet respectively. These ore body sands are synonymous with the 30, 40, 50, and 60-Sands located at Highland.

A typical stratigraphic interval to be mined by the in situ mining method is shown by the geologic cross sections of the Production Wellfields as found in the Wellfield #1, #3, #4, and #4A Pre-Operational Data Submittals, dated May 27, 1999, June 1, 1998, April 26, 1999, and July 18, 2000, respectively. The designations of the intervals identified on the cross sections are Company designations. For an ISL wellfield, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

3.2.4.2 Wellfield Areas

Wellfield areas are developed as needed to meet production requirements and are generally about 50 acres each. Injection and recovery wells in a wellfield are completed in the mineralized intervals of only one production zone at any one time. Injection and recovery wells are completed as described in Section 3.2.4.5 to isolate the open hole or screened ore bearing interval from all other aquifers. Production zone monitor wells are located in a ring around the wellfield units. Monitor wells for overlying and underlying aquifers are installed at a density of one for each four acres of wellfield area. The distance between overlying or underlying monitor wells in the same zone shall not exceed 1,000 feet and all such wells are installed within the confines the wellfield unit area.

When areas within a prospective wellfield are encountered which exhibit very thin or absent vertical confining layers, PRI evaluates the local stratigraphy and may adjust the monitoring and operating programs to account for such a situation. These adjustments may include placement of the overlying/underlying monitor wells in different stratigraphic horizons within the same wellfield, and perhaps in the same sandstone unit containing the mineralized intervals (at different horizons), or in some instances overlying or underlying wells may not be needed. Additional operational controls may also be instituted in the absence or breach of a confining layer, such as localized increased rates of over-recovery.

There are currently (March 2003) 11 wellfields installed at the SR-HUP. Locations of the wellfields are shown on Plate 1. Wellfields A, B, C, D, E, F, D-Extension, and H are located at Highland. The A and B-Wellfields were the first wellfields installed at Highland in 1987 and are currently (March 2003) in ground water restoration status. Active ground water restoration was completed in the A-Wellfield in 1999 and it is anticipated that active ground water restoration will be completed in the B-Wellfield in 2003. It is anticipated that the surface reclamation will follow soon after the regulatory agencies concur with ground water restoration. The C-Wellfield was installed in 1989 and is currently undergoing ground water restoration as well.

The D-Wellfield was installed in 1990 and 1991 and started production in mid-1991. The D-Wellfield is currently in production. The E-Wellfield was installed in 1991 and 1992 and started production in February, 1992. The E-Wellfield is currently in production. The F-Wellfield was sequentially installed during 1993-1996, with production beginning in May 1994. The F-Wellfield is currently in production. The H-Wellfield was sequentially installed during 1996 and 1997 with production beginning in 1997. The H-Wellfield is currently in production. The D-Extension Wellfield is the newest wellfield at Highland. It was installed during 2000.

There are currently (March 2003), five wellfields (1, 2, 3, 4, and 4A) installed and in production at Smith Ranch. No wellfields at Smith Ranch are currently in ground water restoration. Production operations began at Wellfield 1 in 1997, Wellfield 3 in 1998, Wellfield 4 in 1999, Wellfield 4A in 2001, and Wellfield 2 in March 2003. Currently (March 2003), production operations are occurring in all of these wellfields with portions of Wellfield 2 still undergoing development. Plate 1 also shows planned wellfield areas that will be potentially mined, dependent on uranium market conditions and economic feasibility.

3.2.4.3 Wellfield Injection/Production Patterns

The wellfield injection/production pattern employed is based on the conventional square five spot pattern which is modified as needed to fit the characteristics of the orebody. The standard production cell for the five spot pattern contains four injection wells surrounding a centrally located recovery well. The cell dimensions vary depending on the formation and the characteristics of the orebody. The injection wells in a normal pattern are expected to be between 75 feet and 150 feet apart. All wells are expected to be completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each wellfield, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient the natural groundwater movement from the surrounding area is toward the wellfield providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed."

The minimum over production or bleed rates will be a nominal 0.5% of the total wellfield production rate and the maximum bleed rate typically approaches 1.5%. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed.

Each injection well and recovery well is connected to the respective injection or recovery manifold in a wellfield Headerhouse building. The manifolds deliver the leaching solutions to the pipelines carrying the solutions to and from the ion exchange facilities. Flow meters and control valves are installed in the individual well lines to monitor and control the individual well flow rates and pressures. Wellfield piping is high density polyethylene (HDPE) pipe, PVC and/or steel. The wellfield piping will typically be designed for an operating pressure of 150 psig, and it will be operated at pressures equal to or less than the rated operating pressure of the pipe and other in-line equipment. If a higher design pressure is needed, the pressure rating of the materials will be evaluated and if necessary, materials with a higher pressure rating will be used.

The individual well lines and the trunk lines to the ion exchange facilities are buried to prevent freezing. The use of field header buildings and buried lines is a proven method for protecting pipelines. A typical wellfield development pattern is illustrated in Figure 3-11.

3.2.4.4 Wellfield Operations

The production areas have been divided into wellfields for scheduling development plans and for establishing baseline data, monitoring requirements, and restoration criteria. A wellfield will consist of a reserve block generally about 50 acres and will represent an area that is expected to be developed, produced and restored as a unit. Up to twenty such units may be required to develop the total project area. A wellfield will typically have a flow rate in the 1000-4000 GPM range. Aquifer restoration of a wellfield will begin as soon as practical after mining in the unit is complete. If a mined out unit is adjacent to another unit being mined, restoration of a portion of the unit may be deferred to minimize interference with the mining operation. The wellfields as currently projected are shown in Plate 1. However, the size and location of the wellfields will be modified as needed based on final delineations of the ore deposit, performance of the area and development requirements.

The projected mining schedule for existing and proposed wellfields along with the anticipated groundwater restoration and decommissioning schedule is provided in Figure 3-12. It should be realized that it is not possible to determine a precise schedule of future operating wellfields due to the types of activities involved and the over-riding fluctuating uranium market conditions. As a result, the only proposed wellfield shown on Figure 3-12 is Wellfield 7 at the Smith Ranch Project. It is anticipated that this will be the next wellfield to go into production at the combined SR-HUP. The exact schedule for other proposed wellfields (as shown in Plate 1) will depend on future economic analyses of ore reserves and anticipated production costs.

The development schedule provided in Figure 3-12 is affected by various factors. These factors typically involve adjustments as necessary to meet production schedules and contractual agreements, longer (or shorter) than predicted mining or restoration times or delays in wellfield installations. To account for such changes, PRI provides an Annual Report to the WDEQ with a map of the permit area showing the wellfields being developed, in production, in restoration, and areas where restoration has been completed. New areas where production or restoration is expected to begin in the subsequent year will also be identified in the Annual Report.

3.2.4.5 Well Completion

Pilot holes for monitor, production, and injection wells are drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. The cement will be placed by pumping it down the casing and forcing it out the bottom of the casing and back up the casing-drill hole annulus.

Typical well completion schematics for production wells, injection wells, and monitor wells are shown on Figures 3-13 through 3-15, respectively. The well casing will be fiberglass or PVC. A typical fiberglass casing will be Centron's 2.1 pound per foot well casing with a 0.175 inch wall thickness or similar casing. The Centron casing has a standard joint length of 30 feet and is rated for 950 pounds per square inch operating pressure. PVC well casing is 4.5 or 5 inch Schedule 40 or SDR-17 (or equivalent). The PVC casing joints normally have a length of approximately 20 feet each. When Schedule 40 PVC casing is used, each joint is bonded with PVC cement and secured with three self-tapping screws. When SDR-17 PVC casing is used, each joint is connected by a water tight o-ring seal which is located with a high strength nylon spline. Currently (March 2003), all production and injection wells are constructed with SDR-17 PVC casing that utilizes the o-ring seal and nylon spline.

Three casing centralizers, located approximately 30 feet, 90 feet and 150 feet above the casing shoe, are normally run on the casing to ensure it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare instances, however, the drilling may result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is called "topping off".

After the well is cemented to the surface and the cement has set, the well is drilled out and completed either as an open hole or it is fitted with a screen assembly (slotted liner), which may have a sand filter pack installed between the screen and the underreammed formation. The well is then air lifted for about 30 minutes to remove any remaining drilling mud and/or cuttings. A small submersible pump is frequently run in the well for final clean-up and sampling.

3.2.4.6 Well Casing Integrity

After an injection or production well has been completed, and before it is made operational, a Mechanical Integrity Test (MIT) of the well casing is conducted. In the integrity test, the bottom of the casing adjacent to or below the confining layer above the production zone is sealed with a plug, downhole packer, or other suitable device. The top of the casing is then sealed in a similar manner or with a threaded cap, and a pressure gauge is installed to monitor the pressure inside the casing. The pressure in the sealed casing is then increased to a specified test pressure. A well must maintain 90% of this pressure for 10 minutes to pass the test.

If there are obvious leaks, or the pressure drops by more than 10% during the 10 minute period, the seals and fittings will be reset and/or checked and another test is conducted. If the pressure drops less than 10% the well casing is considered to have demonstrated acceptable mechanical integrity.

If a well casing does not meet the MIT criteria, the casing will be repaired and the well re-tested. If a repaired well passes the MIT, it will be employed in its intended service. If the well defect occurs at depth, the well may be plugged back and re-completed for use in a shallower zone provided it passes the MIT. If an acceptable test cannot be obtained after repairs, the well will be plugged and abandoned.

During wellfield operations, injection pressure at the injection well heads will not exceed the integrity test pressure. In no event will injection wells be used for injection purposes if they do not demonstrate mechanical integrity.

The MIT of a well is documented to include the well designation, date of the test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the MITs are maintained on site and are available for inspection by NRC and WDEQ. In accordance with WDEQ and EPA requirements, the results of MITs are reported to the WDEQ on a quarterly basis. In accordance with WDEQ and EPA requirements, MITs are repeated once every five years for all wells used for injection of lixiviant, or injection of fluids for restoration operations.

Additionally, a MIT will be conducted on any well to be used for injection purposes after any well repair where a downhole drill bit or underreaming tool is used. Any injection well with evidence of suspected subsurface damage will require a new MIT prior to the well being returned to service.

3.2.4.7 Monitoring of Wellfield Flow and Pressure

Injection well and production well flow rates and pressures are monitored in order that injection and production can be balanced for each pattern and the entire wellfield. This information is also needed for assessing operational conditions and mineral royalties. The flow rate of each production and injection well is determined by monitoring individual flow meters in each wellfield headerhouse. Production well flow rates are determined on a daily basis. Injection well flow rates are determined at least every three days. Injection well flow rates are monitored less often than production well flow rates as there are no royalty considerations with injection wells. Additionally, through operating experience and the fact that injection pressures remain relatively constant, PRI has found that monitoring injection well flow rates at least every three days is more than adequate to ensure that wellfield patterns are adequately balanced.

The pressure of each production well and the production trunk line are determined in each wellfield headerhouse on a daily basis. The pressure of the injection trunk line is also determined daily in each wellfield headerhouse. The surface injection pressures will not exceed the maximum surface pressures posted in each headerhouse.

Data records for these monitoring activities are maintained on-site.

3.2.4.8 Pipeline Monitoring

Pressure and flow indicators on the main pipelines to and from the recovery plant will also be recorded daily to ensure the pressures and flows are maintained within the safe working limits of the pipeline.

3.2.5 Chemical Storage Facilities

Chemical storage facilities at the SR-HUP include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, are stored outside and segregated from areas where licensed materials are processed and stored. Other non-hazardous bulk process chemicals (sodium chloride, sodium carbonate) that do not have the potential to impact radiological safety are stored within the Central Plant facilities.

3.2.5.1 Process Related Chemicals

Hazardous materials which have the potential to impact radiological safety include anhydrous ammonia, hydrogen peroxide, and acid (sulfuric and/or hydrochloric). Anhydrous ammonia and hydrogen peroxide are used for pH control in the precipitation circuit at the Smith Ranch CPP. Sulfuric acid is also used at the CPP to initiate the precipitation cycle. These hazardous materials are stored outside of the CPP in a chemical tank farm area where they are segregated from process areas until their point of use within the process system. All outside bulk liquid storage tanks are contained within concrete curbed secondary containment structures. A similar setup for bulk process chemicals is utilized at the Highland CPF. Currently (March 2003), the Highland CPF is on standby status and no bulk process chemicals are used and/or stored in this area. The locations of chemical storage areas at the Smith Ranch CPP and Highland CPF are shown in Figures 3-3 and 3-5, respectively.

Additional process-related chemicals stored in bulk at the SR-HUP include carbon dioxide and oxygen. Carbon dioxide is typically stored adjacent to the Central Plant and/or Satellite facilities where it is added to the lixiviant prior to leaving the IX facilities. Oxygen is also typically stored at the Central Plant and Satellite facilities, or within wellfield areas, where it is centrally located for addition to the injection stream in each header house. Currently (March 2003) carbon dioxide is stored a the Smith Ranch CPP and Satellite Nos. 2, 3, and SR-1, while oxygen is stored at the Smith Ranch CPP, Satellite Nos. 2 and SR-1, and at a storage pad at the east end of the F-Wellfield. The locations of carbon dioxide and oxygen storage tanks are shown on Plate 1.

Hazardous materials typically used during ground water restoration activities include the use of an acid (hydrochloric acid) for pH control and the addition of a chemical reductant (sodium sulfide or hydrogen sulfide gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Currently (March 2003) bulk hydrochloric acid is stored at Satellite No. 1. Additional hydrochloric acid tanks may be located near other Satellite facilities as ground water restoration commences in other wellfield areas. All hydrochloric acid tanks will be contained within sufficient secondary containment structures.

Sodium sulfide is currently (March 2003) used at the SR-HUP as a chemical reductant during ground water restoration. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacs of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. No hydrogen sulfide gas is currently (March 2003) stored at the site. In the event that hydrogen sulfide is used as a chemical reductant, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the EHS Management System, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified anhydrous ammonia as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The anhydrous ammonia storage and distribution system at the Smith Ranch CPP (see Figure 3-3) has a maximum capacity of approximately 90,000 lbs. Administrative controls limit ammonia storage in the tank to 80% of maximum capacity. Strict unloading procedures are utilized to ensure that this limit is not exceeded and that other safety controls are in place during the transfer of anhydrous ammonia. Process safety controls are also in place at the CPP where anhydrous ammonia is added to the precipitation circuit. These safety controls include the installation of a process area ammonia detector and alarm and emergency shut off solenoid for isolation of the ammonia distribution system in the event of a major release.

The ammonia system at the Smith Ranch CPP is covered under the EPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

3.2.5.2 Non-Process Related Chemicals

Non-process related chemicals that are stored at the SR-HUP include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities are stored outside of process areas at the CPP and Satellite facilities. All gasoline and diesel storage tanks are located above ground and within concrete curbed secondary containment structures.

3.3 INSTRUMENTATION AND CONTROL

Smith Ranch CPP monitoring and alarm instrumentation are employed to provide centralized monitoring of key process components. Operator control of key elements will be maintained with a series of remotely controlled valves and power switches. In addition to alerting the operations personnel of upset conditions within the facility, the instrumentation also monitors the operations and records routine operational data for both production and regulatory reporting requirements.

When operating parameters move outside specified normal operating ranges, an alarm will notify the operator to initiate corrective action to alleviate the problem. Excessively high or low levels or pressure alarms activate automatic shutdown of the related equipment. Operational areas such as pipelines, headerhouses, and the disposal wells comprise a significant component of the automatic shutdown system since those areas provide the greatest risk to large spills of source and byproduct material to the environment. These systems use high and low pressure alarms to automatically shutdown headerhouses, wellfields, and/or ion exchange facilities depending on the location and scale of the alarms. The CPP also has alarms for high/low pressures, high/low flow, or low vacuum (in the case of the rotary vacuum dryers) that will alert the operator of the upset condition to either initiate a corrective action or shutdown that operational area.

Alarm responses as well as recovery from automatic shutdowns will follow designated procedures as provided in the Standard Operating Procedures. The system was designed and installed to minimize the risk of uncontrolled releases of leaching solutions or other fluids and provide maximum safety and protection for the CPP Operators and Maintenance personnel.

Handheld radiation detection instruments are used to monitor the operation. Specifications for this equipment are included in the Health Physics Manual of the EHS Management System. The location of monitoring points and monitoring frequency for in-plant radiation safety is discussed in Chapter 9.

