APPENDIX D11:

BACKGROUND RADIOLOGICAL SURVEYS

November 2007

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D11.1.0 BACKGROUND RADIOLOGICAL CHARACTERISTICS

D11.1 SURFACE SOILS, SUBSURFACE SOILS, AND SEDIMENT

D11.1.1 Purpose and Procedure

In June of 2007, an extensive soil and sediment sampling program was completed for the Nichols Ranch and Hank Units of the Nichols Ranch ISR Project. The purpose of the effort was to develop a representative radiological baseline for surface and subsurface soils and sediments.

Prior to conducting a field reconnaissance and collecting the samples, a map was prepared on a large-scale U.S. Geological Survey (USGS) topographic base showing the license boundary, plant site location and ore zone footprint (in as much as it was known at the time). Because of their importance in an assessment such as this, the location of cultural features (residences, ranches, water wells, water impoundments, roads, etc.) with respect to the future process facility, production areas and license boundary were considered in the sampling design.

After completing the base map described above, a field reconnaissance was conducted to visually inspect the project area. All of the features just noted were considered in terms of their respective locations to the license boundary. Following the reconnaissance, a sample site map was prepared. Coordinates for each sample site were included with the map.

In determining the number, type (surface, subsurface and sediment) and areal distribution of sampling locations, pertinent NRC documents were used, along with judgment based on many years of experience developing pre-operational and operational environmental monitoring programs for in situ recovery (ISR) operations. The primary documents included: (1) NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills," USNRC, April 25, 1980; (2) NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications," Final Report, USNRC, June 2003; and (3) NUREG-1748 "Environmental Review Guidance for Licensing Actions Associated with NMISS Programs," Final Report, USNRC, August 2003.

Regulatory Guide 4.14 is the document that outlines the specifics of a pre-operational radiological monitoring program. Table 1 in the guide, for example, lists the suggested number, type, location and frequency of samples. Because of the age of the guide, and because it primarily addresses conventional mills, Uranerz employed a modified baseline sampling program designed for a modern ISR facility. From a standpoint of physical disturbance and radiological alteration, it is widely recognized that a modern-day ISR operation has minimal impact on surface and subsurface soils.

There are three major reasons why the impacts are insignificant: (1) the recovery technique does not require the removal of overburden nor does it require the physical removal of the ore zone; (2) it is a wet process up to the stage of drying and packaging; and (3) modern dryers and packaging systems do not have significant particulate discharges. Thus in the absence of significant particulate sources, radiological impacts on soils and sediments through aerial dispersal and subsequent deposition are not associated with modern ISR operations.

Experience shows that potential radiological impacts are almost exclusively associated with accidental spills from pipe leaks or ruptures that occur off of the process facility pad (i.e., within the wellfields and between the wellfields and the process facility). Spills occurring on the process pad are fully contained by the curbed volume of the pad and its sump system. It should be noted that an accidental spill from a pipe break in a wellfield does not necessarily result in a major impact on soils or sediments. Engineering controls and a management program based on the principles of ALARA provide a high degree of assurance that impacts will be minimal. To illustrate, a pipeline break would cause a loss in pressure and this would be quickly detected by the monitoring system. In addition to engineering controls, employees who are in the wellfields on a daily basis are trained to observe routinely the condition pipelines and wellheads. Leaks or breaks would be reported immediately. In the event of a break, the wetted area would be surveyed, sampled and recorded on a spill map. Soils with significantly elevated levels of uranium and radium-226 would be removed and disposed at a licensed site.

Knowing that potential impacts are attributed to pipeline ruptures and leaks, the pre-operational sampling program was designed to thoroughly characterize radiological baseline conditions in

the areas most likely to experience potential impacts. A review of Exhibit D11-1, Nichols Unit-Soil and Sediment Sample Location Map, and Exhibit D11-2 (see map pocket), Hank Unit Soil and Sediment Sample Location Map clearly shows that the focus of the baseline characterization was on the wellfield areas and the intermittent/ephemeral streams passing through the license area. A close examination of the map shows that sediment samples were collected from upstream and downstream locations in all of the streambeds. In addition to thoroughly sampling the wellfields and water courses, the radiological baseline was supplemented by including samples from areas within the license area (see sample sites labeled LAS on the map), the process facility location and the Rn-222/Gamma monitoring stations. Again, using Regulatory Guide 4.14 for general guidance, all soils and sediments were analyzed for Ra-226 and a large percentage of the total number of samples included analyses for U, Pb-210 and Th-230. In brief, the extensive coverage of the sampling effort provides a representative radiological baseline against which operational activities can be measured.

D11.1.2 Sampling Methodology

The sample site map and coordinates described above, guided field personnel to the sample site locations. Surface and subsurface soils were collected with a 3-inch diameter bucket auger. Surface soils were collected from surface to a depth of 6-inches, and subsurface soils were collected in 12-inch increments to a total depth of 36 inches. The depth increments generally follow Regulatory Guide 4.14.

To avoid cross-contamination, the sampler and other tools were cleaned after each use using paper towels and de-ionized water. Samples were placed in 1-gallon plastic freezer bags and stored in ice chests prior to delivery to the laboratory. While collecting the soil samples, gamma measurements were taken using a Ludlum Model 19 μR Survey Meter. The calibration date on the meter for the June 2007 survey was June 8, 2007. While holding the meter at waist level, the area at and proximate to the sample point was surveyed for approximately two minutes. Gamma levels were recorded along with the GPS coordinates for each site.

The procedure for collecting sediment samples varied slightly from the soil sampling methodology. Instead of a single incremental sample, several samples were taken around each site to form a composite sample. As with the soil samples, sediments were placed in 1-gallon plastic freezer bags and placed in ice chests prior to delivery to the laboratory. Gamma measurements were taken following the protocol just described.

D11.1.3 Nichols Ranch Unit Results

Table D11-1, Radiological Background in Surface and Subsurface Soil - Nichols Ranch Unit, provides a summary of the analyses for each sample point as well as some basic statistical measures (minimum, maximum, average and standard deviation).

Most of the surface soil sample and all of the subsurface samples have typical background radiological characteristics (approximately 1 pCi/g or less). For comparison purposes, normal soils typically have a Ra-226 content of 1 pCi/g (NCRP Report No.78). With the exception of one site, (LAS-5), which had a Ra-226 level of 26 pCi/g, the table shows normal background levels. The elevated level at LAS-5 might be attributed to old exploration activities.

With respect to sediment, Table D11-2 Radiological Background in Sediment - Nichols Ranch Unit shows that 40% of the samples exceed normal background levels of 1 pCi/g for Ra-226. Elevated levels were detected at sample sites SD-1, 8, 9 and 10. A possible explanation for this departure could be that earlier exploration activities may have left ore zone cuttings on the surface.

Because a significant percentage of the sites have elevated Ra-226, the average value of 9.6 pCi/g is well in excess of normal background. Pb-210 was also detected at higher than normal background levels at two of the sites, resulting in a slightly higher than normal average.

Table D11-1 Radiological Background in Surface and Subsurface Soil - Nichols Ranch Unit.

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
R-1	0-6	1.85	2.1	0.3	0.8	0.2	0.7	0.1
R-2	0-6	1.42	0.9	0.2	0.8	0.2	ND	
R-3	0-6	1.93	1.1	0.2	0.7	0.2	ND	
R-4	0-6	2.58	1.1	0.2	1.2	0.2	ND	
R-5	0-6	1.66	0.1	0.1	0.6	0.1	ND	
SS-6	0-6				0.8	0.2		
SS-7	0-6				1.3	0.2		
SS-8	0-6	1.12	0.7	0.1	0.6	0.2	ND	
SS-9	0-6				0.8	0.2		
SS-10	0-6				0.9	0.2		
SS-11	0-6	1.39	ND		0.9	0.2	ND	
SS-12	0-6				0.3	0.2		
SS-13	0-6				0.8	0.2		
SS-14	0-6				0.9	0.2		
SS-15	0-6				0.6	0.2		
SS-16	0-6				1.5	0.2		
SS-17	0-6				0.8	0.2		
SS-18	0-6				0.8	0.2		
SS-19	0-6	1.64	ND		1.4	0.2	0.1	0.1
SS-20	0-6				0.8	0.1		
SS-21	0-6				2.4	0.2		
SS-22	0-6	1.89	ND		0.9	0.1	0.8	0.6
SS-23	0-6				0.6	0.1		
SS-24	0-6				0.4	0.1		
SS-25	0-6				0.5	0.1		
SS-26	0-6				0.7	0.1		
SS-27	0-6				0.7	0.1		
SS-28	0-6				0.7	0.1		
SS-29	0-6				0.8	0.1		
SS-30	0-6				1.2	0.1		
LAS-1	0-6	0.97	ND		0.4	0.1	0.3	0.1
LAS-2	0-6	2.96	ND		0.9	0.2	0.7	0.1
LAS-3	0-6	2.58	ND		0.8	0.2	0.3	0.1
LAS-4	0-6	1.37	ND		1.0	0.2	0.7	0.1
LAS-5**	0-6	4.72	ND		26.4	3.9	0.6	0.1
LAS-6	0-6	2.19	ND		1.3	0.2	0.6	0.1
LAS-7	0-6	1.73	1.0	0.4	1.0	0.2	0.5	0.1
LAS-8	0-6	1.51	ND		1.0	0.2	0.5	0.1

Table D11-1 (Continued)