FIGURE 3-1
Primary Chemical Reactions Expected in the Aquifer
South Powder River Basin In-Situ Leach Uranium Mining
Converse County, Wyoming

Uranium Extraction

Oxygen is added to the injection solution to oxidize the uranium in the formation.

Uranitite Oxidation

$$UO_2(s) + ½O_2 + 2H^+ = 2UO_3^{2+} + H_2O \quad \text{(eq. 1)}$$

Leaching and Complexing

$$UO_3 + Na_2CO_3 + NaHCO_3 = UO_2(CO_3)_2^{2-} + 3Na^+ + 2H^+ \quad \text{(eq. 2)}$$

The soluble uranyl dicarbonate complex moves to the production wells in solution and is recovered in the processing plant. The uranium is collected on ion exchange beads where the chloride ions are exchanged with the uranyl dicarbonate complex, and chloride is added to the lixiviant as a contaminant for restoration.

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

(R is ion exchange resin) (eq.3)

Sediment Derived Contaminants

Two principle contaminants derived from ISL mining are calcium as Ca^{2+} and sulfate SO_4^{2-}.

Calcium (derived from consolidation of formation sands and clays)

$$CaCO_3(s) + H^+ = Ca^{2+} + HCO^- \quad \text{(eq. 4)}$$

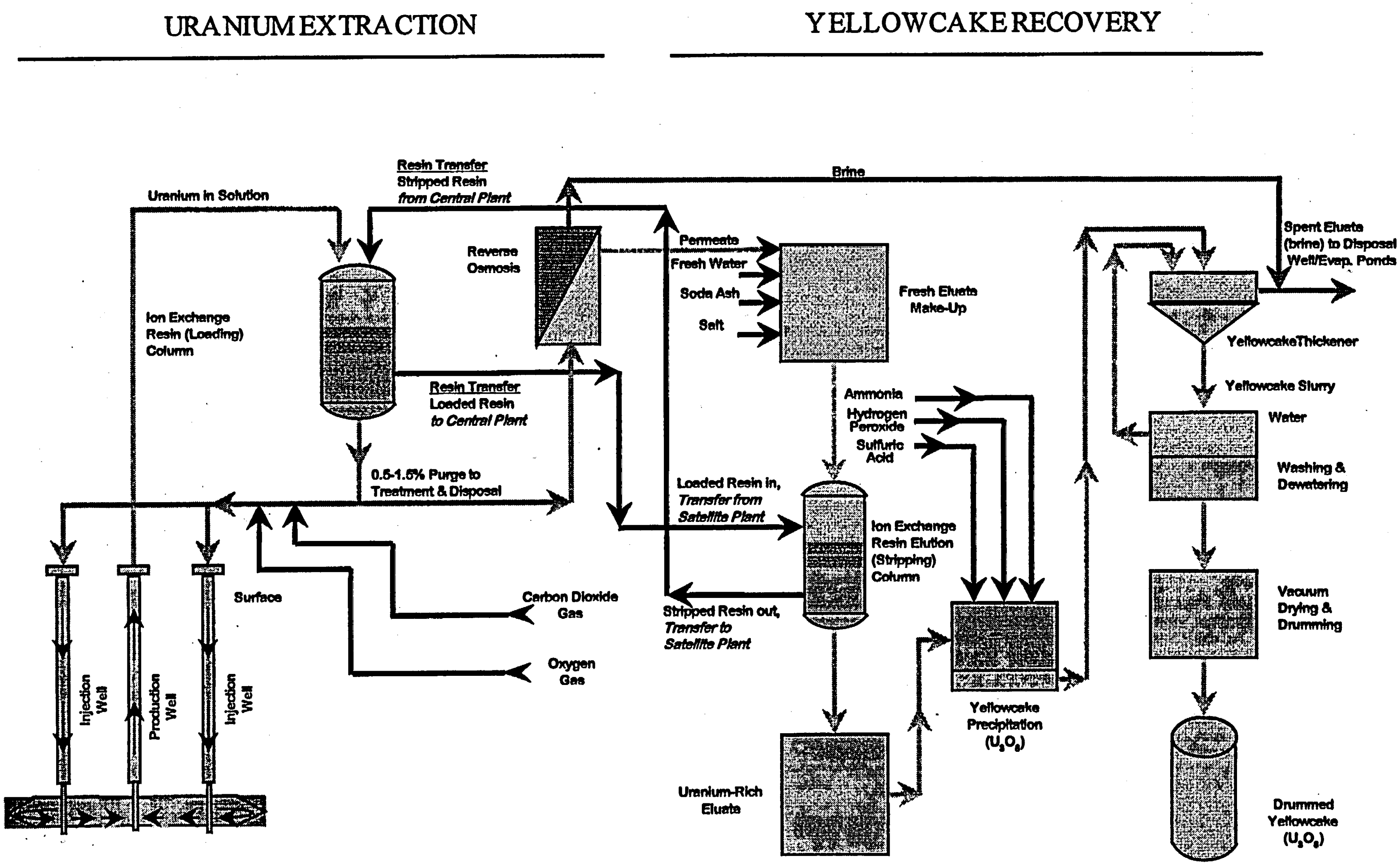
At normal pH and temperature associated with ISL mining, calcium remains in solution. However, changes in pressure and temperature may cause calcium carbonate precipitate to form as a scale.

Sulfate is created by the oxidation of pyrites associated with uranium roll front geochemistry.

$$2FeS_2(s) + 7.5O_2 + 7H_2O = 2Fe(OH)_3(s) + 4SO_4^{2-} + 8H^+ \quad \text{(eq. 5)}$$

The ferric hydroxide will precipitate when formed. Excess calcium developed in eq. 4 coupled with excess sulfate in eq. 5 may develop $CaSO_4$ as a precipitate under the proper temperature and pressure.

FIGURE 3-2
FLOW PROCESS SCHEMATIC



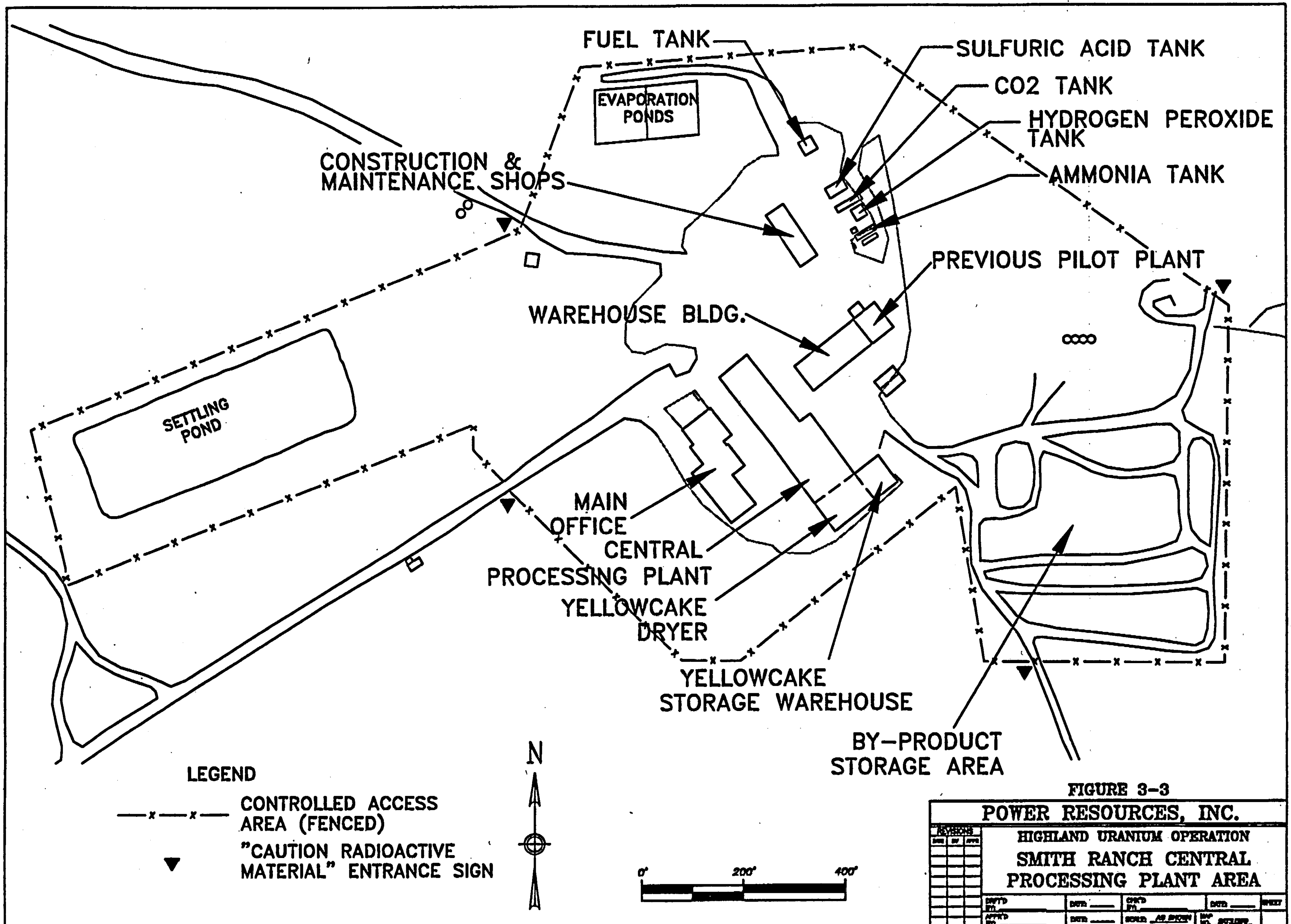
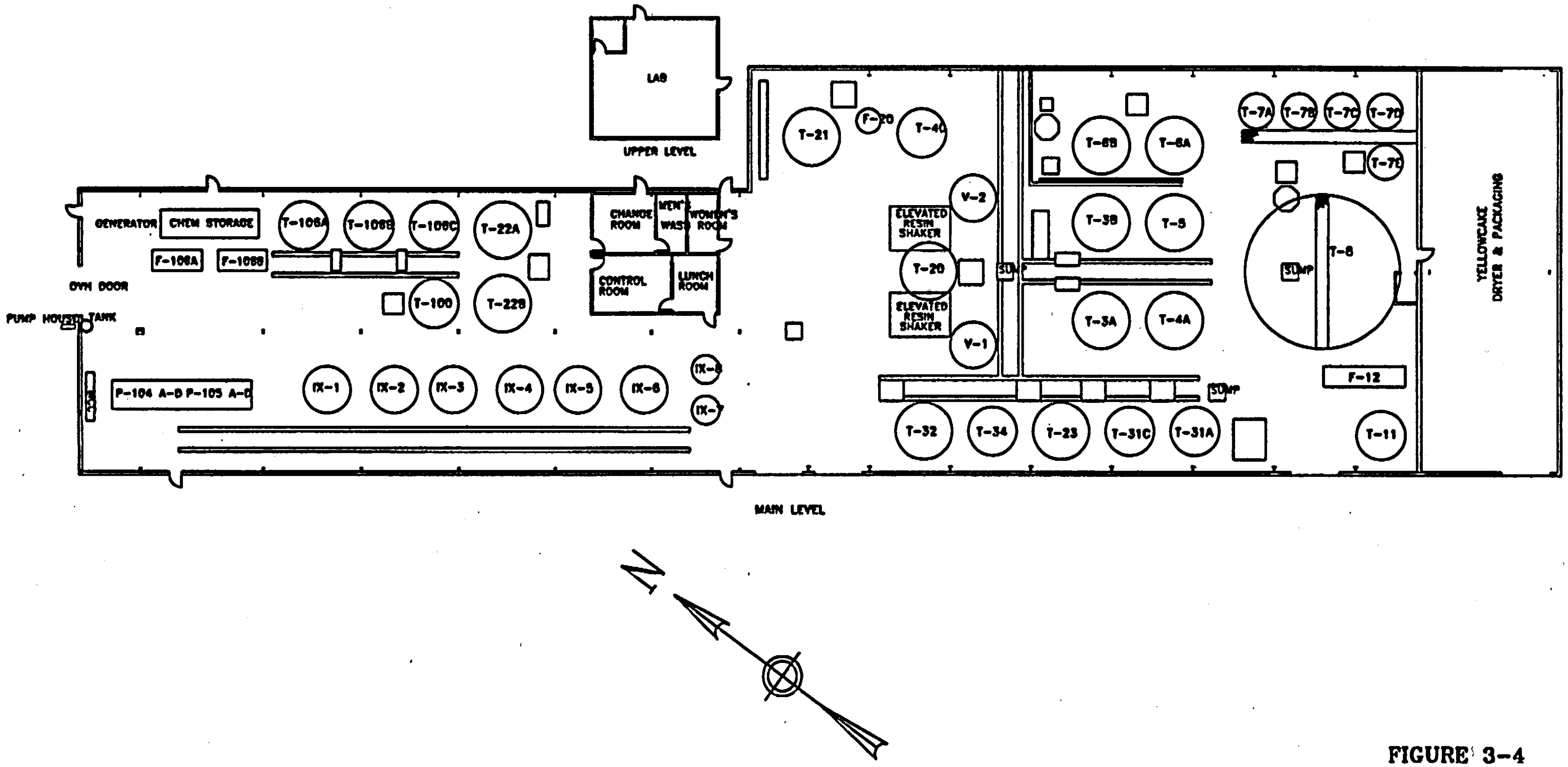


FIGURE 3-3

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SMITH RANCH CENTRAL PROCESSING PLANT AREA



0 20 40

FIGURE 3-4

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SMITH RANCH CENTRAL PLANT PROCESS EQUIPMENT

REVISIONS		
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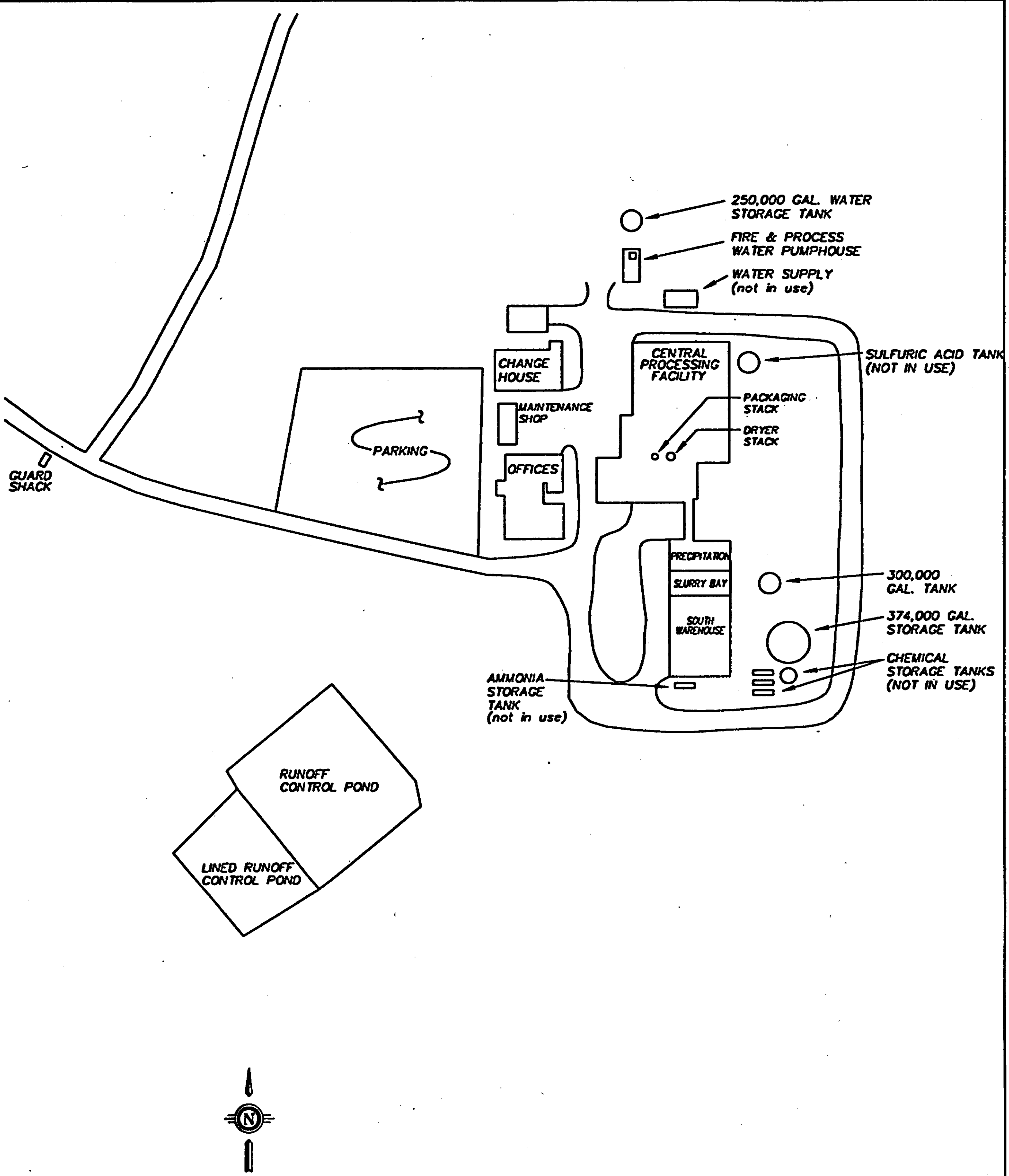

FIGURE 3-5

POWER RESOURCES, INC.