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
Plant Site								
Center	0-12	1.43	ND		1.0	0.2	0.5	0.1
	12-24	1.22	0.5	0.4	1.0	0.2	0.4	0.1
	24-36	1.37	ND		0.7	0.2	0.6	0.1
NW	0-6	1.43	0.4	0.1	1.2	0.2	ND	
NE	0-6	1.42	0.6	0.1	0.9	0.2	ND	
SE	0-6	1.2	0.3	0.1	1.1	0.2	ND	
SW	0-6	1.45	1.0	0.2	1.0	0.2	1.1	0.6
SB-4	0-12	2.7	ND		1.0	0.1	0.5	0.1
	12-24	3.95	ND		1.0	0.1	0.6	0.1
	24-36	2.34	ND		0.8	0.1	0.4	0.1
SB-5	0-12	1.00	ND		0.7	0.1	0.4	0.1
	12-24	1.35	1.6	0.4	0.6	0.1	0.4	0.1
	24-36	1.91	0.7	0.3	0.7	0.1	0.2	0.1
SB-6	0-12	1.29	ND		0.8	0.2	0.5	0.1
	12-24	1.8	0.5	0.4	1.6	0.2	0.4	0.1
	24-36	2.05	0.4	0.4	0.8	0.2	0.5	0.1
SB-7	0-12	1.01	ND		0.8	0.1	0.3	0.1
	12-24	1.45	ND		0.9	0.2	0.4	0.1
	24-36	1.73	ND		0.9	0.2	0.6	0.1
SB-8	0-12	1.88	ND		1.1	0.2	0.7	0.1
	12-24	2.23	ND		1.0	0.1	0.7	0.1
	24-36	2.59	ND		1.0	0.1	0.5	0.1

Table D11-1 (Continued)

Sample Site		Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
Surface Soil:								
Minimum		**0.97**	**0.1**		**0.3**		**0.1**	
Maximum		**4.72**	**1.1**		**26.4**		**1.1**	
Average		**1.69**	**0.7**		**0.9**		**0.6**	
Standard Deviation		**0.52**	**0.3**		**0.4**		**0.2**	
Subsurface Soil:								
Minimum		**1.00**	**0.4**		**0.6**		**0.2**	
Maximum		**3.95**	**1.6**		**1.6**		**0.7**	
Average	**0-12**	**1.55**	**ND**		**0.9**		**0.5**	
	12-24	**2.00**	**0.4**		**1.0**		**0.5**	
	24-36	**2.00**	**0.2**		**0.8**		**0.5**	

Notes:
R-1: Nearest Residence. R-1 through R-4: Rn-222 and Gamma Monitoring Locations.
*Reporting Limit: 0.50.
SS: Surface Soil.
SB: Subsurface Soil.
LAS: License Area Sample.
ND: Not Detected
See Exhibit D11-1 for sample site locations.
**U and Ra-226 values for LAS-5 appear to be anomalies and were not used in the statistics.

Table D11-2 Radiological Background in Sediment - Nichols Ranch Unit.

Sample Site	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
SD-1	2.1	ND		16.2	3.0	0.5	0.1
SD-2	2.02	ND		0.6	0.1	0.5	0.1
SD-3	1.84	0.7	0.3	0.7	0.1	0.5	0.1
SD-4	1.77	ND		0.7	0.1	0.4	0.1
SD-5	1.96	2.0	0.4	1.0	0.2	0.4	0.1
SD-6	0.95	ND		0.5	0.1	0.2	0.1
SD-7	3.07	0.5	0.4	1.0	0.2	0.6	0.1
SD-8	2.67	1.8	0.4	32.2	4.2	1.0	0.2
SD-9	3.03	ND		23.5	3.6	0.6	0.1
SD-10	4.02	ND		19.4	3.3	0.9	0.1
Minimum	**0.95**	**ND**		**0.5**		**0.2**	
Maximum	**4.02**	**2.0**		**32.2**		**1.0**	
Average	**2.34**	**1.3**		**9.6**		**0.6**	
Standard Deviation	**0.87**	**0.8**		**12.1**		**0.2**	

Notes:
SD: Sediment.
*Reporting Limit: 0.50.
ND: Not Detected.
See Exhibit D-11-1 for sample site locations.

D11.1.4 Hank Unit Results

Table D11-3 Radiological Background in Surface and Subsurface Soil - Hank Unit provides a summary of the analyses for each sample point as well as some basic statistical measures (minimum, maximum, average and standard deviation). With just a few exceptions, the values in the table are within the expected ranges. Briefly, the average value for Ra-226 is 1.1 pCi/g, and this nearly matches the reference radium concentration of 1 pCi/g in normal soil (NCRP Report No. 78). Similarly, values for U, Th-230 and Pb-210 also fall within expected background ranges. One site, LAS-2, had the highest values for uranium (8.4 mg/kg), Pb-210 (1.2 pCi/g), Ra-226 (3.8 pCi/g) and Th-230 (2.5 pCi/g).

Table D11-3 Radiological Background in Surface and Subsurface Soil - Hank Unit.

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
R-1	0-6	1.26	3.9	0.4	1.3	0.2	0.9	0.2
R-2	0-6	1.71	ND		0.5	0.1	ND	
R-3	0-6	1.04	ND		0.4	0.1	ND	
R-4	0-6	2.77	0.3	0.2	0.3	0.1	ND	
R-5	0-6	2.46	ND		1.0	0.2	ND	
SS-6	0-6				1.5	0.1		
SS-7	0-6	2.19	ND		1.7	0.2	1.2	0.6
SS-8	0-6				1.2	0.1		
SS-9	0-6				1.1	0.1		
SS-10	0-6				2.1	0.1		
SS-11	0-6				1.1	0.1		
SS-12	0-6				1.0	0.1		
SS-13	0-6				0.9	0.1		
SS-14	0-6				1.3	0.1		
SS-15	0-6				1.1	0.1		
SS-16	0-6	1.37	ND		1.3	0.2	ND	
SS-17	0-6				1.3	0.1		
SS-18	0-6				0.8	0.1		
SS-19	0-6				0.9	0.1		
SS-20	0-6				1.2	0.1		
SS-21	0-6				1.1	0.2		
SS-22	0-6				1.3	0.2		
SS-23	0-6				0.9	0.2		
SS-24	0-6				1.1	0.2		
SS-25	0-6	1.81	ND		1.0	0.2	1.2	0.6
SS-26	0-6				0.7	0.1		
SS-27	0-6				0.7	0.1		
SS-28	0-6				0.9	0.2		
SS-29	0-6				1.1	0.2		
SS-30	0-6				1.2	0.2		
SS-31	0-6				0.7	0.2		
SS-32	0-6				1.2	0.2		
SS-33	0-6				0.9	0.2		
SS-34	0-6	2.10	ND		1.3	0.2	1.2	0.5
SS-35	0-6				1.1	0.2		
LAS-1	0-6	1.60	0.5	0.1	0.9	0.1	0.3	0.1
LAS-2**	0-6	8.40	1.2	0.1	3.8	0.1	2.5	0.1
LAS-3	0-6	1.40	ND		0.8	0.1	0.4	0.1
LAS-4	0-6	1.00	ND		0.8	0.1	0.2	0.1
LAS-5	0-6	1.60	0.6	0.1	1.1	0.1	0.5	0.1
LAS-6	0-6	1.50	ND		0.9	0.1	0.4	0.1
LAS-7	0-6	1.00	0.3	0.1	0.6	0.1	0.3	0.1
LAS-8	0-6	1.10	ND		0.6	0.1	0.5	0.1

Table D11-3 (Continued)

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
LAS-9	0-6	1.39	ND		1.3	0.2	0.7	0.2
LAS-10	0-6	1.47	ND		1.2	0.2	0.7	0.2
LAS-11	0-6	2.35	ND		1.0	0.2	0.5	0.2
LAS-12	0-6	2.40	ND		1.3	0.1	0.6	0.1
LAS-13	0-6	1.90	ND		1.2	0.1	0.8	0.1
LAS-14	0-6	1.50	0.3	0.1	1.0	0.1	0.5	0.1
SB-4	0-12	2.30	0.9	0.1	1.6	0.1	0.9	0.1
	12-24	2.00	0.7	0.1	1.1	0.1	0.5	0.1
	24-36	1.70	ND		0.8	0.1	0.4	0.1
SB-5	0-12	1.30	ND		0.9	0.1	0.5	0.1
	12-24	ND	0.7	0.1	1.1	0.1	0.4	0.1
	24-36	1.80	0.6	0.1	1.1	0.1	0.4	0.1
SB-6	0-12	1.60	0.3	0.1	1.2	0.1	0.5	0.1
	12-24	1.40	0.2	0.1	1.2	0.1	0.7	0.1
	24-36	1.60	ND		1.2		0.7	0.1
SB-7	0-12	3.11	ND		0.9	0.1	0.4	0.1
	12-24	2.33	ND		0.9	0.2	0.6	0.1
	24-36	3.62	ND		1.1	0.2	0.7	0.2
SB-8	0-12	1.43	ND		1.3	0.2	0.4	0.1
	12-24	1.42	ND		1.2	0.2	0.4	0.1
	24-36	1.60	ND		0.8	0.2	0.6	0.2
SB-9	0-12	1.13	ND		0.9	0.2	0.5	0.3
	12-24	1.30	ND		0.8	0.2	0.2	0.1
	24-36	1.43	ND		1.0	0.2	0.6	0.3

Table D11-3 (Continued)

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
Plant Site								
Center	0-12	1.35	ND		1.0	0.2	0.5	0.1
	12-24	1.28	ND		0.9	0.2	0.7	0.1
	24-36	1.57	0.7	0.04	0.9	0.2	0.5	0.1
NW	0-6	1.83	ND		1.0	0.2	ND	
NE	0-6	2.18			1.0	0.2	0.9	0.5
SE	0-6	1.82	ND		1.2	0.2	ND	
SW	0-6	1.67	0.3	0.2	1.0	0.2	ND	
Surface Soil:								
Minimum		**1.00**	**0.3**		**0.3**		**0.2**	
Maximum		**8.40**	**0.6**		**2.1**		**1.2**	
Average		**1.73**	**0.4**		**1.0**		**0.6**	
Standard Deviation		**0.48**	**0.1**		**0.3**		**0.3**	
Subsurface Soil:								
Minimum					**0.8**		**0.2**	
Maximum					**1.6**		**0.9**	
Average	**0-12**	**1.75**	**0.2**		**1.1**		**0.5**	
	12-24	**1.39**	**0.2**		**1.0**		**0.5**	
	24-36	**1.90**	**0.2**		**0.8**		**0.6**	

Notes:
R-1: Nearest Residence. R-1, 2, 3, 4 and 5: Rn-222 and Gamma Monitoring Locations.
*Reporting Limit: 0.50.
SS: Surface Soil.
SB: Subsurface Soil.
LAS: License Area Sample.
ND: Not Detected
See Exhibit D11-2 for sample site locations.
**Values for LAS-2 appear to be anomalies and were not used in the statistics.