HIGHLAND URANIUM PROJECT
HIGHLAND CENTRAL PROCESSING FACILITY
CONVERSE COUNTY, WYOMING

REVISIONS		
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NRC_PERMIT_02_03/FIG_3_4_HUP_FACILITY.DWG

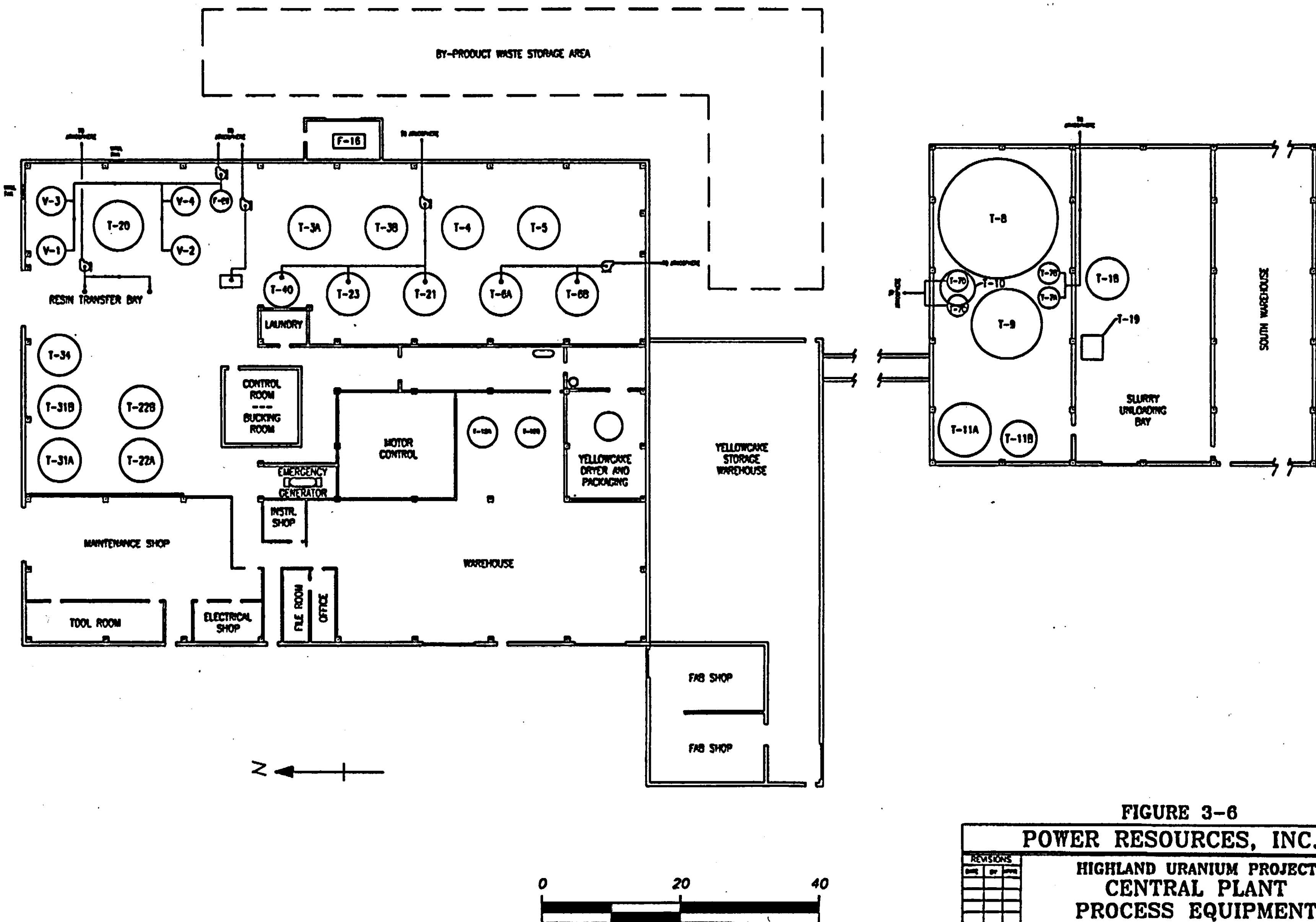

FIGURE 3-6

POWER RESOURCES, INC.

HIGHLAND URANIUM PROJECT
CENTRAL PLANT
PROCESS EQUIPMENT

REVISIONS

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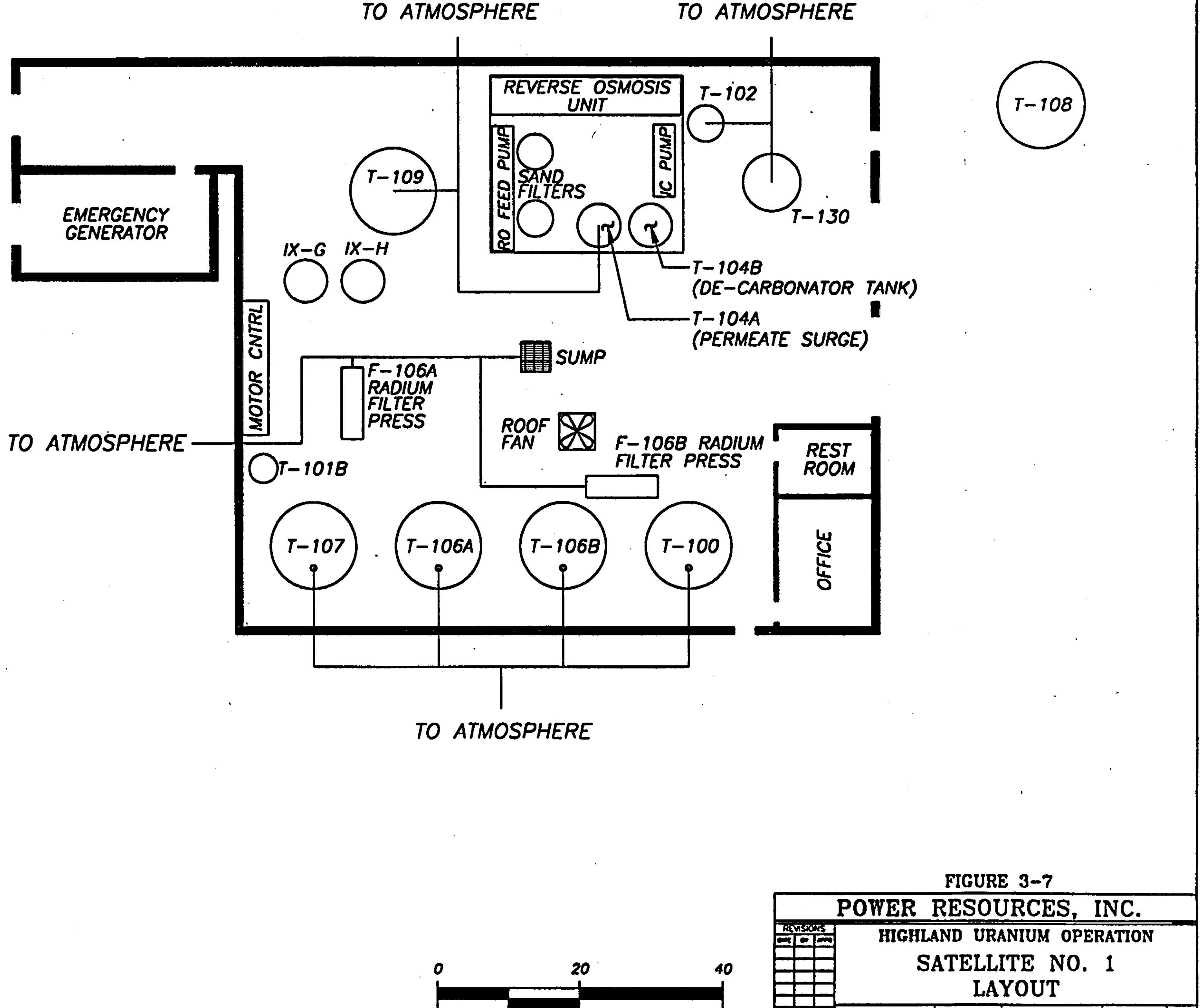


FIGURE 3-7

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SATELLITE NO. 1
LAYOUT

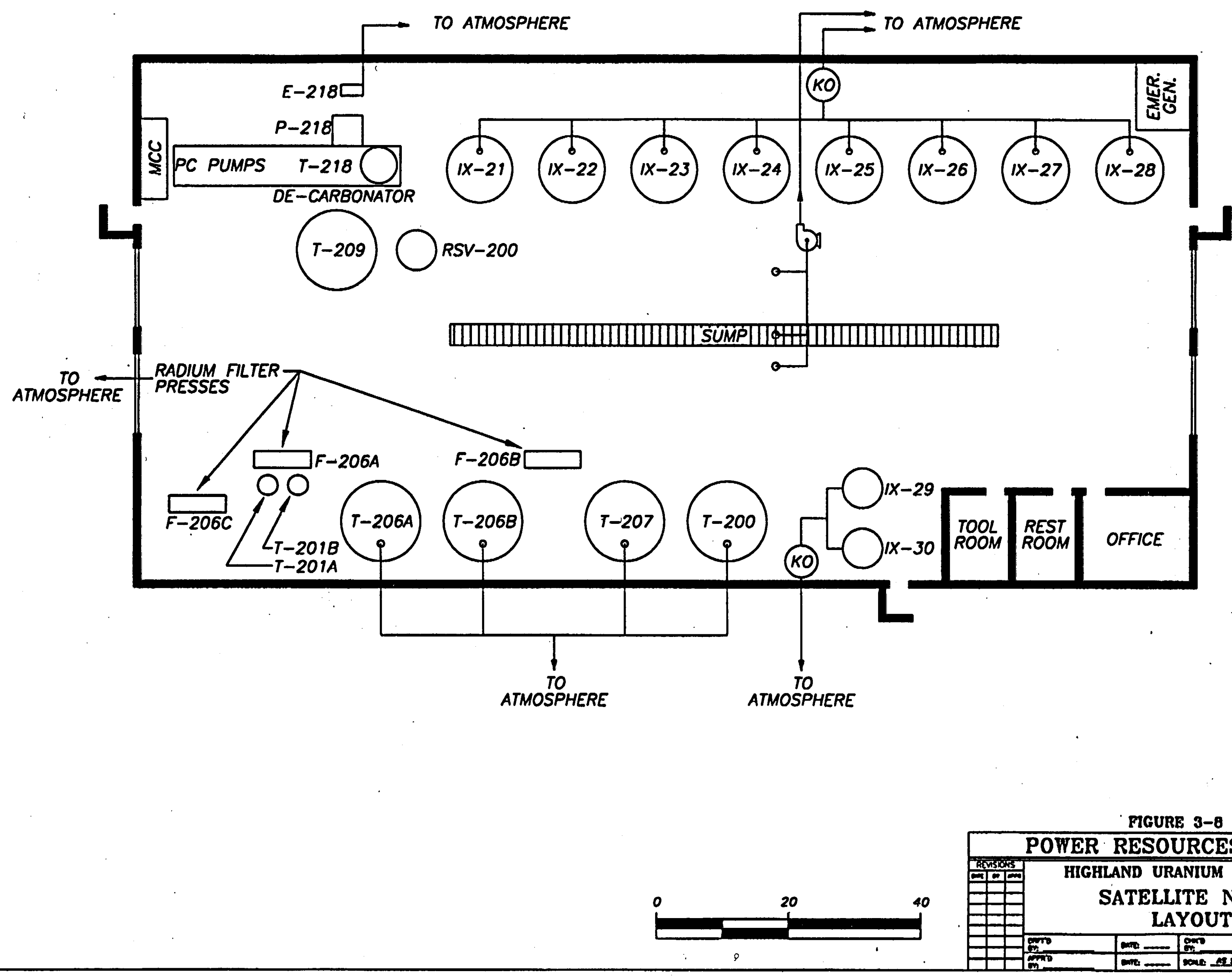


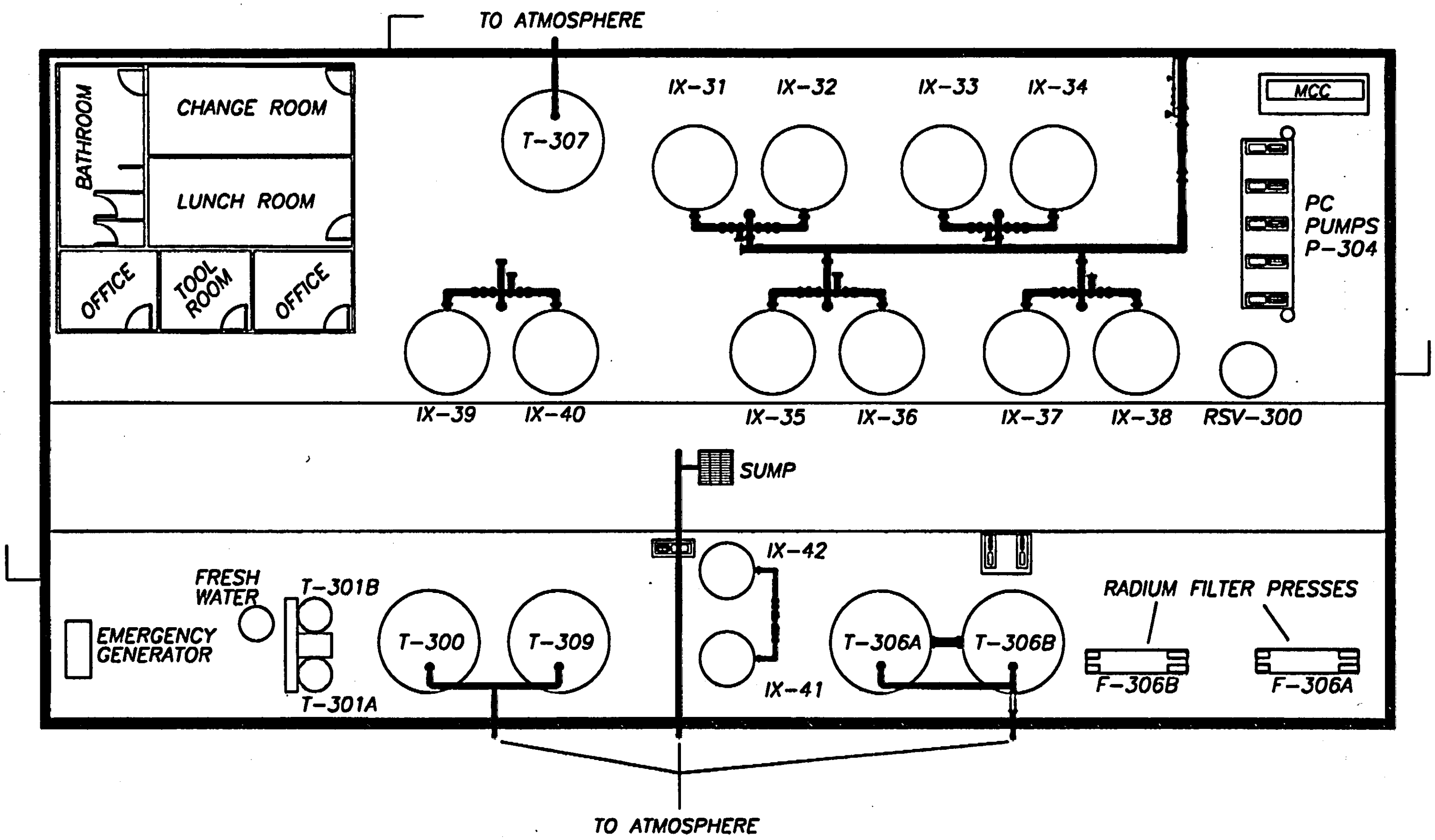
FIGURE 3-8

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SATELLITE NO. 2

LAYOUT



0 20 40

FIGURE 3-9

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SATELLITE NO. 3
LAYOUT

SCALE: AS SHOWN

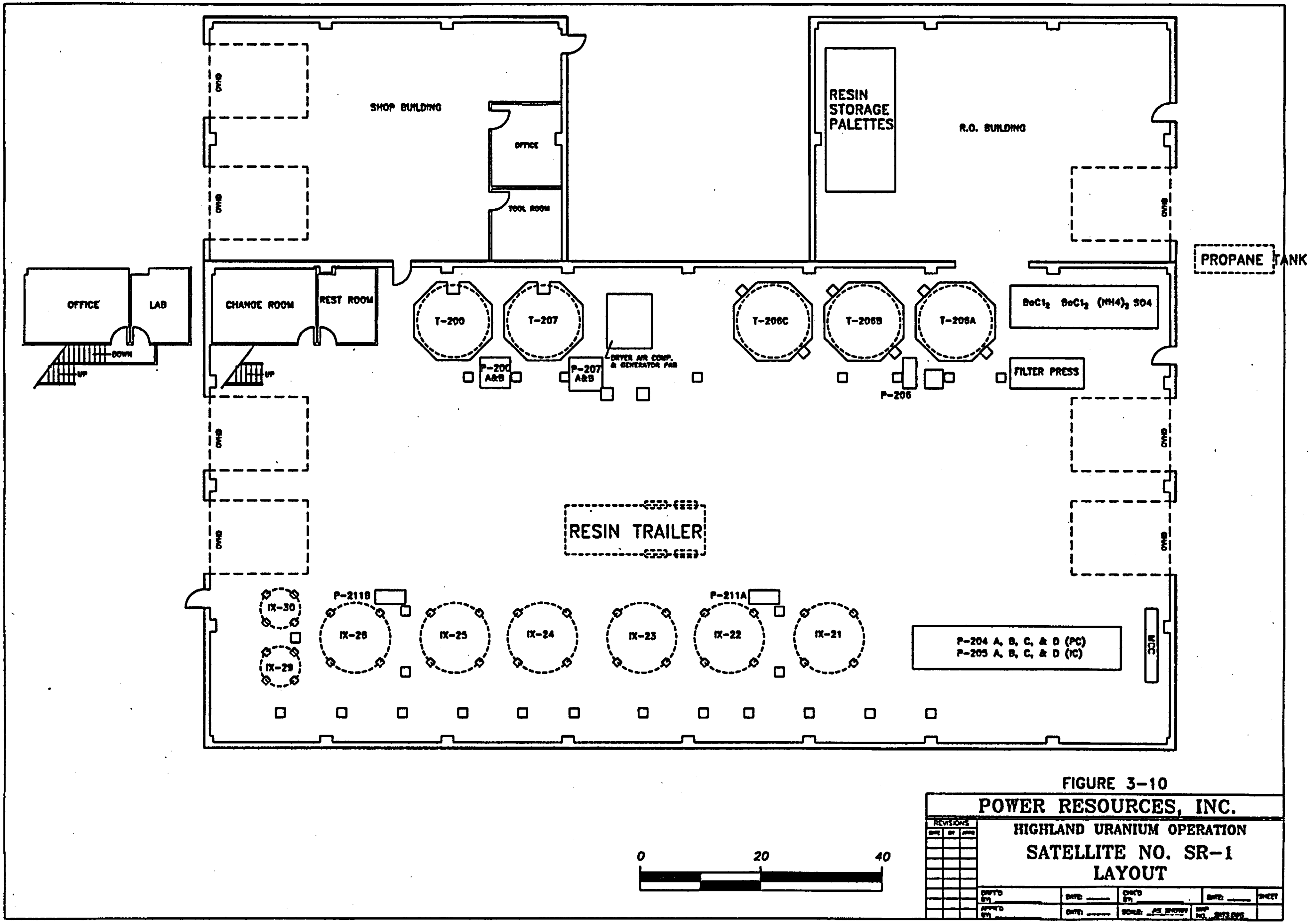


FIGURE 3-10

POWER RESOURCES, INC.

HIGHLAND URANIUM OPERATION

SATELLITE NO. SR-1

LAYOUT

Figure 3-11
Smith Ranch – Highland Uranium Project
Typical Wellfield Development Pattern

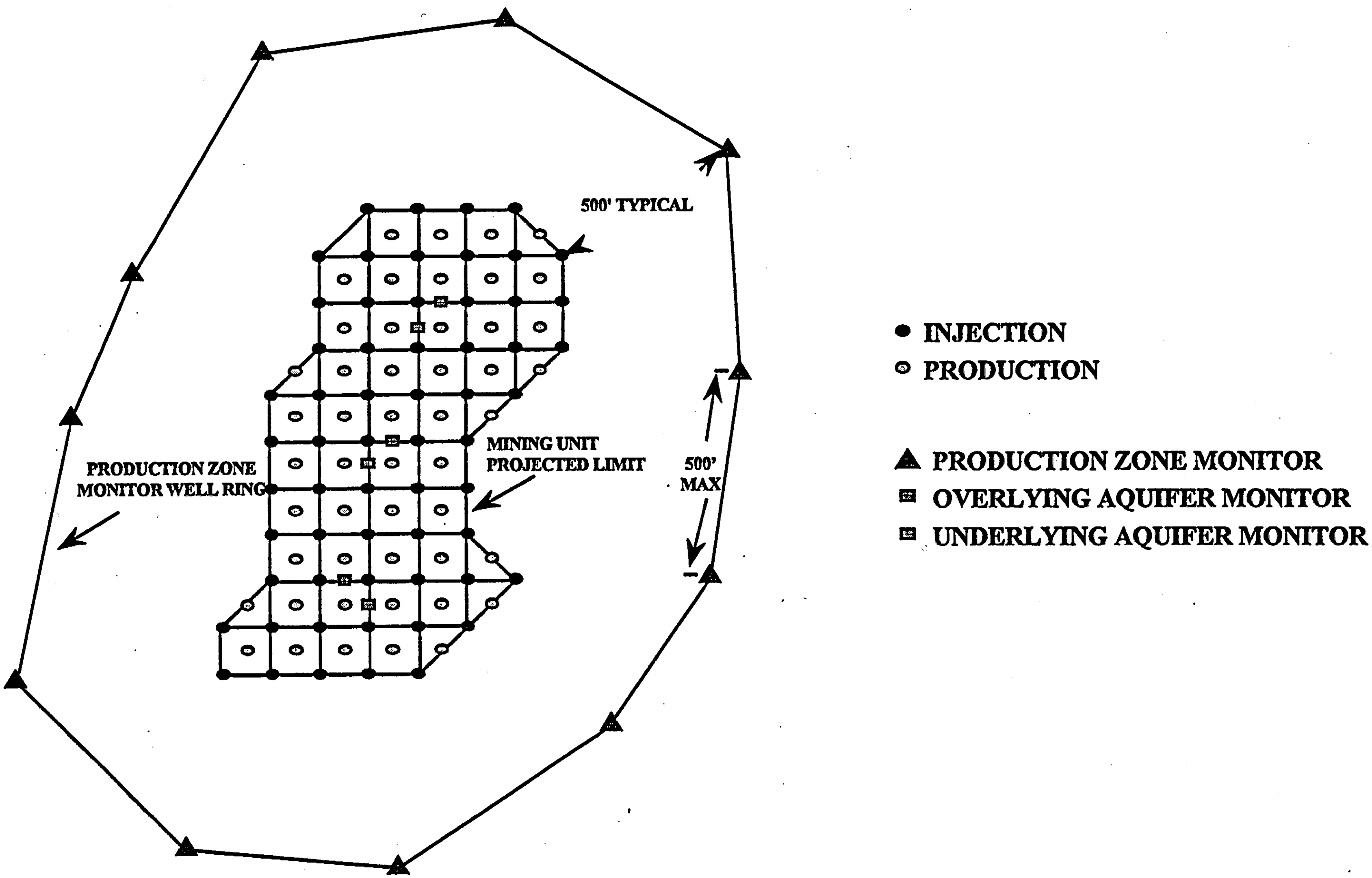
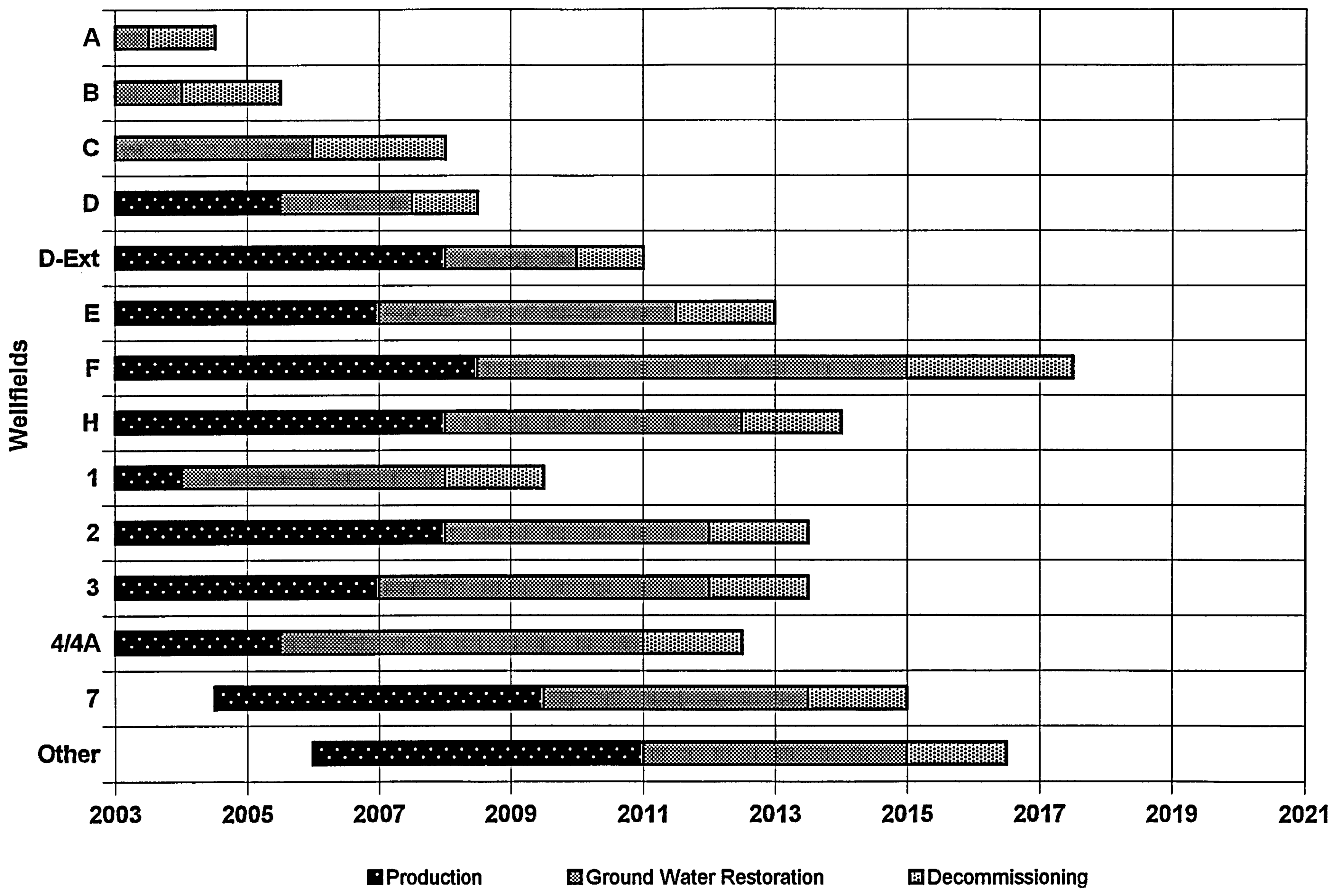


Figure 3-12

Smith Ranch-Highland Uranium Project - Estimated Time Table of Mining Related Activities



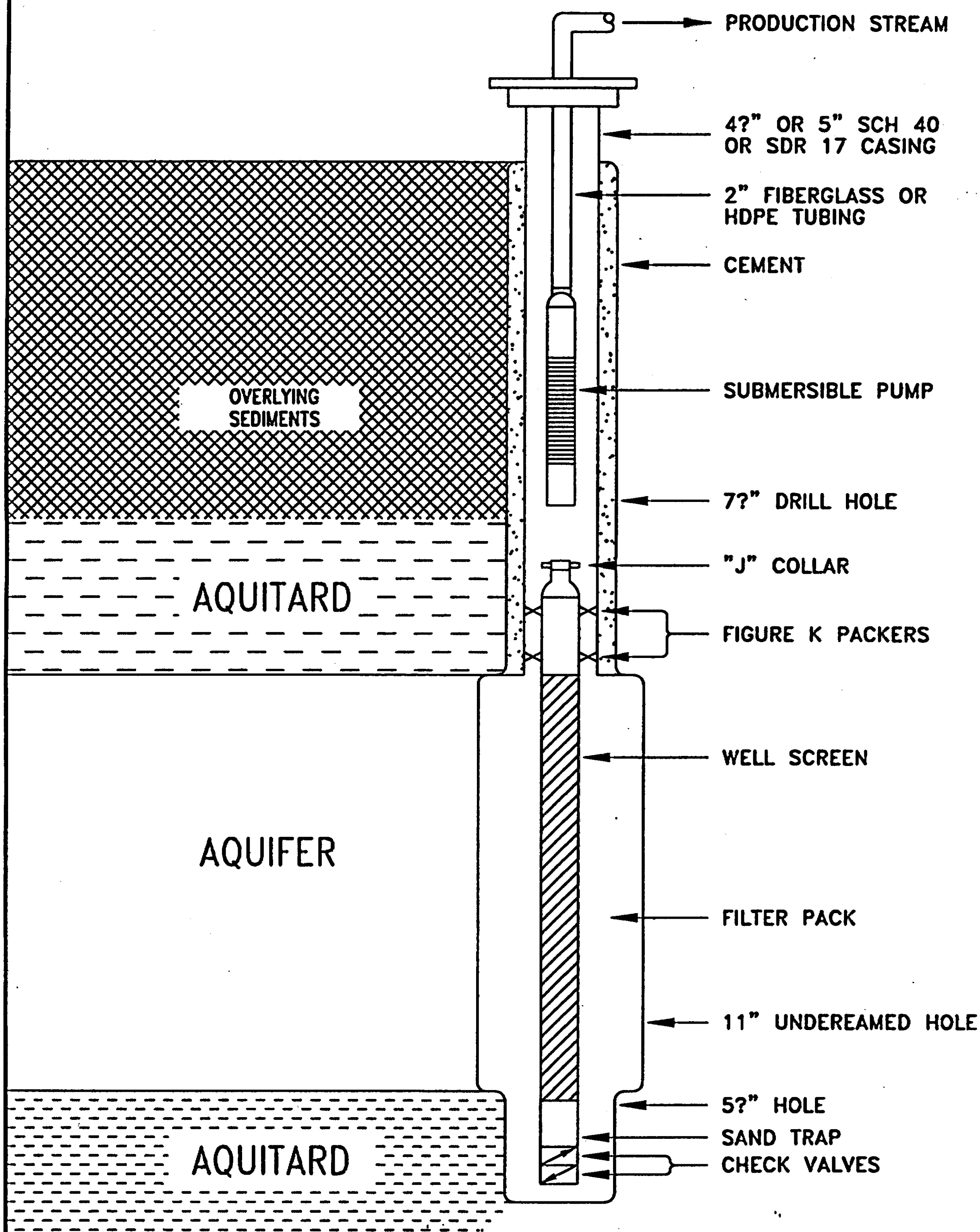


FIGURE 3-13

POWER RESOURCES, INC.