Radiological background levels were measured at 26 different sediment sample sites at the Hank Unit. Table D11-4 Radiological Background in Sediment - Hank Unit summarizes the individual values and provides basic statistical information (minimum, maximum, average and standard deviation). Sample site SD-25 has a Pb-210 value (2.5 pCi/g) that is a few times higher than normal background but the rest of the sites are typical of what one would normally expect to find.

Table D11-4 Radiological Background in Sediment - Hank Unit.

	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
SD-1	2.8	ND		1.3	0.2	0.7	0.1
SD-2	3.5	ND		1.1	0.2	0.5	0.1
SD-3	2.5	0.4	0.2	1.0	0.2	0.6	0.1
SD-4	1.3	0.5	0.2	1.1	0.2	0.6	0.1
SD-5	1.8	1.8	0.3	1.0	0.2	0.6	0.1
SD-6	1.8	0.7	0.2	1.6	0.2	0.8	0.1
SD-7	2.6	ND		1.4	0.2	0.8	0.1
SD-8	3.1	0.6	0.1	1.4	0.2	0.7	0.1
SD-9	2.7	0.9	0.1	1.6	0.2	1.0	0.2
SD-10	2.6	0.6	0.1	0.8	0.2	0.5	0.1
SD-11	2.5	ND		1.1	0.2	0.5	0.1
SD-12	2.1	ND		1.2	0.2	0.7	0.1
SD-13	1.91	ND		0.9	0.2	0.5	0.2
SD-14	2.80	ND		1.4	0.2	0.6	0.2
SD-15	2.92	ND		2.2	0.2	0.6	0.2
SD-16	2.52	ND		1.0	0.2	0.3	0.1
SD-17	1.98	ND		1.0	0.2	0.5	0.1
SD-18	3.46	ND		1.2	0.2	0.9	0.2
SD-19	2.23	ND		0.9	0.2	0.3	0.1
SD-20	1.85	ND		0.8	0.2	0.2	0.1
SD-21	2.17	ND		1.2	0.2	0.4	0.1
SD-22	3.74	ND		1.9	0.2	1.1	0.2
SD-23	1.91	ND		1.3	0.2	1.0	0.2
SD-24	2.08	ND		0.9	0.2	0.3	0.1
SD-25	1.18	2.5	0.5	1.0	0.2	0.6	0.1
SD-26	1.79	ND		1.0	0.2	0.4	0.2
Minimum	**1.18**	**ND**		**0.8**		**0.2**	
Maximum	**3.74**	**2.5**		**2.2**		**1.1**	
Average	**2.38**	**1.0**		**1.2**		**0.6**	
Standard Deviation	**0.65**	**0.7**		**0.3**		**0.2**	

Notes:
SD: Sediment.
*Reporting Limit: 0.50.
ND: Not Detected.
See Exhibit D11-2 for sample locations.

D11.2 BASELINE GAMMA SURVEY

D11.2.1 Purpose and Procedure

The purpose of a gamma survey is the same as it is for establishing other radiological levels; namely to characterize baseline conditions. Baselines serve as a backdrop against which operational impacts can be measured.

The gamma survey that was performed for the project site differs in pattern from the survey described in Regulatory Guide 4.14. The layout of the pattern given in the guide is based on a conventional mine and mill, which have significant particulate source terms. Particulate sources at ISR facilities are negligible. Because of the vast difference between ISR and conventional mining and milling, a procedure was developed to measure baseline gamma levels in a more concentrated pattern in the areas where operational activities will occur. Since the operational areas are the most likely targets for potential impacts, these areas were given a higher degree of sampling. Referring back to the discussion in the soils section, it was noted that potential impacts on soils and sediments from ISR operations is attributed to accidental spills from pipeline breaks or leaks.

This aspect of potential impact played a major part in the baseline sampling pattern for soils, sediments and gamma. In addition to the large number of gamma readings taken throughout the future production area and process site, readings were also taken in the drainages passing through the license area; at the nearest residence; and near the license boundary. Exhibit D11-3 (see map pocket), Nichols Ranch Unit - Gamma Sample Location Map, shows the sample sites within and near the license boundary.

D11.2.2 Survey Methodology

A Ludlum Model 19 μR Survey Meter was the instrument used in the gamma survey. The calibration date on the meter for the June 2007 survey was June 8, 2007. As described in the soils section of the application, a sample site map was developed prior to conducting the survey.

Gamma measurements were recorded by holding the meter at waist level and slowly passing it over each soil/sediment sample point and over the area proximate to the sample location.

D11.2.3 Nichols Ranch Unit Results

Table D11-5 summarizes the gamma readings and cross-references the gamma sites with the soil and sediment sample locations. A total of 57 gamma measurements were taken over an area of approximately 116 acres. The 116 acre-area consisted of the future production areas (113 acres) and the plant site (3 acres). On a per acre basis, the density of the survey was 1 reading per 2 acres.

As can be readily seen from Table D11-5, gamma readings are for the most part tightly grouped between 12 to 13 μR/hr. The average, minimum and maximum values are not unusual for this part of the U.S. To illustrate, the values recorded at the Nichols Ranch Unit are very much in line with earlier surveys completed at nearby North Butte. In brief, the detailed gamma survey completed at the North Butte ISL project site in 1979 was compared to a verification survey conducted by Uranerz in 1992. The mean gamma reading in the verification study was 11.7 μR/hr and the range was 11 to 13 μR/hr. These values were consistent with the North Butte survey. When compared to the average natural background range for the U.S. (8 to 15 μR/hr), it can be seen that the Nichols project site falls near the high end of the average.

There are a few sites with slightly elevated gamma levels of 15 μ R/hr. Some of the 15 μ R/hr values correspond with some of the soil and sediments sites that had elevated levels of Ra-226. For example, SS-21 has a radium value of 2.4 pCi/g; SD-8 radium is 32 pCi/g; and SD-9 radium is 23.5 pCi/g.

Table D11-5 Nichols Ranch Unit Gamma/Soil and Sediment Sample Locations.

Sample Site	µR/hr	Gamma Site
R-1 Dry Fork Ranch	13	G-54
R-2	14	G-55
R-3	12	G-56
R-4	13	G-57
SS-6 Nichols URZ	15	G-45
SS-7 Nichols URZ	15	G-40
SS-8 Nichols URZ	12	G-36
SS-9 Nichols URZ	12	G-32
SS-10 Nichols URZ	13	G-20
SS-11 Nichols URZ	13	G-17
SS-12 Nichols URZ	14	G-14
SS-13 Nichols URZ	13	G-12
SS-14 Nichols URZ	13	G-11
SS-15 Nichols URZ	13	G-8
SS-16 Nichols URZ	13	G-7
SS-17 Nichols URZ	13	G-5
SS-18 Nichols URZ	13	G-4
SS-19 Nichols URZ	14	G-1
SS-20 Nichols URZ	12	G-2
SS-21 Nichols URZ	15	G-6
SS-22 Nichols URZ	13	G-9
SS-23 Nichols URZ	12	G-13
SS-24 Nichols URZ	11	G-16
SS-25 Nichols URZ	12	G-18
SS-26 Nichols URZ	13	G-24
SS-27 Nichols URZ	13	G-33
SS-28 Nichols URZ	12	G-37
SS-29 Nichols URZ	14	G-41
SS-30 Nichols URZ	13	G-47
LAS-1 Nichols URZ	12	G-21
LAS-2 Nichols URZ	11	G-23
LAS-3 Nichols URZ	13	G-35
LAS-4 Nichols URZ	13	G-44
LAS-5 Nichols URZ	13	G-51
LAS-6 Nichols URZ	13	G-46
LAS-7 Nichols URZ	14	G-38
LAS-8 Nichols URZ	13	G-25

Table D11-5 (Continued)

Sample Site		Gamma Site
SB-4 Nichols URZ	12	G-3
SB-5 Nichols URZ	11	G-26
SB-6 Nichols URZ	12	G-43
SB-7 Nichols URZ	13	G-42
SB-8 Nichols URZ	13	G-22
Plant Site:		
Center	13	G-29
Northwest	13	G-27
Northeast	13	G-28
Southeast	13	G-31
Southwest	13	G-30
Minimum	**11**	
Maximum	**15**	
Average	**13**	
Standard Deviation	**1**	
SD-1 Nichols URZ	13	G-53
SD-2 Nichols URZ	13	G-10
SD-3 Nichols URZ	12	G-15
SD-4 Nichols URZ	13	G-19
SD-5 Nichols URZ	13	G-39
SD-6 Nichols URZ	11	G-34
SD-7 Nichols URZ	14	G-48
SD-8 Nichols URZ	15	G-49
SD-9 Nichols URZ	15	G-50
SD-10 Nichols URZ	13	G-52
Minimum	**11**	
Maximum	**15**	
Average	**13**	
Standard Deviation	**1**	

Notes:
R-1through R-4 are the locations of the baseline Rn-222 and Gamma monitors.
SS: Surface Soil Site.
SB: Subsurface Soil Site.
SD: Sediment Sample Site.
LAS: License Area Sample.
See Exhibits D-11-1 and D11-3 for sample site locations.

Although it is well known that gamma readings taken with a general survey-type meter do not have a high degree of correspondence with chemically measured radium content, a higher-than-background gamma reading (usually 2.5 to 3 times background) can serve as a first level screening test for detecting sites that might have elevated levels of radionuclides. In summary, the density of the survey and its consistent values provide reasonable assurance that a representative baseline was established.

D11.2.4 Hank Unit Results

Table D11-6 summarizes the gamma readings and cross-references the gamma sites with the soil and sediment sample locations. A total of 86 gamma readings were recorded across the site (see Exhibit D11-4). Although the survey was designed to thoroughly characterize baseline conditions in the areas where activities will occur (production areas and process facility site), it also provided background levels for sites at the license boundary, nearest residence and numerous stream courses passing through and near the site. Based on the approximate 156 acres in the production areas and the 3-acre process facility site, the resulting survey density is 1 reading per 2 acres.

Table D11-6 Hank Unit Gamma/Soil and Sediment Sample Locations.

Sample Site	µR/hr	Gamma Site
R-1 Pfsister Ranch Hank URZ	13	G-82
R-2	13	G-83
R-3	12	G-84
R-4	11	G-85
R-5	14	G-86
SS-6 Hank URZ	15	G-5
SS-7 Hank URZ	15	G-7
SS-8 Hank URZ	12	G-9
SS-9 Hank URZ	12	G-10
SS-10 Hank URZ	14	G-11
SS-11 Hank URZ	13	G-14
SS-12 Hank URZ	13	G-15
SS-13 Hank URZ	13	G-20
SS-14 Hank URZ	13	G-21
SS-15 Hank URZ	13	G-23
SS-16 Hank URZ	13	G-28
SS-17 Hank URZ	12	G-32
SS-18 Hank URZ	13	G-40
SS-19 Hank URZ	13	G-41
SS-20 Hank URZ	14	G-44
SS-21 Hank URZ	14	G-48
SS-22 Hank URZ	14	G-50
SS-23 Hank URZ	12	G-52
SS-24 Hank URZ	14	G-53
SS-25 Hank URZ	12	G-81
SS-26 Hank URZ	13	G-57
SS-27 Hank URZ	12	G-61
SS-28 Hank URZ	13	G-62
SS-29 Hank URZ	14	G-64
SS-30 Hank URZ	13	G-66
SS-31 Hank URZ	13	G-67
SS-32 Hank URZ	14	G-68
SS-33 Hank URZ	15	G-71
SS-34 Hank URZ	13	G-75
SS-35 Hank URZ	13	G-76
LAS-1 Hank URZ	14	G-17
LAS-2 Hank URZ	18	G-25
LAS-3 Hank URZ	13	G-18
LAS-4 Hank URZ	12	G-24
LAS-5 Hank URZ	13	G-30
LAS-6 Hank URZ	13	G-31

Table D11-6 (Continued)

Sample Site	µR/hr	Gamma Site
LAS-7 Hank URZ	11	G-46
LAS-8 Hank URZ	12	G-42
LAS-9 Hank URZ	14	G-59
LAS-10 Hank URZ	13	G-47
LAS-11 Hank URZ	15	G-55
LAS-12 Hank URZ	13	G-43
LAS-13 Hank URZ	14	G-34
LAS-14 Hank URZ	14	G-29
SB-4	16	G-6
SB-5	12	G-16
SB-6	13	G-33
SB-7	14	G-51
SB-8	12	G-65
SB-9	13	G-77
Plant Site:		
Center	13	G-37
Northwest	15	G-35
Northeast	13	G-36
Southeast	13	G-39
Southwest	13	G-38
Minimum	**11**	
Maximum	**18**	
Average	**13**	
Standard Deviation	**1**	
SD-1 Hank URZ	14	G-1
SD-2 Hank URZ	16	G-3
SD-3 Hank URZ	14	G-2
SD-4 Hank URZ	11	G-4
SD-5 Hank URZ	13	G-12
SD-6 Hank URZ	13	G-13
SD-7 Hank URZ	15	G-8
SD-8 Hank URZ	15	G-19
SD-9 Hank URZ	14	G-22
SD-10 Hank URZ	14	G-27
SD-11 Hank URZ	15	G-26
SD-12 Hank URZ	14	G-80
SD-13 Hank URZ	16	G-49
SD-14 Hank URZ	13	G-45
SD-15 Hank URZ	18	G-54
SD-16 Hank URZ	17	G-58

Table D11-6 (Continued)

Sample Site	µR/hr	Gamma Site
SD17 Hank URZ	15	G-60
SD-18 Hank URZ	17	G-56
SD-19 Hank URZ	16	G-63
SD-20 Hank URZ	15	G-70
SD-21 Hank URZ	17	G-72
SD-22 Hank URZ	16	G-73
SD-23 Hank URZ	14	G-69
SD-24 Hank URZ	14	G-74
SD-25 Hank URZ	13	G-79
SD-26 Hank URZ	13	G-78
Minimum	**11**	
Maximum	**18**	
Average	**15**	
Standard Deviation	**2**	

Notes:
R-1 through R-5 are the locations of the baseline Rn-222 and Gammma monitors.
SS: Surface Soil Site.
SB: Subsurface Soil Site.
SD: Sediment Sample Site.
LAS: License Area Site.
See Exhibits D11-2 and D11-4 for sample site locations.

As can be seen from Table D11-6, gamma readings do not vary significantly across the area. However, there are a few sites with elevated gamma (16 to 18 µ R/hr levels). Comparing the elevated gamma levels with the soil and sediment analyses show some correspondence. Sample site LAS-2, for example, has the highest gamma level of 18 µ R/hr and it also has the highest U (8.4 mg/kg), Pb-210 (1.2 pCi/g), Ra-226 (3.8 pCi/g) and Th-230 (2.5 pCi/g) values.

As shown below, the minimum, maximum and average values recorded at the Hank Unit compare favorably with those measured at the Nichols Ranch Unit.

	Nichols Ranch Unit (µR/hr)	Hank Unit (µR/hr)
Minimum	11	11
Maximum	15	18
Average	13	13

Between the Hank Unit and the Nichols Ranch Unit, there are 143 gamma sample points. With a combined area of 275 acres (production areas and plant site areas), the overall survey density is 1 sample per 2 acres. This density, coupled with the close agreement between the measurements taken at both sites, provides a good baseline for gamma levels.

D11.3 BASELINE RADON-222 AND DIRECT GAMMA EXPOSURE RATES

D11.3.1 Purpose and Procedure

As noted in the discussion on soil and sediment baseline sampling, ISR operations do not generate significant levels of particulates, but they do have Rn-222 emissions, which include radon daughter products with varying half-lives. For this reason, ambient baseline Rn-222 levels should be established. In establishing the baseline, the monitoring procedure outlined in Regulatory Guide 4.14 was followed, and it involved deploying Rn-222 detectors and gamma dosimeters at suggested locations.

D11.3.2 Survey Methodology

The detectors that were used in the one-year monitoring program were Landauer Extra Sensitive Outdoor Rn-222 Detectors and X-9 Gamma Dosimeters. Prior to installing the detectors, the prevailing wind direction was obtained from the National Climatic Data Center for Gillette. The data covered a period from 1996 through 2005. Data from this period was compared to data from Casper and to a data collected between 1978 and 1979 by AeroVironment for Cleveland Cliffs Iron Company (CCI), who operated a meteorological station near North Butte (Pathfinder Mines Corporation, 1988). CCI's baseline data was used in support of their NRC license application for the North Butte ISL Project. A comparison of the databases showed that Casper has a stronger southwest/west-southwest/south-southwest component, while North Butte and Gillette have a component from the south/southwest/southeast.

The detectors were deployed and retrieved at the same time for each location. Exposure time was on a quarterly basis. Detector locations included: (1) the nearest residence or structure that

could be occupied; (2) locations at or near the license boundary; and (3) a control point to reflect background (upwind of the site). Exhibits D11-3 and D11-4 show the locations of the Rn-222 and gamma dosimeters.

Given that the prevailing wind direction is from the south, two monitoring stations were placed in the northern parts of both sites (see previously referenced Exhibits D11-3 and D11-4 [see map pocket). In contrast, control detectors were placed in the extreme southern parts of the license areas. During operations, the downwind monitors will reflect the maximum change from baseline while the control detectors will measure the minimum change. In addition to these placements, two monitors were placed near the license boundary on the east and west side of the Hank Unit and one was placed at a nearest residence (Dry Fork Ranch), which is approximately 1.3 mi to the southwest of the process facility location.

D11.3.3 Nichols Ranch Unit Results

The one-year monitoring results are given in Table D11-7. A comparison of the values shows background levels to be within the expected range. When compared to historical radon levels measured over a one year period (1988-1989) at the nearby North Butte Project site, it can be seen that values at Nichols are not surprisingly different. North Butte's annualized average was 0.8 pCi/l compared to Nichols' 1.2 pCi/l average. Because radon levels are known to vary widely from place to place, the difference between 0.8 pCi/l and 1.2 pCi/l is not significant. It must also be remembered that some of difference between the two annual averages can be attributed to the detectors. Significant improvements have been made in this area over the past 10 years. As noted above, Extra Sensitive detectors were used in the monitoring program at the Nichols and Hank Units. Differences in the prevailing weather conditions at the two sites would also play a role in the background concentrations.