HIGHLAND URANIUM PROJECT
TYPICAL
PRODUCTION WELL
CONVERSE COUNTY, WYOMING

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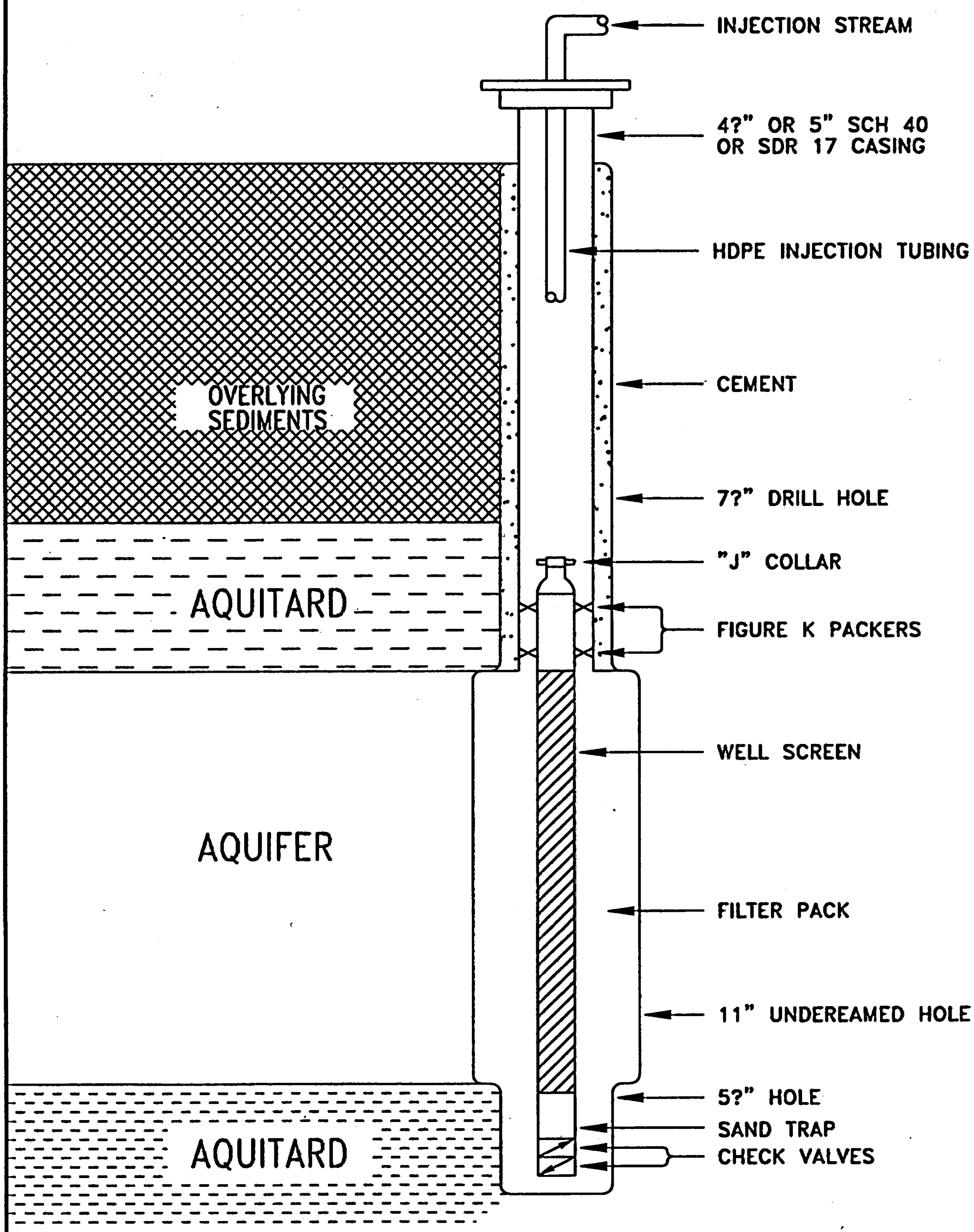

FIGURE 3-14

POWER RESOURCES, INC.

HIGHLAND URANIUM PROJECT
TYPICAL
INJECTION WELL
CONVERSE COUNTY, WYOMING

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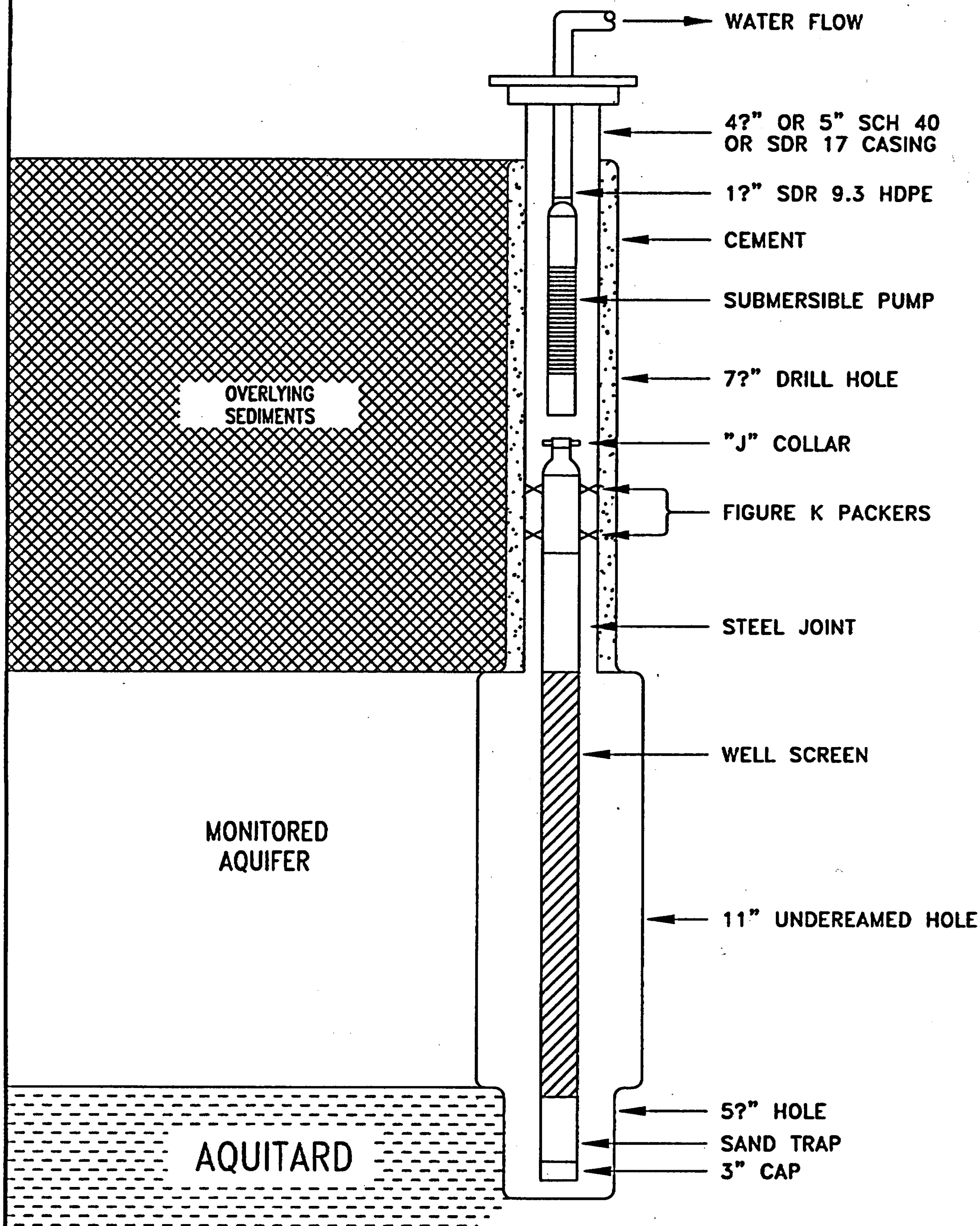

FIGURE 3-15

POWER RESOURCES, INC.

HIGHLAND URANIUM PROJECT
TYPICAL
MONITOR WELL
CONVERSE COUNTY, WYOMING

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CHAPTER 4
EFFLUENT CONTROL SYSTEM

This section describes the effluent control systems used at the SR-HUP. The effluents of concern at ISL operations include the release or potential release of radon gas (radon-222) and dried yellowcake. Currently (March 2003), yellowcake processing and drying operations are only conducted at the Smith Ranch CPP as the Highland Central Plant remains on standby status.

The yellowcake drying facilities at the Smith Ranch CPP are comprised of two vacuum dryers that have their own ventilation system. These vacuum dryers do not discharge any uranium when operating. Section 4.1.3 further discusses yellowcake drying at the Smith Ranch CPP. Yellowcake drying at the Highland Central Plant is conducted with a natural gas fired rotary hearth that utilizes a wet scrubber and vacuum system to limit the release of uranium during drying. Section 4.1.4 further discusses the effluent controls for this system.

Routine washdown procedures at both drying facilities keeps work areas clean of accumulating uranium as well as dirt and dust from outside sources.

4.1 GASEOUS AND AIRBORNE PARTICULATES

The principal radiological gas representing a potential radiological dose to man is radon-222 gas released to the atmosphere from the circulating leach solution and/or in the elution and precipitation circuit. Some carbon-dioxide gas and some acid fumes will evolve also from the elution/precipitation circuit, but these gases do not present a health problem at the anticipated concentrations. In order to alleviate potential discomfort or health problems due to the in-plant accumulation of gases and fumes, three ventilation systems have been installed. A ventilation system is connected to all process vessels where significant radon-222 or process fumes could reasonably be expected to be released. For the general work areas in the CPP building, a forced air ventilation system is installed for use when the buildings are normally closed due to weather or other factors. A third ventilation system is installed as a part of the yellowcake drying operation.

4.1.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system is installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks to exhaust fumes to the outside atmosphere. Air flow through any openings in the vessel will be from the process area into the vessel and into the ventilation system controlling any releases that occur inside the vessel. Where needed, exhaust fans can pull the air from the top of the tanks and discharge the air with any gases and fumes to a vent placed on the outside of the building near the roof level. Separate ventilation systems are used as needed for the functional areas within the CPP.

A tank ventilation system of this type was utilized in the pilot process plant and in-plant monitoring for radon concentrations has proven it to be an effective system for minimizing employee exposure. Operational data collected during operation of the CPP has confirmed that the ventilation system is effective.

4.1.2 Work Area Ventilation System

The work area ventilation system is designed to force air to circulate within the separate CPP process areas. The systems for the ion exchange area and for the precipitation area include a minimum of two exhaust fans each. A third system is provided for yellowcake drying and packaging area. The ventilation system exhausts are located on the north or leeward side of the buildings. During favorable weather open doorways and the convection vents in the roof have provided satisfactory work area ventilation.

The maximum calculated annual radon release for the commercial ISL operations is based on NRC procedures used in NUREG-0925 Appendix C assuming all produced fluids are in equilibrium. Using these basis, radon is released at the maximum rate of 6738 Ci/year during the period of maximum production and restoration flows of 11,000 gpm and 3,000 gpm respectively (Table 4-1).

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic and small amounts of process chemicals such as ammonia, carbon dioxide, oxygen, hydrogen peroxide, sodium hydroxide, sulfuric acid and hydrochloric acid. There are no significant combustion related emissions from the process facility as commercial electrical power is available at the site.

4.1.3 Yellowcake Drying at the Smith Ranch CPP

The wet yellowcake from the precipitation circuit is vacuum dried and packaged in fifty-five (55) gallon drums for shipment. The vacuum drying system is proven technology, which is being used successfully in several ISL sites where uranium oxide is being produced.

The vacuum drying system consists of the following:

1) Drying Chamber: A S.S. vessel is heated externally and is fitted with a mechanical agitator to stir the yellowcake.

The chamber has a top port for loading the wet cake and a bottom port unloading the dry powder. Additional ports are provided for venting of vapors during the drying procedure.

2) Bag House: This air and vapor filtration unit is mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house is heated to prevent condensation of water vapor during the drying cycle. It is kept under negative pressure by the vacuum system.

3) Condenser: This unit is located downstream of the bag house and is water cooled. It is used to remove the water vapor from the non-condensable gases coming from the drying chamber. The gases are moved through the condenser by the vacuum system. Dust passing through the bag filters is wetted and entrained in the condensing moisture within this unit.

4) Vacuum Producer: The vacuum producer is a water sealed unit that provides a negative pressure on the entire system during the drying cycle. It is also used to provide ventilation during transfer of the dry powder from the drying chamber to fifty-five (55) gallon drums. The water seals captures entrained particulate matter remaining in the gas streams.

5) Packaging: The system is operated on a batch basis. When the yellowcake is dried sufficiently, it is discharged from the drying chamber through a bottom port into drums. A level gauge, a weigh scale, or other suitable device is used to determine when a drum is full. As noted in 4) above, ventilation is provided by the vacuum pump when the powder is being transferred.

6) Heating: The heat for drying is supplied by a heat transfer medium such as Dow-Therm or other suitable heat transfer materials. The yellowcake drying is accomplished under 325° F and at pressures less than atmospheric.

7) Effluent Monitoring: Because of the low, intermittent air flow exiting the vacuum pump, isokinetic sampling of the effluent is not possible. The air flow from the vacuum pump associated with the yellowcake dryer does not exit the building. The water that is collected from the condenser is recycled to the precipitation circuit or filtered and discharged with other process water. Room air will be monitored routinely for airborne dust and radionuclides as described in Chapter 9.

8) Controls: The system is instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the

emission control system is not performing within operational specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded as part of routine operations, if currently loaded, or reloaded, if currently empty, until the emission control system is returned to service within specified operational conditions.

To ensure that the emission control system is performing within specified operating conditions, instrumentation is installed that signal an audible alarm if the air pressure (i.e. vacuum level) falls below specified levels, and the operation of this system is checked and documented during dryer operations. In the event this system fails, the operator will perform and document checks of the differential pressure or vacuum every four (4) hours. Additionally, during routine operations, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

4.1.4 Yellowcake Drying at the Highland Central Plant

When operating, the yellowcake drying and packaging facilities at the Highland Central Plant emit minor quantities of radioactive airborne particulates. To ensure adequate building ventilation, the following is utilized as required:

1) CPF building – Five 36 inch hooded axial fans providing a nominal ventilation capacity of 64,000 cfm and one 48 inch wall mounted axial fan providing an additional ventilation capacity of 20,900 cfm.

2) Precipitation area – Ventilation of this area is provided, when needed, by a 42 inch hooded axial roof fan, nominally rated at 15,000 cfm. Design criteria specifies that the system provides not less than 6 air exchanges per hour, approximately 12,900 cfm exhaust capability.

3) Yellowcake Dryer and Packaging Rooms – The exhaust air systems in these areas consist of two separate systems, each equipped with wet scrubbers for dust removal, and each discharging to the atmosphere via separate stacks.

   The Packaging Room scrubber system services the yellowcake drum filling hood, product drum lidding station and the product packaging enclosure. Collected air, fumes, particulates and gases are ducted to the Packaging Room exhaust system scrubber (a wet-baffled orifice unit), and discharged to the atmosphere via a 6 inch diameter stack extending 1 foot above the ridgeline of the building and 60 feet above the ground. The associated air-mover is a centrifugal blower. Design criteria provide for an inlet gas volume of 700 cfm, with a dust loading of 5 grains of yellowcake dust per cubic foot. Fresh water is supplied to the scrubber at about 1.5 gpm.

A second scrubber system services the Yellowcake Dryer. Collected air, fumes, particulates and gases are ducted to a wet scrubber, and discharged to the atmosphere via a 13.5 inch diameter stack extending one foot above the ridgeline of the building and 60 feet above the ground. The associated air-mover is a centrifugal blower. Design intake to the scrubber is 3,300 cfm of air containing 0.73 grains per cubic foot of minus 10 micron yellowcake dust. Water feed to the scrubber is approximately 5-10 gpm. The overall design efficiency of this system at design loading and operating conditions is greater than 99%.

Performance criteria for the Yellowcake Drying and Packaging scrubber systems are as follows:

1. Drafts of 10-15 inches of water are maintained at the intakes of both scrubbers.

2. Pressure drops of not less than 10 inches of water are maintained across both scrubbers.

3. Discharge volumes from 2,000 to 2,500 cfm and from 550 to 900 cfm are maintained from the Dryer and the Packaging exhaust stacks, respectively.