Both sites have ambient radon levels that are much above the U.S. average. According to EPA, the U.S. outdoor average radon concentration is 0.4 pCi/l. The higher-than-background levels are not surprising given that with the exception of two counties, Weston and Platte, indoor radon

Table D11-7 Ambient Radon-222 Levels - Nichols Ranch Unit.

		Fourth Quarter (10/06 to 1/07) pCi/l	First Quarter (1/07 to 3/07) pCi/l	Second Quarter (4/07 to 7/07) pCi/l	Third Quarter (7/07 to 10/07) pCi/l
R-1	Nearest Residence	1.2	0.7	0.9	1.1
R-2	Upwind Control	0.9	0.8	1.1	1.7
R-3	Downwind Boundary	0.6	27.7*	2.3	1.4
R-4	Downwind Boundary	0.7	0.8	1.9	1.4
Site Averages		0.9	0.8	1.6	1.4

1. *The adhesive that holds the detector within the protective housing failed and the detector was found on the ground. The anomalous value was not used in the average.
2. The annualized average for all sites combined is 1.2 pC/l.
3. The annualized average measured between 1988 and 1989 at the nearby North Butte; Project was 0.8 pCi/l.
4. The U.S. average outdoor Rn-222 level is 0.4 pCi/l (U.S. EPA).

levels in Wyoming are at or above the EPA Action Level of 4 pCi/l (EPA, 2007). The indoor average for the U.S. is 1.3 pCi/l--this puts Wyoming at 3 times the average.

Background gamma exposure rates from the one year monitoring program are summarized in Table D11-8. The averages range from 35 mrem to 48 mrem. When compared to the gamma survey results from the North Butte Project mentioned earlier, the values are similar. The North Butte quarterly averages ranged from 32.3 mrem to 39.7 mrem. To put these values into perspective, the following exposure rates are given.

- Average dose to the U.S. Public from natural sources: 300 mrem.
- Background radiation (total) in the Colorado Plateau: 75 to 140 mrem.
- Terrestrial background (Rock Mountains): 40 mrem.
- Average dose to the public from all sources: 360 mrem.

Table D11-8 Background Gamma Exposure Rate - Nichols Ranch Unit.

		Fourth Quarter (10/06 to 1/07) mrems	First Quarter (1/07 to 3/07) mrems	Second Quarter (4/07 to 7/07) mrems	Third Quarter (7/07 to 10/07) mrems
R-1	Nearest Residence (Dry Fork Ranch)	34.7	41.1	49.3	37.4
R-2	Downwind Boundary (Northwest)	36.4	41.9	48.2	38.0
R-3	Boundary (Northeast)	35.2	49.4	41.1	39.1
R-4	Upwind Control (South)	33.6	57.6	52.8 (LP)	44.0
Site Averages		35.0	47.5	47.9	39.6

Notes: LP: Low energy photon.

D11.3.4 Hank Unit Results

Not unexpectedly, Rn-222 levels measured at the Hank Unit match up well with those just discussed for the Nichols Ranch Unit. The one high value (9.2 pCi/l) was caused by the detector being on the ground for some unknown period of time. This value was not used in calculating the average shown on Table D11-9.

Table D11-9 Ambient Radon-222 Levels - Hank Unit.

		Fourth Quarter (10/06 to 1/07) pCi/l	First Quarter (1/07 to 3/07) pCi/l	Second Quarter (4/07 to 7/07) pCi/l	Third Quarter (7/07 to 10/07) pCi/l
R-1	Nearest Residence	1.2	1.2	1.4	2.2
R-2	Downwind Boundary	0.4	0.6	0.7	3.4
R-3	Boundary	0.5	0.3	0.9	1.4
R-4	Upwind Control	0.3	9.2*	1.0	1.0
R-5	Boundary	0.4	0.5	0.8	1.7
Site Averages		0.6	0.6	1.0	1.9

Notes:
1. *The adhesive that holds the detector within the protective housing failed and the detector was found on the ground. The anomalous value was not used in the average.
2. The annualized average for all sites combined is 1.0 pC/l.
3. The annualized average measured between 1988 and 1989 at the nearby North Butte; Project was 0.8 pCi/l.
4. The U.S. average outdoor Rn-222 level is 0.4 pCi/l (U.S. EPA).

Table D11-10 Background Gamma Exposure Rate - Hank Unit.

		Fourth Quarter (10/06 to 1/07) mrems	First Quarter (1/07 to 3/07) mrems	Second Quarter (4/07 to 7/07) mrems	Third Quarter (7/07 to 10/07) mrems
R-1	Nearest Residence (Pfister Ranch)	33.5	39.0	45.1	H
R-2	Downwind Boundary (North)	33.5	50.0 (LP)	49.9	H
R-3	Boundary (Northwest)	33.5	40.5	53.9	44.0
R-4	Upwind Control (South)	34.1	114.5 (LP)	51.8	39.1
R-5	Boundary (Southeast)	37.5	31.3	52.0	41.4
Site Averages		34.4	55.0	50.5	41.5

Notes: LP = Low energy photon

D11.4 FLORA AND FAUNA

D11.4.1 Purpose and Procedure

The purpose of establishing baseline radiological conditions prior to initiating operations is to have a reference for comparing potential impacts. When designing a pre-operational baseline sampling program, the operational features of the activity should be kept in mind. In other words, particular attention should be given to the pathways through which contaminants could enter the environment. In developing the baseline sampling program, pathways were considered in conjunction with guidance given in Regulatory Guide 4.14.

According to Section 2.1.4 in Regulatory Guide 4.14, vegetation, food and fish samples should be collected if, in individual licensing cases, a significant pathway to man is identified. As discussed in Sections D11.1.1 and D11.5, pathways for radiological contaminants to enter the environment from modern ISR operations have been markedly reduced or virtually eliminated. ISR operations do not have fluid discharges nor do they generate significant particulate emissions. The main avenue for radiological constituents to enter the environment is limited to

the emission of Rn-222. Because emissions are restricted to nearly-particulate-free Rn-222, significant build up of radionuclides in soil, vegetation and other media is not likely to occur. The minimal accumulation of radionuclides is supported by MILDOS modeling results, and is borne out in operational monitoring data that had been collected at various ISR facilities over the past 25 years.

The baseline sampling program was modified somewhat from the guidance given in Regulatory Guide 4.14. Departure from the guide is discussed in the Methods Section below. While developing the pre-operational baseline studies, it was understood through experience and through the evolution of ISR, that pathways to flora and fauna and hence to human populations are not significant. The reasons supporting this assertion were given above and are discussed in other sections of this application.

Even though potential impacts from ISR operations on flora, fauna and the food chain have been shown to be insignificant, good baseline characterizations continue to be an important part of a RML application. Measured baseline values can be compared to values during actual operations to validate the minimal to no-impact prediction of the MILDOS model. Additionally, having baseline data to compare with values recorded during operations, underscores the fact that modern ISR activities do not have a significant impact on human health and the environment. Following is a description of the baseline sampling program that was performed at the Nichols Ranch Unit and the Hank Unit.

D11.4.2 Methods

Regulatory Guide 4.14 suggests that vegetation, crops, livestock and fish samples should be collected and analyzed for Ra-226 and Pb-210. According to the field reconnaissance, no permanent surface water exists at or immediately adjacent to the sites. Given the absence of water, fish too are absent. The sites were surveyed for the presence a crop-growing areas and none was found. Agricultural activities appear to be limited to cattle grazing. Although the guide suggests sacrificing livestock to obtain samples, it is Uranerz's opinion that this is not necessary for ISR operations. To reiterate, ISR operations do not cause significant build up of

radionuclides in soil or vegetation and therefore a significant pathway for exposure does not exist. In addition, since operational monitoring will include routine sampling of vegetation, food crops (if they are grown in the area) and grazing/forage foods, a mechanism will be in place to monitor this pathway to local fauna.

Given this setting, baseline sampling included samples from grazing areas and vegetation from the nearest residences and Rn-222/gamma monitoring locations. Grab samples were collected in mid-August. While collecting the samples, care was taken to clip the vegetation approximately one inch above the ground to avoid mixing with surface soil. Samples were placed in large plastic bags and transported to the laboratory with 24 hours of collection. All samples were analyzed for Ra-226, Pb-210, Po-210, Th-230, Uranium, Arsenic and Selenium.

D11.4.3 Nichols Ranch Unit Results

Table D11-11 summarizes the radiological and nonradiological (arsenic and selenium) background concentrations found in the samples. Although there is the usual variation in concentrations for the radiometric parameters, the values are within normal background ranges. The same generalization can be made for the arsenic and selenium values.

D11.4.4 Hank Unit Results

Background values for the Hank Unit are given in Table D11-12. A comparison of the concentrations with those reported for the Nichols Ranch Unit shows a great deal of consistency. In brief, the values are not unusual for baseline conditions.

D11.5 MILDOS

Release rates of airborne radioactivity were estimated for the Nichols Ranch ISR Project. Dose commitments received by individuals and the general population within an 80 km radius of site were estimated from atmospheric dispersal of such radioactivity with respect to regional meteorological data. Only airborne releases of radon are considered. Particulate emissions are

Table D11-11 Radiological and Nonradiological Background Levels in Vegetation Nichols Ranch Unit.

	Radiological Elements				
Sample Location	Ra-226 (µCi/kg)	Pb-210 (µCi/kg)	Po-210 (µCi/kg)	Th-230 (µCi/kg)	Uranium (µCi/kg)
R-1 Dry Fork Ranch	3.7E-04	4.2E-04	9.3E-05	3.7E-06	1.1E-04
+/-	5.1E-06	2.9E-05	2.7E-05	1.8E-06	4.6E-07*
R-2 Control Upwind	8.8E-05	4.5E-04	1.5E-04	2.8E-06	6.6E-05*
+/-	6.0E-06	2.3E-05	2.3E-05	4.2E-06	3.0E-07*
R-3 Downwind NE	1.4E-04	7.5E-04	1.1E-04	3.6E-05	9.5E-05*
+/-	8.0E-06	3.0E-05	2.3E-05	4.4E-04	3.3E-07*
R-4 Downwind NW	2.7E-04	6.6E-04	9.9E-05	1.4E-04	2.4E-04*
+/-	1.1E-05	2.6E-04	2.2E-05	9.9E-06	2.8E-07*
Grazing Area	6.7E-05	4.3E-04	7.2E-05	2.4E-05	8.3E-05*
+/-	4.2E-06	1.8E-05	1.7E-05	3.6E-05	2.1E-07*

	Non-radiological Elements			
Sample Location	c (mg/kg-dry)	RL*	m (mg/kg-dry)	RL*
R-1 Dry Fork Ranch	ND	0.5	ND	0.5
R-2 Control Upwind	ND	0.5	ND	0.5
R-3 Downwind NE	1.0	0.5	0.7	0.5
R-4 Downwind NW	0.7	0.5	1.3	0.5
Grazing Area	ND	0.5	1.2	0.5

Notes: *RL is the reporting limit for U.
+/- is the counting error.

Table D11-12 Radiological and Non-radiological Background Levels in Vegetation Hank Unit.

	Radiological Elements				
Sample Location	Ra-226 (µCi/kg)	Pb-210 (µCi/kg)	Po-210 (µCi/kg)	Th-230 (µCi/kg)	Uranium (µCi/kg)
R-1 Pfister Ranch	7.5E-05	4.0E-04	4.1E-05	2.3E-06	4.5E-05
+/-	5.7E-06	2.1E-05	1.3E-05	3.6E-06	2.8E-07*
R-2 Downwind	4.6E-05	5.8E-04	2.9E-05	2.0E-05	4.9E-05*
+/-	2.0E-06	2.1E-05	8.5E-06	4.5E-06	2.1E-07*
R-3 West Boundary	6.3E-05	2.5E-04	1.5E-04	6.8E-06	1.5E-05*
+/-	6.1E-06	2.1E-05	2.9E-05	2.1E-06	3.9E-07*
R-4 Control South	7.3E-05	2.6E-04	4.9E-05	2.4E-05	4.5E-05*
+/-	5.4E-06	1.8E-05	1.3E-05	4.2E-06	2.8E-07*
R-5 East Boundary	9.6E-05	5.9E-04	1.1E-04	3.5E-05	7.1E-07*
+/-	6.9E-06	2.8E-05	2.8E-05	4.9E-06	3.4E-07
Grazing Area	6.7E-05	2.5E-04	5.9E-05	8.1E-06	4.0E-05*
+/-	7.0E-06	2.4E-05	2.3E-05	2.7E-06	4.5E-07*

	Non-radiological Elements			
Sample Location	Arsenic (mg/kg-dry)	RL*	Selenium (mg/kg-dry)	RL*
R-1 Pfister Ranch	ND	0.5	0.8	0.5
R-2 Downwind	ND	0.5	0.6	0.5
R-3 West Boundary	1.0	0.5	ND	0.5
R-4 Control South	ND	0.5	ND	0.5
R-5 East Boundary	ND	0.5	1.7	0.5
Grazing Area	ND	0.5	1.0	0.5

Notes: *RL is the reporting limit for U.
+/- is the counting error.

not considered since such releases are not expected under normal operating conditions for vacuum dryers.

The computer code MILDOS-Area (MILDOS) was used to calculate both the release rates (source terms) and the dose commitments. The dose commitments include contribution from each of the Nichols Ranch and Hank Unit sites. Extra-regional population doses are also estimated as a result of transport of radon. The results are provided as total effective dose equivalent per year.

D11.5.1 Site Description

The physical description of the sites is provided in the Mine Plan. The location of the sites is described in Figure D11-1 (see map pocket). The dose estimates are provided for intervals, directions, and elevations relative to the drying/packaging location at the Nichols Ranch facility; this location is subsequently referred to as the Nichols Ranch Central Processing Plant (mill center).

D11.5.2 Population Distribution

The population distribution within 80 km of the mill center is provided in Table D11-13. Figure D11-2 (see map pocket) shows the locations of the cities within 80 km of the mill center.

The population dose beyond 80 km is estimated using the code's predetermined population dose for year 1978. The population dose is adjusted for population growth by the ratio of estimated United States population for year 2000 of 268 million to the estimated United States population for year 1980 of 228 million, or 1.2.

Table D11-13 Population Distribution Within 80 km of Nichols Ranch Central Processing Plant.

Cities Within 80 km of Mill Center	Population	Distance from Mill Center (km)	Direction from Mill Center
Gillette	19,646	74	NE
Kaycee	249	56	W
Midwest	408	40	SW
Edgerton	169	37	SW
Wright	1,347	35	E

D11.5.3 Individual Receptor Locations

The locations of the nearest residents to the Nichols Ranch Central Processing Plant are provided in Table D11-14. Locations of site boundaries to the Nichols Ranch Central Processing Plant are provided in Table D11-15. Figure D11-1 (see map pocket) shows the locations of the nearest residents to the mill center.

Table D11-14 Nearest Residents to Nichols Ranch Central Processing Plant.

Nearest Residence	Number of Inhabitants	Distance from mill center km x(E)	Distance from mill center km y(N)	Elevation from mill center z m
T-Chair (Rolling Pin) Ranch	5	3.7	-2.2	-7
Dry Fork Ranch	3	-2.7	-1.1	-58
Christensen Ranch	1	1.8	7.8	-1
Pfister Ranch	3	7.8	7.4	78
Pumpkin Butte Ranch	2	11.1	3.6	218
Van Buggenum Ranch	0	15.4	5.3	130
Ruby Ranch	2	19.0	2.9	101
Hank Satellite Plant	0	7.9	3.5	121

Table D11-15 Center of Site Boundary from Nichols Ranch Central Processing Plant.

Location	Distance from mill center km x(E)	Distance from mill center km y(N)	Elevation from mill center z m
Nichols Ranch			
- north central	-0.4	1.3	57
- east central	0.6	0.2	-2
- south central	-0.3	-1.1	-18
- west central	-1.4	0.5	12
Hank			
- north central	7.9	6.6	86
- east central	8.8	3.3	160
- south central	7.9	1.3	139
- west central	7.1	4.2	102

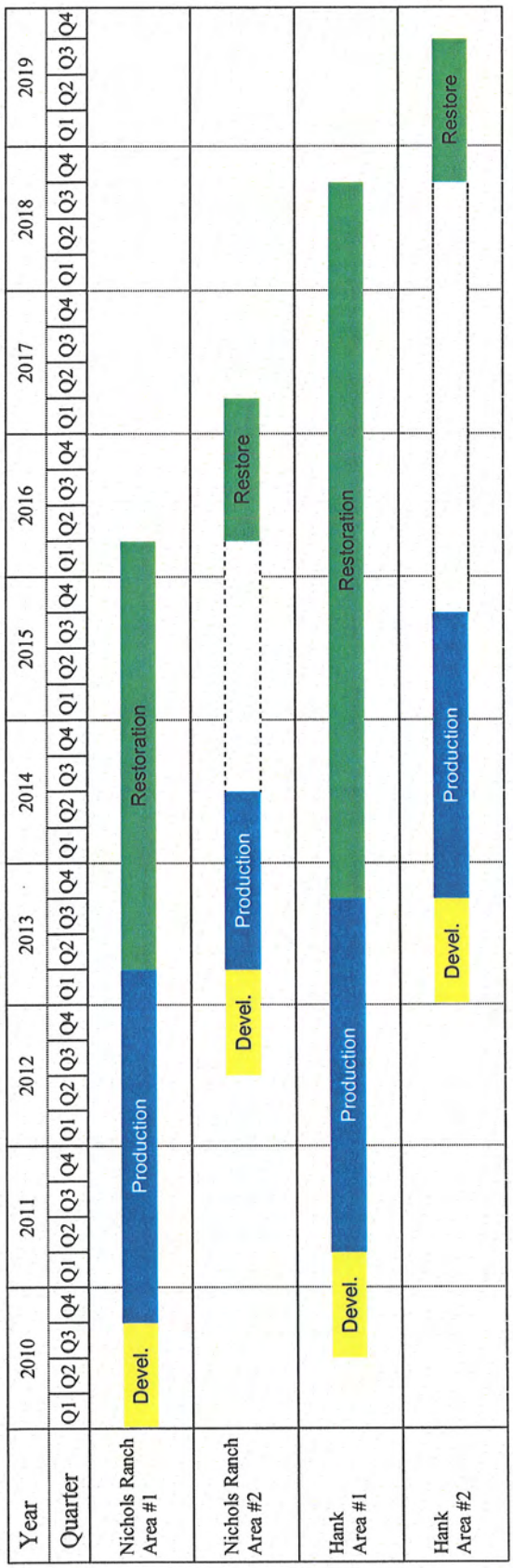
D11.5.4 Time Parameters

The dose commitments were completed for development, production, and restoration of wellfields for the operating years 2011 through 2019. The respective schedule is provided in Table D11-16.

The time parameters were input as:

- Beginning Year: 2011.
- Number of Time Steps: 9.
- Time Increment: 1 year.
- Population Adjustment: 1.2 (see above "Population Distribution")
- Source Adjustment: varied per source to reflect development, production, and restoration schedule of Table D11-16.