4. Total particulate concentrations of gaseous effluents from the Dryer and Packaging scrubbers normally do not exceed 0.03 grains per cubic foot of air discharged. This exceeds 99.9% scrubber efficiency at 750 pounds per hour throughput.

5. Continuous monitoring instruments are provided for the following at each scrubber system.

   - drafts at the fan intakes
   - pressure drops (differential) across the scrubbers
   - water flow rates

6. The Central Plant Process Computer continuously monitors the Yellowcake Dryer and Packaging scrubber drafts, differential pressures, and water flow rates. The computer records the drafts, differential pressures, and water flow rates every two hours. This data is printed in a daily report which is reviewed by the Central

Plant Superintendent, or designee. Any abnormal conditions are noted, and any needed repairs are initiated.

7. The Central Plant Process Computer also continuously controls the Dryer scrubber interlock system which prevents operation if an inadequate scrubber draft, differential pressure, or inadequate water flow to the system is detected. In the event of such a condition, the process computer also sounds an audible alarm in the CPF. The process computer also controls an audible alarm in the case that the Packaging scrubber draft, pressure differential, or water flow are determined to be inadequate.

8. Yellowcake drying and packaging operations are suspended if any of the equipment at the scrubber systems is not operating in accordance with design specifications.

9. As appropriate, specific operating parameter values presented above may be changed; however, they will be selected and used in a manner to maintain or improve the scrubber system efficiency. The appropriate Standard Operating Procedures (SOPs) will be revised to reflect these changes.

10. A stack emissions survey is performed semiannually on the Dryer and Packaging scrubber exhaust stacks to determine the emission rate of particulates, U-natural, radium-226 and thorium-230.

11. The Dryer and Packaging scrubber systems are inspected and cleaned on a routine basis (at least every 30 days of operation).

4.2 LIQUIDS AND SOLIDS

Liquid effluents from the operation include the production bleed stream, excess fluids from the elution and precipitation process, regeneration of the water softener system (calcium control), yellowcake rinse water, plant washdown water, restoration equipment (EDR/RO) waste, restoration bleed, analytical laboratory waste, and facility sanitary waste.

The net production bleed stream is approximately one half to one and one half percent of the production. The bleed is taken after the ion exchange units have removed the uranium. The bleed stream and washdown water from Satellite IX facilities is transferred to the CPP through a pipeline connecting the two facilities. The bleed is then commingled with the other liquid effluents and either discharged to one of the deep disposal injection wells or alternatively as shown in Figure 4-1 the water may be routed to a reverse osmosis unit. The resulting RO brine may be commingled with other plant water for disposal in a deep disposal injection well. The RO permeate effluent may be used as process water for chemical makeup or returned to the leaching circuit.

The production bleed stream, washdown water, and ground water restoration waste water generated at the Highland Satellites (Satellites Nos. 1, 2 and 3) is treated for removal of uranium and radium-226 and is then pumped to either Purge Storage Reservoir No. 1 or No. 2 prior to disposal via land application (irrigation) at one of the two pivot irrigators.

Excess liquids from the Smith Ranch CPP elution and precipitation circuit and water softener regeneration are expected to average about 60 gallons per minute and will be routed to lined evaporation ponds or to a disposal injection well. Less than 2 gallons per minute of water will result from plant wash water. This water will be commingled with other plant waste water or may be used as process make-up water if it is of satisfactory quality.

Excess liquids from the Highland Central Plant are disposed at Morton 1-20 deep disposal well located approximately one mile north of the plant. Currently (March 2003), no liquids from the Highland Central Plant are disposed of as the facility remains on standby status.

During restoration two additional liquid waste streams are expected at Smith Ranch, Figure 4-2. The operation of electrodialysis (EDR) or reverse osmosis (RO) units will generate a stream in which most of the dissolved solids in the total EDR/RO stream are concentrated in 15% to 30% of the water volume. When operating at full capacity this concentrated stream may be about 250 gallons per minute per ion exchange facility. This stream will be routed to a lined evaporation pond or to a deep waste disposal well. When water quality from restoration areas improve to the point that after uranium and radium removal it is suitable for discharge under an NPDES permit, it may be routed from the separate radium removal settling system to a water treatment system. When the recovery plant is operating at normal capacity it is expected that this stream could be more than 1000 gallons per minute.

A projected water balance for Smith Ranch operating at 12000 gpm with a one and one half percent production bleed is shown in Figure 4-2. The water balance represents the highest production flowrate matched with the corresponding restoration flowrate from Table 4-1(ad). These flowrates represent the total water balance with 3 ion exchange facilities and the Central Processing Plant. As capacity is added to the facility to meet these production and restoration levels, disposal capacity will be added in the form of additional deep disposal injection wells, (currently (March 2003), there are two deep disposal wells at Smith Ranch and one at the HUP. Two more deep wells may be installed at Smith Ranch and one additional well at the HUP) or future evaporation ponds. Additional reductions in wastewater volumes may be obtained by increasing the efficiency of the reverse osmosis process. Figure 4-3, Recovery Plant Flow Rates, provides additional detail on the individual streams of the water going to the deep disposal injection wells.

The future lined evaporation ponds are expected to consist of several cells of five (5) to fifteen (15) acres each. Some waste streams may be routed to selected cells for additional treatment and/or processing. If treatment or processing can improve the water quality such that it meets Wyoming DEQ criteria for NPDES discharge or for irrigation and NRC radionuclide criteria for release to unrestricted areas, the water may be discharged through the water treatment plant or used for irrigation.

4.2.1 Deep Disposal Injection Wells

Currently (March 2003), the SR-HUP utilizes three deep disposal injection wells to dispose of waste water generated by both wellfield and yellowcake processing operations. One well is associated with the Highland facilities and two wells are associated with the Smith Ranch facilities. The locations of the wells are shown on Plate 1.

The Smith Ranch Facility currently operates two Deep Disposal Injection wells, and these are currently permitted under the Underground Injection Control Program through the Wyoming Department of Environmental Quality – Water Quality Division (WDEQ-WQD). Both of these wells are approved to operate under UIC Permit 99-347 as Class I Non-Hazardous Waste Disposal Wells and authorized by U.S. NRC for the facility under Amendment 16 to Source Material License SUA-1548. PRI currently plans to construct additional deep disposal injection wells during the course of operations as water disposal needs are anticipated and with regulatory approval through WDEQ and U.S. NRC.

The two Smith Ranch operating disposal wells are designated as WDW #1 and WDW #2, and they are located in Township 36N and Range 74W. WDW #1 is located in the NE¼ Section 35 approximately ½ mile west of the CPP. WDW #2 is located in the NE¼ of Section 27 approximately 800 feet north of Satellite SR-1. The description of the construction and testing of these wells are found in submittals from the original licensee (Rio Algom Mining Corp.) to U.S. Nuclear Regulatory Commission dated October 25, 1995 for WDW #1 and November 22, 1999 for WDW #2. Both wells are permitted to inject into the Parkman, Teapot and Teckla formations, and the permit authorizes injection of up to 432,000 gallons per day of process effluents, laboratory wastes, and production bleed at a maximum injection wellhead pressure of 1,566 psig.

The Highland operating Morton 1-20 Disposal Well is also permitted with the WDEQ-WQD UIC Permit 99-347 as a Class I Non-Hazardous Waste Disposal Well. This permit also includes an additional deep disposal well (Vollman 33-27) located near the center of Section 27 T36N, R73W, approximately 1.5 miles east of Satellite No. 3. To date (March 2003) this well has not been constructed. The construction and operation of the Vollman 33-27 well was approved by NRC via License Amendment No. 9. (License SUA-1511), dated December 31, 1998. Similar to the two deep disposal wells associated with Smith Ranch operations, both the existing Morton 1-20 well and the planned Vollman 33-27 are, or will be, completed in a deep injection zone within intervals from 8,629 to 9, 141 feet below the surface in the Teapot and Parkman formations.

4.2.2 Satellite No. 1 Radium Settling Basins

The Radium Settling Basins consist of two 3 acre feet (AF) clay lined ponds located east of Satellite No. 1. They are used to settle out residual radium-barium sulfate which remains after removal by the radium treatment system and filter presses located in Satellite No. 1. After treated wastewater passes through the Radium Settling Basins, it is transported to the Satellite No. 1 Purge Storage Reservoir where it is stored prior to periodic land application. The Radium Settling Basins are connected to Satellite No. 1 by a 3 inch HDPE pipeline and are connected to the Satellite No. 1 Purge Storage Reservoir by an 8-inch HDPE pipeline.

During early 1988 Everest Minerals Corporation (predecessor to Power Resources, Inc.) notified the NRC that very small quantities of water seepage had been detected in the underdrain system of the Radium Settling Basins. As discussed in the June 1, 1988 correspondence from Everest Minerals Corporation to the NRC, the seepage rates were much lower than the theoretical seepage rates through the clay liner which contained "as-built" permeabilities on the order of 1.0E-7 to 7.8E-7 cm/sec. Upon inspection of the clay liner during 1988 it was determined that erosion protection was needed to protect the sides of the clay liner from wave action. Therefore, a geotextile fabric was installed in September 1988 to protect against future erosion concerns.

The two radium settling basins continued to function as designed, with seepage rates and seepage water quality unchanged from previous periods. The small amount of seepage entering the underdrain system was periodically pumped back to the basins. The geotextile fabric installed to protect against erosion of the clay liner has proven to be very effective. The water quality data resulting from monitoring of the underdrain system was reported to the NRC in the 10 CFR 40.60 Semi-Annual Reports.

During August and September 2002 PRI made modifications to the filtering equipment at Satellite No. 1 in order that continued operation of the Radium Settling Basin was no longer needed. Therefore, they were drained in October 2002. Treated wastewater from Satellite No. 1 is now directly pumped to Purge

Storage Reservoir No. 1. This operation is consistent with the treatment systems at Satellite Nos. 2 and 3.

PRI plans to start the decommissioning and reclamation of the Radium Settling Basins when the clay liner has adequately dried out enough that the material can be removed and transported. Due to the presence of low levels of uranium and radium-226 in the clay liner the material will require disposal as "by-product" waste.

The Radium Settling Basins were originally permitted by the WDEQ-WQD under Permit 93-178 and are currently permitted under the WDEQ/LQD Permit to Mine No. 603. The application package for this facility was submitted to the NRC on February 16, 1987.

4.2.3 Satellite No. 1 Purge Storage Reservoir and Irrigation Area

The Satellite No. 1 Purge Storage Reservoir (PSR-1) is located east of Satellite No. 1 and is used to store treated wellfield purge water and treated water from wellfield restoration activities. The reservoir contains 54 AF when at full capacity. Water stored in the reservoir is periodically land applied by sprinkler irrigation on a 58 acre irrigation area when weather conditions permit.

The reservoir is underlain by a natural clay soil that contains an average permeability of approximately 1.8E-8 cm/sec. Use of the reservoir began in January 1988 with the start of production from the Satellite No. 1 area. The reservoir performed as designed until August 1994 at which time a small amount of leakage was discovered seeping at the two ephemeral drainages located immediately east and south of the reservoir. A Corrective Action Plan (CAP), which addressed the conditions at the reservoir and corrective measures to be implemented, including the installation of two pumpback sumps (North and South Pumpback Sumps), was submitted to the NRC in correspondence dated October 3, 1994. It was determined that the seepage resulted from erosion of the natural clay liner along the eastern most portion of the reservoir. The erosion was caused mostly by wave action. Erosion of the clay liner exposed an underlying sandstone which allowed seepage to move out of the reservoir, to the south and east, where the sandstone outcropped in the ephemeral draws.

On November 9, 1994 all of the treated wastewater was diverted to the Satellite No. 2 Purge Storage Reservoir (PSR-2) in order that the PSR-1 could be dried out and repairs to the liner accomplished. Due to the abnormally wet spring of 1995, construction activities, which included repair of the clay liner and the addition of a geotextile fabric along the eastern side of the reservoir to protect against erosion, were not completed until August 1995. The CAP also included the construction of an 800 foot long Interceptor Trench approximately 300 feet south of PSR-1 in August 1996. The trench captures subsurface seepage from the south side of PSR-1 and pumps it back into the reservoir. The pumping system is fully automatic and continuously operates. To date (March 2003) the Interceptor Trench has been very effective in preventing seepage from PSR-1 from surfacing and entering the drainage south of the system. After the Interceptor Trench went into service, it was no longer necessary to operate the South Pumpback Sump.

As of March 2003, both the Interceptor Trench and North Pumpback Sump are fully operational. It is expected that the system will operate until PSR-1 is no longer used to store treated wastewater. The system is monitored in accordance with requirements of the WDEQ-LQD.

PSR-1 was originally permitted by the WDEQ-WQD under Permit No. 93-178. The PSR-1 and associated pumpback system are currently permitted under the WDEQ-LQD Permit to Mine No. 603. The original application package PSR-1 was submitted to the NRC on February 16, 1987.

The Satellite No. 1 Irrigation Area is located east of Satellite No. 1 near PSR-1. The area consists of a center pivot sprinkler irrigation system which covers 58 acres. Water from PSR-1 is periodically land applied by sprinkler irrigation on this area.

The Satellite No. 1 Irrigation Area was originally permitted by the WDEQ-WQD under Permit No. 92-077 and is currently permitted under the WDEQ-LQD Permit to Mine No. 603. The application package for this facility was submitted to the NRC on July 17, 1986 and approved with the original license approval in July 1987.

4.2.4 Satellite No. 2 Purge Storage Reservoir and Irrigation Area

An additional purge storage reservoir and irrigation area were constructed in 1994 northeast of Satellite No. 2. These facilities, known as the Satellite No. 2 Purge Storage Reservoir (PSR-2) and Irrigation Area are used for the storage and disposal of purge and ground water restoration fluids from wellfields served by Satellite Nos. 2 and 3.

The locations of the Satellite No. 2 PSR and Irrigation Area and the 4 inch HDPE pipeline which is used to transport treated wastewater from Satellite No. 3 to the Satellite No. 2 PSR are shown on Plate 1. The facilities are sized, constructed, and operated in a fashion similar to the existing Satellite No. 1 PSR and Irrigation Area. The facilities were originally permitted by the WDEQ-WQD under Permit No. 93-410 and are currently permitted under the WDEQ-LQD Permit to Mine No. 603. On June 10, 1994 the NRC approved Amendment No. 53 which approved the construction and use of these facilities. Similar to PSR-1, PSR-2 is underlain by several low permeability clay units which minimizes seepage to any potential useable aquifer. Use of the Irrigation Area started during September 1995.

4.2.5 Existing Lined Evaporation Ponds

Currently, two small, lined solar evaporation ponds are in operation at the Smith Ranch Facility. These ponds were initially constructed in 1981 and authorized under the Q-Sand Pilot Project License SUA-1387. These ponds are located just to the north of the CPP, and they are currently used for limited process effluent disposal and for solids retention prior to transfer to the deep disposal injection wells. The capacity of each pond is 0.78 acre feet of water. Each pond is 100 ft. x 100 ft. and 8 feet deep. During operations, a 3 feet freeboard is maintained in each pond to protect the berms from wave action due to winds.

Each pond is constructed with a compacted sandy clay base overlain by a 30 mil Hypalon liner. The bottom of each pond has a two way slope toward the center. A sand layer is placed over the bottom of the pond with the synthetic liner on top of the sand. For each pond, a perforated PVC pipe is installed in the sand layer parallel to the bottom slope. The perforated pipe is connected to a collection sump. The sumps will be monitored for leaks of process solutions, as described in Chapter 5.

4.2.6 Future Solar Evaporation Pond(s)

The future solar evaporation ponds for the SR-HUP will consist of five to fifteen acre cells typically ten to twenty feet deep for holding process waste waters containing high total dissolved solids. The design plan and method of construction for the individual cells will be similar to that used for the pilot plant lined evaporation ponds.

A preliminary subsurface study of potential evaporation pond sites was conducted by Chen & Associates of Casper, Wyoming. Eleven subsurface test holes drilled in the permit area encountered as much as 45 feet of clay and sandy clay material that would be suitable for use in constructing the pond embankments. No water was encountered in any of the test holes, which were 25 to 50 feet deep.