Table D11-16 Development, Production, and Restoration Schedule.



D11.5.5 Food Pathway Parameters

The MILDOS code requires four inputs to describe the feeding habits of livestock near the sites. The inputs used to describe the fraction of total annual livestock feed requirements are:

- Pasture Grass/Individual: 0.5 (default)
- Pasture Grass/Population: 0.5 (default)
- Hay/Individual: 0.5 (default)
- Hay/Population: 0.5 (default)

The MILDOS code also requires input of the areal food-production rate per unit area around the facility. The inputs used are:

- Vegetables: 3120 kg/y-m2
- Meat: 345 kg/y-m2
- Milk: 134 kg/y-m2

D11.5.6 Meteorological Parameters

The meteorological parameters for the MILDOS code were input as:

- The annual average morning and afternoon mixing heights each as the code default of 100 m
- The Briggs height cutoff vertical dispersion coefficient as the code default of 50 m
- The fractional joint frequency distribution of wind speed, direction and stability for Gillette, Wyoming for years 1996 through 2005. Atmospheric stability class G was summed with class F.

D11.5.7 Source Terms

The parameters and values used to develop the source terms and the resulting annual releases are listed in Tables D11-17 and D11-18 for Nichols Ranch and Hank Units, respectively. The respective source terms determined by MILDOS are included in these tables.

Table D11-17 MILDOS Input Parameters - Nichols Ranch Unit.

	(values in gray are calculated by MILDOS)*		
	Common Parameters (each wellfield)	Units	
Location	X (location relative to the plant which is considered (0,0,0)	-0.9	km
	Y (location relative to the plant which is considered (0,0,0)	0.4	km
	Z (location relative to the plant which is considered (0,0,0)	6	m
	area of active drilling (ore zone)	228644	m^2
	emanation fraction	0.2	
	Ra concentration in ore	311	pCi/g
	thickness	2.2	m
	density	1.9	g/cm3
	porosity	0.3	
	fraction of Rn	0.75	
	rate of Rn venting	0.01	/d
	volume in circulation	149068519	L
	New Wellfield Source Parameters (each wellfield)		
Mud pits	storage time in pit	30	d
	ore material into pit	136534	g/y
	number of mud pits	966	
	Total amount of Rn-222 released from drilling activities	0.045	Ci/yr
	Production Wellfield Source Parameters (each wellfield)		
Ore zone	Rn-222 source	1.1 E+13	pCi/d
Process water	treated water purge rate	190779	L/d
	Rn-222 release from purge water	20	Ci/yr
	Rn-222 release from well venting	150	Ci/yr
Ion exchange columns	column volume	14158	L
	column unloading rate	2	/d
	porosity of resin	0.4	
	Rn-222 release from ion exchange column	1.2	Ci/yr
	Total amount of Rn-222 released from production activities	170	Ci/yr
	Restoration Wellfield Source Parameters (each wellfield)		
Ore zone	Rn-222 source	1.1 E+13	pCi/d
Process water	treated water purge rate	310698	L/d
	operating days	360	d/yr
	Rn-222 release from purge water	31	Ci/yr
	Rn-222 release from well venting	150	Ci/yr
	Total Rn-222 released from restoration activities	180	Ci/yr

* Values may not sum within table due to rounding.

Table D11-18 MILDOS Input Parameters - Hank Unit.

	(values in gray are calculated by MILDOS)*		
	Common Parameters (each wellfield)	Units	
Location	X (location relative to the plant which is considered (0,0,0)	8.2	km
	Y (location relative to the plant which is considered (0,0,0)	3.5	km
	Z (location relative to the plant which is considered (0,0,0)	142	m
	area of active drilling (ore zone)	313627	m^2
	emanation fraction	0.2	
	Ra concentration in ore	277	pCi/g
	thickness	2.6	m
	density	1.9	g/cm3
	porosity	0.3	
	fraction of Rn	0.75	
	rate of Rn venting	0.01	/d
	volume in circulation	245770913	L
Mud pits	**New Wellfield Source Parameters** (each wellfield)		
	storage time in pit	30	d
	ore material into pit	160949	g/y
	number of mud pits	776	
	Total amount of Rn-222 released from drilling activities	0.038	Ci/yr
Ore zone	**Production Wellfield Source Parameters** (each wellfield)		
	Rn-222 source	1.6 E+13	pCi/d
Process water	treated water purge rate	408813	L/d
	Rn-222 release from purge water	37	Ci/yr
	Rn-222 release from well venting	220	Ci/yr
Ion exchange columns	column volume	14158	L
	column unloading rate	2	/d
	porosity of resin	0.4	
	Rn-222 release from ion exchange column	1.0	Ci/yr
	Total amount of Rn-222 released from production activities	260	Ci/yr
Ore zone	**Restoration Wellfield Source Parameters** (each wellfield)		
	Rn-222 source	1.6 E+13	pCi/d
Process water	treated water purge rate	119918	L/d
	operating days	360	d/yr
	Rn-222 release from purge water	11	Ci/yr
	Rn-222 release from well venting	220	Ci/yr
	Total Rn-222 released from restoration activities	230	Ci/yr

* Values may not sum within table due to rounding.

The fraction of radon attributable to the site was input as one for Casper, Wyoming.

A source term for release of particulates from drying and packaging activities was not developed since no particulate emissions are expected under normal operating conditions for vacuum dryers.

D11.5.8 Results

Dose modeling was completed as described above for the primary years of operation of the Nichols Ranch ISR Project, Nichols Ranch and Hank sites. The operations modeled included wellfield development, production, and wellfield restoration. The source terms were adjusted to reflect actual periods of activity per year. The results of the dose modeling are summarized below with respect to the nearest residents, site boundaries, and the surrounding population. The 40 CFR 190 doses are zero because does from radon is excluded from the scope of the standard. The report of the MILDOS code execution is provided as Addendum D11A.

D11.5.8.1 Individual Receptor Dose

Estimated annual doses at individual receptor locations are shown in Table D11-19. The estimated doses result exclusively from radon daughters, since there are no particulate releases from the facility. The total effective dose equivalent (TEDE) is at least 100 times less than the dose limit to individual members of the public in 10 CFR 20 of 100 mrem/y.

Estimated annual doses at site boundary locations are shown in Table D11-20. The estimated doses result exclusively from radon daughters, since there are no particulate releases from the facility. The total effective dose equivalent (TEDE) is substantially less than the dose limit to individual members of the public in 10 CFR 20 of 100 mrem/y.

Table D11-19 Summary of Total Effective Dose Equivalent to Individual Receptors, mrem/year.

	Year								
Receptor	2011	2012	2013	2014	2015	2016	2017	2018	2019
T-Chair Ranch	0.09	0.1	0.1	0.2	0.1	0.1	0.05	0.03	0.03
Dry Fork Ranch	0.04	0.04	0.06	0.07	0.05	0.04	0.02	0.01	0.008
Christensen Ranch	0.1	0.1	0.2	0.2	0.2	0.1	0.08	0.06	0.04
Pfister Ranch	0.4	0.5	0.6	0.9	0.8	0.4	0.4	0.04	0.3
Pumpkin Butte Ranch	0.3	0.4	0.5	0.7	0.6	0.4	0.3	0.3	0.2
Van Buggenum Ranch	0.09	0.1	0.1	0.2	0.2	0.1	0.09	0.08	0.06
Ruby Ranch	0.07	0.08	0.1	0.1	0.1	0.08	0.06	0.05	0.04

Table D11-20 Summary of Total Effective Dose Equivalent Site Boundary, mrem/year.

	Year								
Boundary Location	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nichols Ranch									
central	1	1	2	2	2	2	0.4	0.03	0.02
entral	0.5	0.6	0.9	0.9	0.6	0.6	0.2	0.02	0.02
central	0.3	0.3	0.4	0.5	0.3	0.3	0.09	0.02	0.01
entral	2	2	3	3	2	2	0.6	0.02	0.02
Hank									
central	0.5	0.7	0.8	1	1	0.6	0.6	0.5	0.4
entral	2	3	3	5	5	3	2	2	2
central	0.3	0.4	0.6	0.8	0.7	0.4	0.4	0.3	0.3
entral	0.6	0.8	1	2	1	0.7	0.7	0.7	0.5

D11.5.8.2 Population Dose

Estimated annual doses populations are shown in Table D11-21. The estimated doses result exclusively from radon daughters, since there are no particulate releases from the facility. There is no regulatory limit for population dose. The TEDE for the population within 80 km of the mill center is about 162,500 to 32,500 times less than the dose to this population attributable to natural background radon of 300 mrem/y (21819 persons x 0.3 rem/y = 6500 person-rem/y).

Table D11-21 Summary of Total Effective Dose Equivalent to Populations, person-rem/year.

	Year								
Receptor	2011	2012	2013	2014	2015	2016	2017	2018	2019
Population within 80 km	0.09	0.1	0.1	0.2	0.1	0.1	0.07	0.06	0.04
Population beyond 80 km	4	4	6	8	6	4	3	2	2
All populations	4	4	6	8	6	4	3	2	2

D11.2.0 REFERENCES

National Climatic Data Center (NCDS). Relative Frequency Distribution: Gillette, Wyoming, 1996-2005. Climate Services Branch. U.S. Department of Commerce. Asheville, North Carolina.

National Council on Radiation Protection and Measurement. Report No. 78: Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States. Bethesda, MD. 1984.

National Council on Radiation Protection and Measurement. Report No. 77: Exposures from the Uranium Series with Emphasis on Radon and its Daughters. Bethesda, MD. 1984.