After all topsoil is removed and stockpiled from the area to be disturbed, the evaporation pond cells will be constructed from a combination of cuts and compacted subsoil embankments using the local clays and sandy clays. Embankment slopes will be on the order of 3 horizontal to 1 vertical and the cells will have an eight foot wide or greater crest on all embankments. The material in the bottom of the cell and interior sides of embankments will be compacted to 90 to 95% of maximum standard Proctor density. Material unsuitable for use in construction of soil liners will be identified and segregated. A leak detection system consisting of perforated pipes placed in a sand layer and designed to drain to a common sump will be installed in each cell. The cell will then be lined with an impervious membrane material such as hypalon or high density polyethylene.

The final design and location of each cell will depend on site-specific soils sampling and testing. The embankments will be designed to divert natural run-off away from the pond and the ponds will be located away from significant surface drainage systems. The ponds will be fenced individually to exclude livestock and wildlife such as antelope. The fences around the evaporation ponds will be posted with warning signs for personnel protection. A Permit to Construct will be obtained from the WDEQ prior to beginning construction.

4.2.7 Solid Waste

The non-radioactive wastes, such as packing material, are disposed in the site's existing solid waste disposal facility as authorized by the WDEQ. The on-site construction waste landfill site was originally permitted by the WDEQ in 1978 and continues to operate for disposal of construction, shipping, and demolition materials. Public access to the disposal site is prohibited by the facility's fencing. Only those materials generated by the facility or in association with its operation are allowed to be disposed at the site. No hazardous, sanitary, or radioactive contaminated wastes are disposed at this landfill. No impact to groundwater is anticipated resulting from this landfill.

The disposal facility is located directly behind the Smith Ranch CPP near the top of a sandstone ridge to prevent run-on from snowmelt and precipitation (see Plate 1). Prior to its original use, topsoil from the site was removed and stockpiled for future use. The disposal site(s) consist of a constructed trench approximately 10-14 feet deep surrounded on either side by litter control fencing. Materials placed within the site are periodically buried in place with sand material originally excavated from the disposal pit. Construction materials, primarily including such items as waste lumber, pallets, or cable spools may be managed by controlled burns authorized by specific county burn permits. Any fugitive materials not managed by the litter fences periodically are collected and placed into the disposal site to assure the litter is appropriately controlled.

4.3 CONTAMINATED EQUIPMENT

Solid wastes generated by this project that are contaminated with uranium consist of materials such as rags, trash, packing material, worn or replaced parts from equipment, piping, sediments removed from process pumps and vessels, the solids remaining in the evaporation pond after the liquids have evaporated and sludge from the radium-226 treatment systems at Satellite Nos. 1, 2, and 3. Radioactive solid waste that has a contamination level requiring controlled disposal are isolated in drums or other suitable containers and disposed in a NRC licensed tailings facility or as otherwise approved by the NRC. The combined operations at the SR-HUP will generate between approximately 100 to 300 yd^3 of radioactive contaminated waste each year. During final decommissioning of the Central Processing facilities and Satellites, the volume will increase.

Table 4-1(a)
Calculations of Source Terms for the Smith Ranch Project

Wellfield 1. – Production

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.05E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 8.5E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 28.6 gpm

(28.6 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.56E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.05E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(8.5E7 L) + (2.65E4 L/d) + (1.56E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.56E5 L/d) = 35 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(8.5E7 L)(0.01/d) = 189 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2200 gpm/3000gpm) = 4.3 Ci/yr

Table 4-1 (b)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 2. – Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (2.65E4 L/d) + (2.83E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-1 (c)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 3. – Production

Operating Days = 360
Area = 1.71E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.71E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.39E8\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

$$(18903\ gal)(0.37)(3.785\ L/gal)\ (1/d) = 2.65E4\ L/d$$

Total Wastewater Purge Rate = 1.3% = 46.8 gpm

$$(46.8\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 2.55E5\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.71E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.39E8\ L) + (2.65E4\ L/d) + (2.55E5\ L/d)]}$$

$$= 6.16E5\ pCi/L$$

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.55E5 L/d) = 57 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.39E8 L)(0.01/d) = 308 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3600 gpm/3000gpm) = 7.1 Ci/yr

Table 4-3 (d)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 4. – Production

Operating Days = 360
Area = 1.14E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.14E5 m2)(3 m)(0.27)(1E3 L/m3) = 9.23E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 31.2 gpm

(31.2 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.70E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.14E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(9.23E7\ L) + (2.65E4\ L/d) + (1.70E5\ L/d)]}$$

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.70E5 L/d) = 38 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(9.23E7 L)(0.01/d) = 205 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2400 gpm/3000gpm) = 4.7 Ci/yr

Table 4-1 (e)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 5. – Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-1 (f)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 6. – Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.9E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (2.65E4\ L/d) + (2.83E5\ L/d)]}$$

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-1 (g)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 7. – Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.7E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(28.6 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (2.65E4 L/d) + (1.42E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.7E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-1 (h)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 8. – Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-1 (i)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 9. – Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-1 (j)
. Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 10. – Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-1 (k)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 11. – Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.6E7\ L$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(26 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(9.5E4\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(7.6E7\ L) + (2.65E4\ L/d) + (1.42E5\ L/d)]}$$

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-1 (I)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 12. – Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (2.65E4 L/d) + (2.83E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-1 (m)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 13. – Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.6E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(26 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.6E7 L) + (2.65E4 L/d) + (1.42E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-1 (n)
Calculations of Source Terms for the Smith Ranch Project

Wellfield 14. – Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.6E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(26 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.6E7 L) + (2.65E4 L/d) + (1.42E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-1 (o)
Calculations of Source Terms for the Smith Ranch Project

Wellfield 1. – Restoration

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.05E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 8.5E7 L

Restoration Removal Rate Maximum = 913 gpm

(913 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.98E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.05E5 m^2)(3 m)1.93 g/cm^3)(0 2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(8.5E7 L) + (4.98E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.98E6 L/d) = 853 Ci/yr

Table 4-1 (p)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 2. – Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$$

Restoration Removal Rate Maximum = 1660 gpm

$$(1660\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 9.05E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.9E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (9.05E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(9.05E6\ L/d) = 1551\ Ci/yr$$

Table 4-1 (q)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 3. – Restoration

Operating Days = 360
Area = 1.71E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.71E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.39E8 L

Restoration Removal Rate Maximum = 1494 gpm

(1494 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 8.14E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.71E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.39E8 L) + (8.14E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(8.14E6 L/d) = 1394 Ci/yr

Table 4-1 (r)
Calculations of Source Terms for the Smith Ranch Project

Wellfield 4. – Restoration

Operating Days = 360
Area = 1.14E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.14E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 9.2E7 L

Restoration Removal Rate Maximum = 996 gpm

(996 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 5.43E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.14E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(9.2E7 L) + (45.43E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(5.43E6 L/d) = 931 Ci/yr

Table 4-1 (s)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 5. – Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Restoration Removal Rate Maximum = 1245 gpm

(1245 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 6.79E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (6.79E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(6.79E6 L/d) = 1164 Ci/yr

Table 4-1 (t)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 6. – Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$$

Restoration Removal Rate Maximum = 1660 gpm

$$(1660\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 9.05E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.9E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (9.05E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(9.05E6\ L/d) = 1551\ Ci/yr$$

Table 4-1 (u)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 7. – Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.7E7\ L$$

Restoration Removal Rate Maximum = 830 gpm

$$(830\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 4.5E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(9.5E4\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(7.7E7\ L) + (4.5E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(4.5E6\ L/d) = 771\ Ci/yr$$

Table 4-1 (v)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 8. – Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Restoration Removal Rate Maximum = 1245 gpm

(1245 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 6.79E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (6.79E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(6.79E6 L/d) = 1164 Ci/yr

Table 4-1 (w)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 9. – Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Restoration Removal Rate Maximum = 1245 gpm

$$(1245\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d) = 6.79E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.43E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (6.79E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(6.79E6\ L/d) = 1164\ Ci/yr$$

Table 4-1 (x)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 10. – Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Restoration Removal Rate Maximum = 1245 gpm

(1245 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 6.79E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (6.79E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(6.79E6 L/d) = 1164 Ci/yr

Table 4-1 (y)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 11. – Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.7E7\ L$$

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-1 (z)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 12. – Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Restoration Removal Rate Maximum = 1660 gpm

(1660 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 9.05E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (9.05E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(9.05E6 L/d) = 1551 Ci/yr

Table 4-1 (aa)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

-Wellfield 13. – Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.7E7 L

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-1 (ab)
Calculations of Source Terms for the Smith Ranch Project (Cont.)

Wellfield 14. – Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.7E7 L

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-1 (ac)
Calculations of Source Terms for the Smith Ranch Project

Wellfield 1. – New Wellfield Example

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d
110 Patterns Representing 330 Wells (3 unique wells per pattern)
1 mud pit per well
Drilled Well Diameter = 8"
Average Ore Material per Well in Grams:

$$(3.14)((8 \text{ in}/2)(2.54 \text{ cm/in}))^2(300 \text{ cm})(1.93 \text{ g/cm}^3) = 1.88\text{E}5 \text{ g/well}$$

Total Ore in Mud Pit/yr = 1.88E5 g

Storage Time = 365 days/yr

Rnnw = 1E-12 Ci/pCi(0.2)(0.181/d)(574 pCi/g)(365 d/yr)(1.88E5 g/well)(330 wells/yr)

= 0.47 Ci/yr

Rn-222 flux = [(1E12 pCi/Ci)(0.47 Ci/yr)]/[1.05E5 m^2)(3.15E7 s/yr)]

= 0.14 pCi/m^2/s

Table 4-1 (Cont'd)
Calculations of Source Terms for the Smith Ranch Project

Irrigation:

Numerous calculations have been performed for soil loading from irrigating with treated mine wastewater. The final concentrations of uranium and radium in the top soils are small and the source terms associated with the irrigation are small compared to other project source terms.

Irrigation water derived from restoration will be treated with barium chloride to reduce Ra-226 to 5 pCi/L. this will leave approximately 2.58E-1 pCi/g above background in the upper 15 cm of soils of the 500 acre irrigation site over the life of the mine.

Ra-226 = 0.258 pCi/g or approximately 0.258 pCi/m^2/s of radon flux

Uranium, treated to 1ppm, will leave approximately 12 pCi/g U238 distributed over the top 45 cm of soil throughout the irrigation area.

Table 4-1 (ad)
Calculations of Cumulative Average Annual Source Terms for the Smith Ranch Project

Central Processing Plant I

ellfield		1997 1st half	1997 2nd half	1998 1st half	1998 2nd half	1999 1st half	1999 2nd half	2001 1st half	2001 2nd half	2002 1st half	2002 2nd half	2003 1st half	2003 2nd half	2004 1st half	2004 2nd half	2005 1st half	2005 2nd half	2006 1st half	2006 2nd half	2007 1st half	2007 2nd half	2008 1st half	2008 2nd half	2009 1st half	2009 2nd half	2010 1st half	2010 2nd half	2011 1st half	2011 2nd half	2012 1st half	2012 2nd half	2013 1st half	2013 2nd half
1	Production		4000	4000	4000	4000	2000	2000																									
	Restoration								1000	1000	1000	1000																					
2	Production							2000	4000	4000	4000	4000	4000																				
	Restoration													1000	1000	1000	1000																
6	Production													4000	4000	4000	4000																
	Restoration																	1000	1000	1000													
12	Production																	4000	4000	4000	4000	2000	2000										
	Restoration																							1000	1000	1000	1000						
13	Production																					2000	2000	2000	2000	2000	2000						
	Restoration																											1000	500	500	500	500	
	Production																							2000	2000	2000	2000	2000					
	Restoration																																
Total IX Flow			4,000	4,000	4,000	4,000	2,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	2,000	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Satellite IX #1

ellfield		1997 1st half	1997 2nd half	1998 1st half	1998 2nd half	1999 1st half	1999 2nd half	2001 1st half	2001 2nd half	2002 1st half	2002 2nd half	2003 1st half	2003 2nd half	2004 1st half	2004 2nd half	2005 1st half	2005 2nd half	2006 1st half	2006 2nd half	2007 1st half	2007 2nd half	2008 1st half	2008 2nd half	2009 1st half	2009 2nd half	2010 1st half	2010 2nd half	2011 1st half	2011 2nd half	2012 1st half	2012 2nd half	2013 1st half	2013 2nd half
3	Production				3000	3000	2000	2000	2000	1000	1000	1000	1000																				
	Restoration													500	500	1000	500	500	500														
4	Production						2000	2000	2000	2000	2000																						
	Restoration											1000	1000	500	500																		
5	Production									1000	1000	3000	3000	2000	2000	2000																	
	Restoration																500	500	500	1000	1000												
7	Production																		1000	2000	2000	2000	2000	2000									
	Restoration																																
8	Production													2000	2000	2000	3000	3000	3000	2000	2000	2000											
	Restoration																						1000	1000	500	500	500	500	1000				
	Production																																
	Restoration																																
Total IX Flow			0	0	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	3,000	3,000	4,000	4,000	4,000	4,000	2,000	2,000	0	0	0	0	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0	0

Satellite IX #2

ellfield		1997 1st half	1997 2nd half	1998 1st half	1998 2nd half	1999 1st half	1999 2nd half	2001 1st half	2001 2nd half	2002 1st half	2002 2nd half	2003 1st half	2003 2nd half	2004 1st half	2004 2nd half	2005 1st half	2005 2nd half	2006 1st half	2006 2nd half	2007 1st half	2007 2nd half	2008 1st half	2008 2nd half	2009 1st half	2009 2nd half	2010 1st half	2010 2nd half	2011 1st half	2011 2nd half	2012 1st half	2012 2nd half	2013 1st half	2013 2nd half
9	Production																		3000	3000	3000	3000	3000										
	Restoration																							1000	1000	1000	1000						
10	Production									2000	2000	2000	2000	2000	2000	2000																	
	Restoration																1000	1000															
11	Production													2000	2000	2000	2000	2000															
	Restoration																		500	500	500	1000											
	Production																																
	Restoration																																
	Production																																
	Restoration																																
	Production																																
	Restoration																																
Total IX Flow			0	0	0	0	0	0	0	3,000	3,000	3,000	3,000	4,000	4,000	4,000	2,000	2,000	3,000	3,000	3,000	3,000	3,000	0	0	0	0	0	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	0	0	0	0	0	0
Cummulative Flow			2,000	2,000	5,000	7,000	6 000	8,000	8,000	11,000	11,000	11,000	11,000	12,000	12,000	12,000	9,000	9,000	11,000	11,000	11,000	11,000	9,000	6,000	4,000	4,000	4,000	2,000	0	0	0	0	0
Cummulative Restoratio			0	0	0	0	0	0	1,000	1,000	1,000	2,000	1,000	2,000	2,000	2,000	3,000	3,000	3,000	3,000	2,000	1,000	1,000	3,000	3,000	3,000	3,000	2,000	2,000	1,000	1,000	1,000	1,000
Avg. Annual Flux Source Term Ci/				228 3		600 4			1573.25		2503.1		2759.9		5419.1		5343.4		6738.6		5109		2251		4774 3		5057 8		2808		1542		1156.5

FIG 4-1
TYPICAL WATER BALANCE
FOR 1.0% PURGE AND FULL PRODUCTION

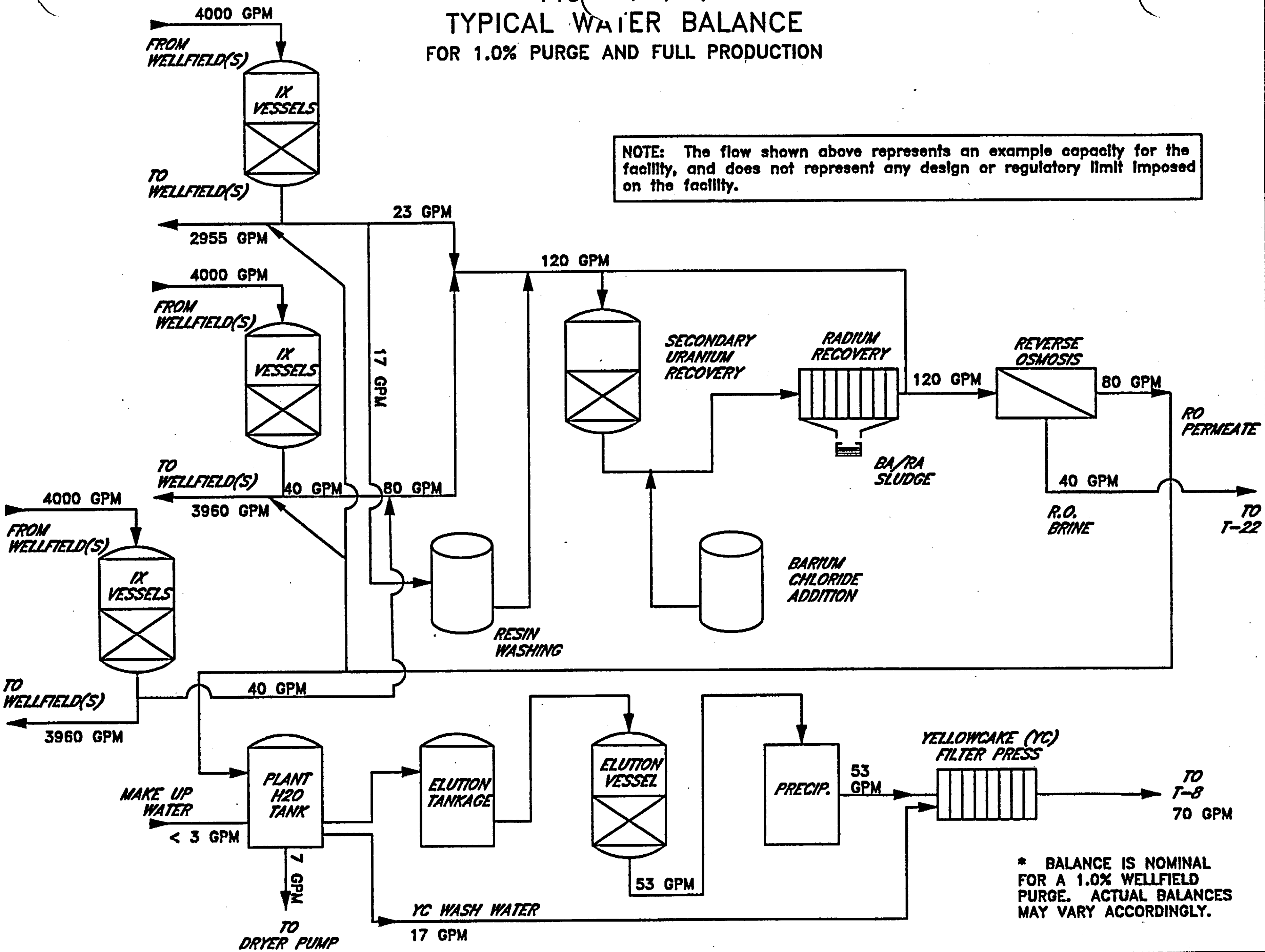
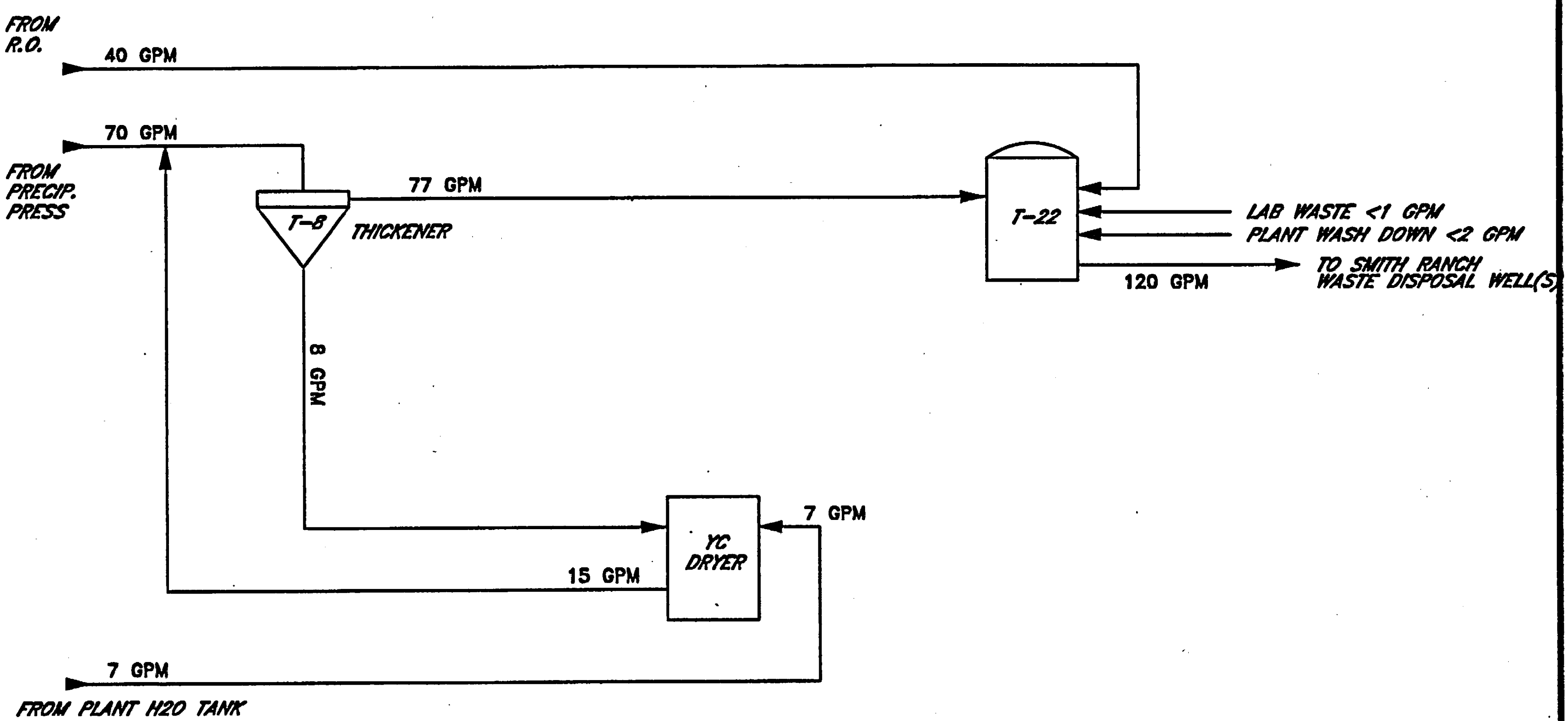


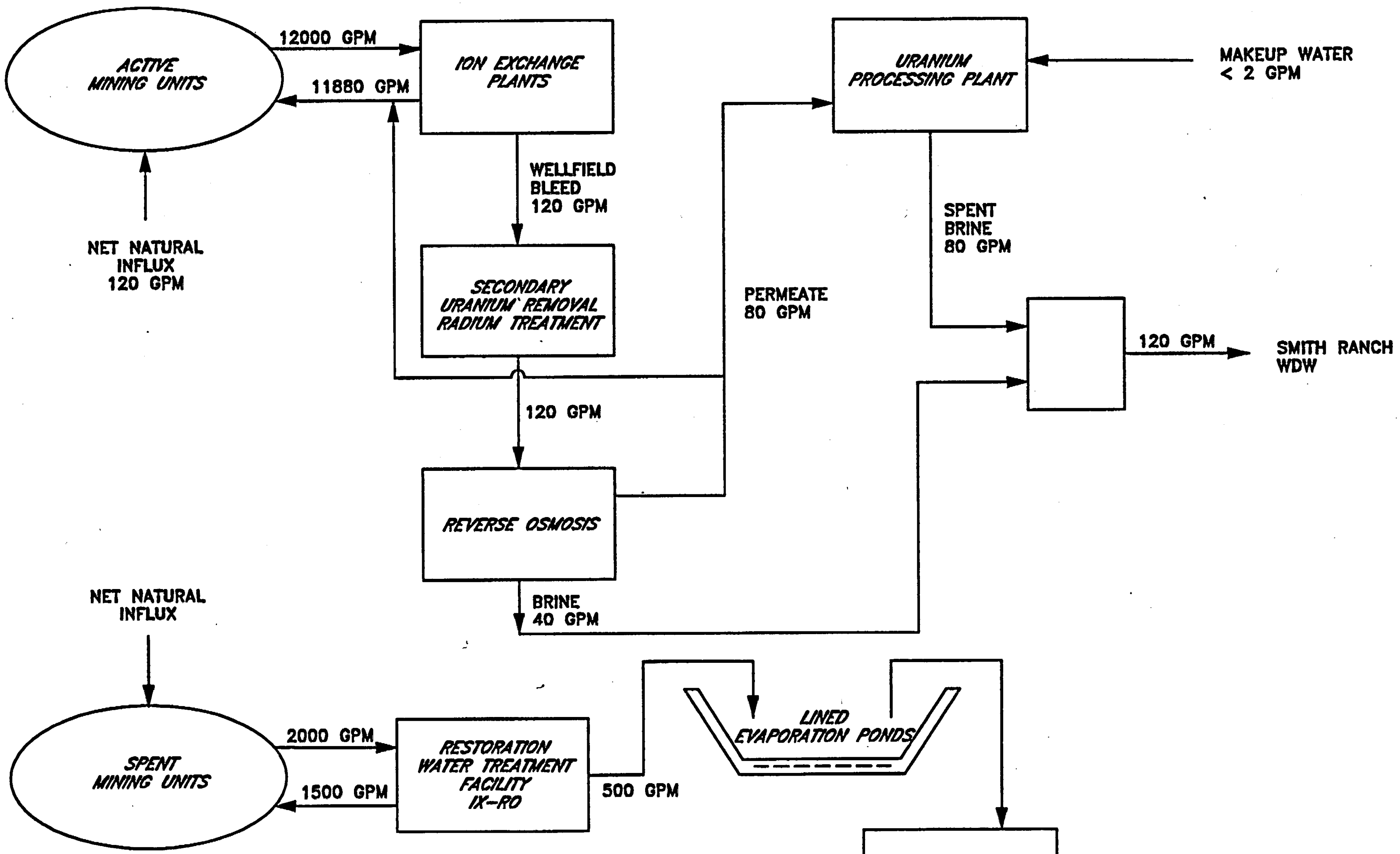
FIGURE 1 (CONT.)



NOTE: The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.

FIGURE 4-2
WATER BALANCE FOR SMITH RANCH PROJECT

WELLFIELD OPERATIONS AT 12000 GPM
WITH 120 GPM PURGE (1.0% BLEED)



NOTE: The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.

FIGURE 4-3
RECOVERY PLANT FLOW RATES

MAIN FLOW THROUGH ION EXCHANGE SYSTEMS @ 12,000 GPM
WELLFIELD PURGE @ 120 GPM (1.0% BLEED)

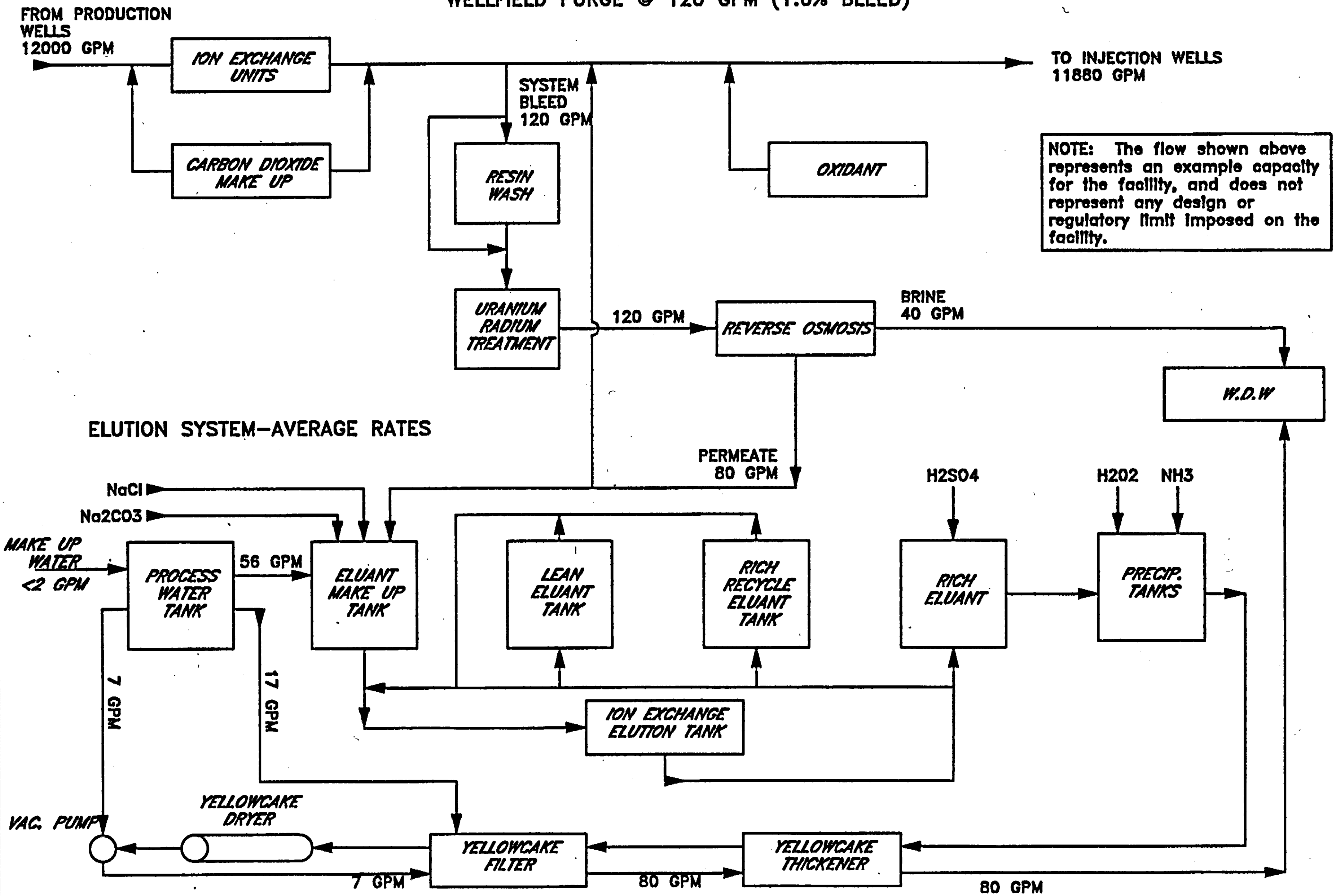
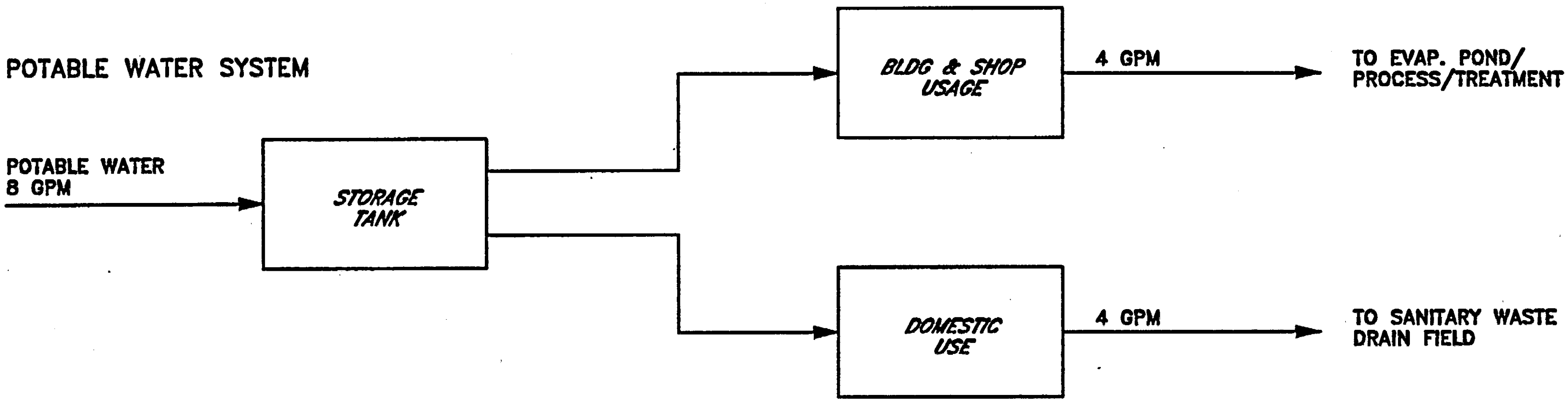


FIGURE 4-3 (CONT'D)



NOTE: The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.