National Council on Radiation Protection and Measurement. Report No. 45: Natural Background Radiation in the United States. Bethesda, MD. 1975.

Nuclear Regulatory Commission. NUREG-1748: Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards Programs: Final Report. Washington, D.C. August 2003.

Nuclear Regulatory Commission. NUREG CR-5849: Manual for Conducting Radiological Surveys in Support of License Termination. Oak Ridge Associated Universities. Oak Ridge, TN. 1992.

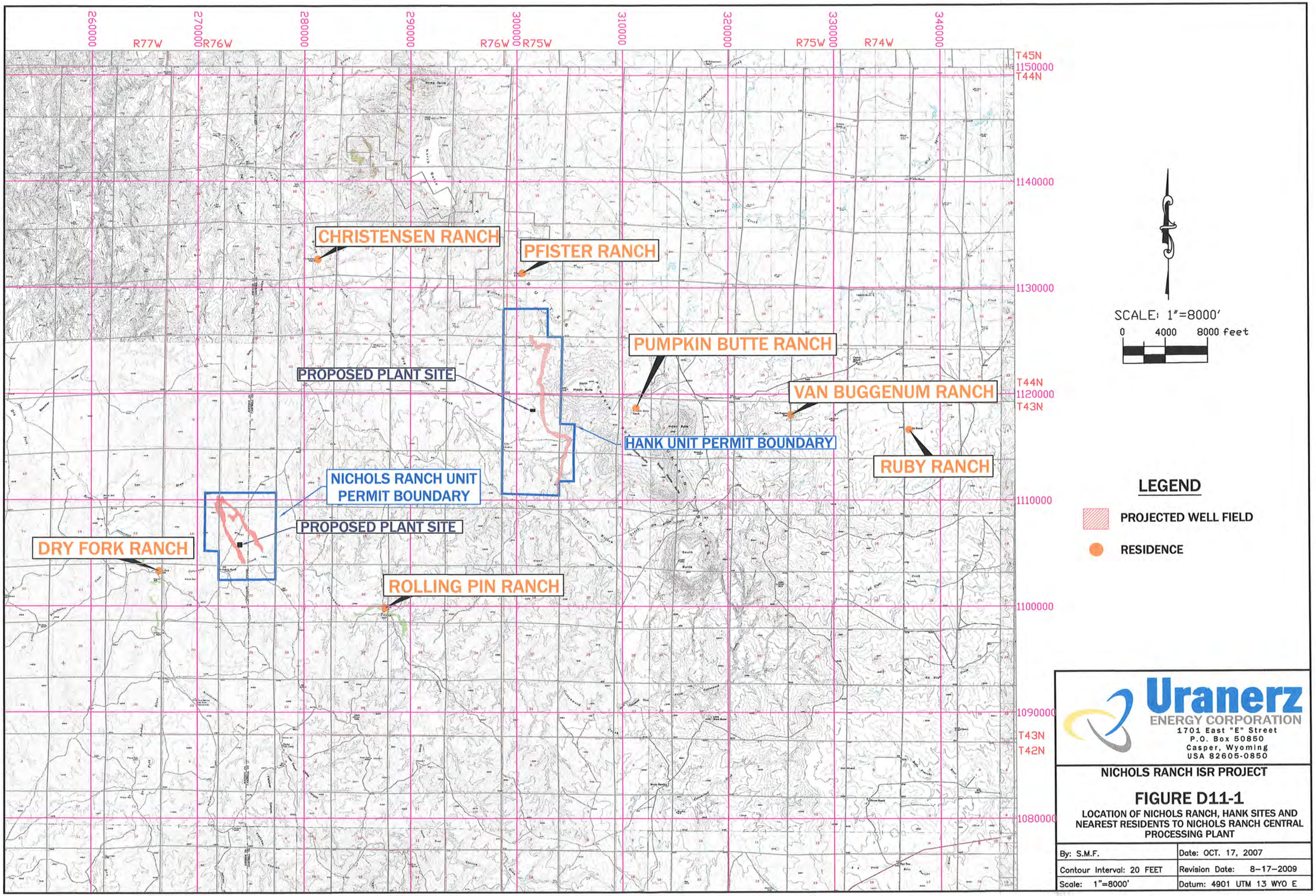
Nuclear Regulatory Commission. NUREG-1569. Standard Review Plan for In Situ Leach Uranium Extraction License Applications: Final Report. Washington, D.C. June 2003.

Nuclear Regulatory Commission. Regulatory Guide 4.14. Radiological Effluent and Environmental Monitoring at Uranium Mills. Washington, D.C. April 25, 1980.

Pathfinder Mines Corporation. North Butte ISL Project. Casper, Wyoming. 1988.

www.census.gov

Yuan, Y.C., J.H.C. Wang, and A. Zielen. "MILDOS-AREA: An Enhanced Version of MILDOS for Large-Area Sources." Report ANL/ES–161. Argonne, Illinois: Argonne National Laboratory, Energy and Environmental Systems Division. 1989. [Code version 2.20β, December 1998.]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T42N
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CHRISTENSEN RANCH
PFISTER RANCH
PUMPKIN BUTTE RANCH
VAN BUGGENUM RANCH
RUBY RANCH
PROPOSED PLANT SITE
HANK UNIT PERMIT BOUNDARY
NICHOLS RANCH UNIT
PERMIT BOUNDARY
PROPOSED PLANT SITE
DRY FORK RANCH
ROLLING PIN RANCH
SCALE: 1"=8000'
0
4000
8000 feet
LEGEND
PROJECTED WELL FIELD
RESIDENCE
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1701 East "E" Street
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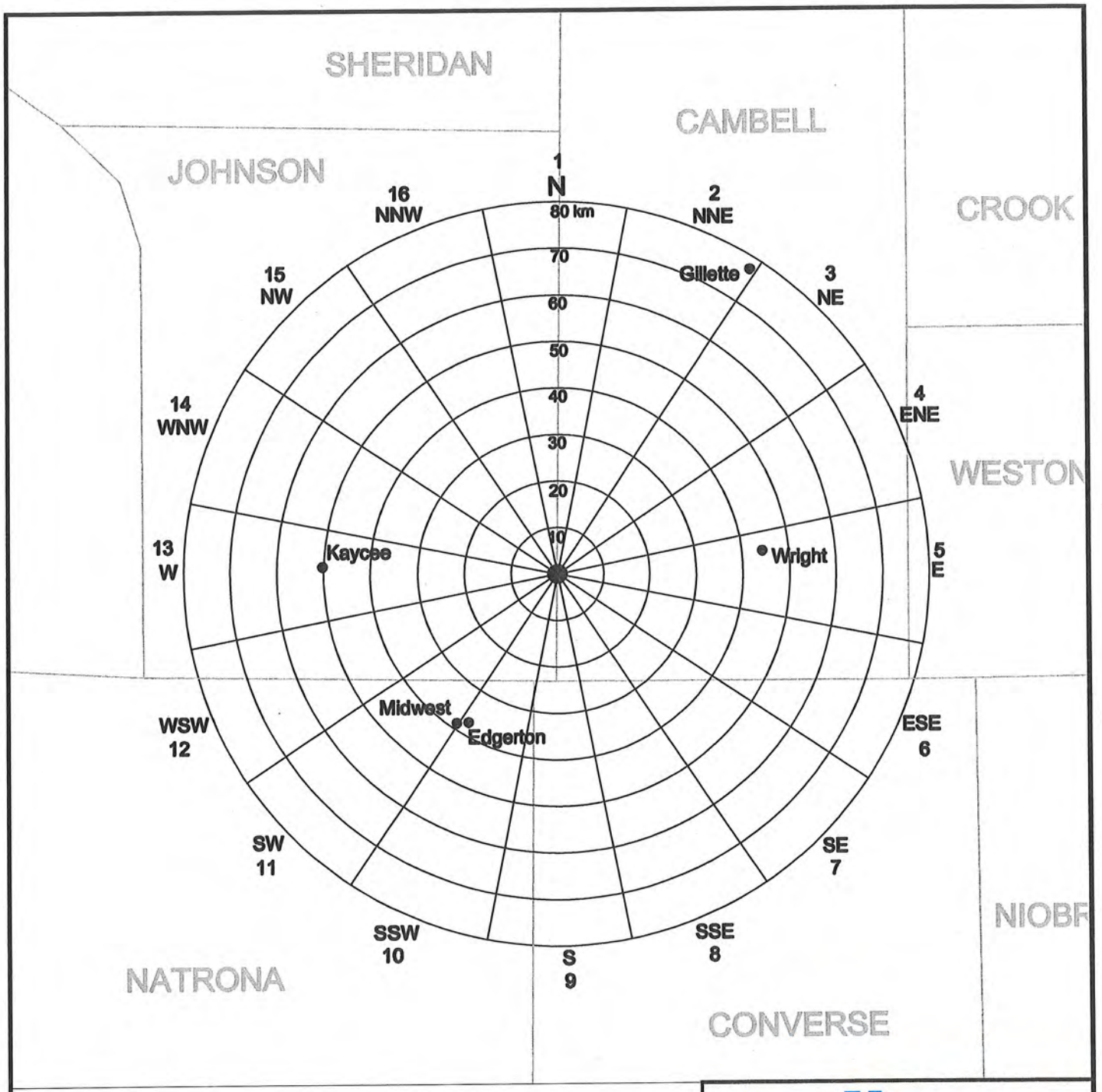
NICHOLS RANCH ISR PROJECT
FIGURE D11-1
LOCATION OF NICHOLS RANCH, HANK SITES AND NEAREST RESIDENTS TO NICHOLS RANCH CENTRAL PROCESSING PLANT
By: S.M.F.
Date: OCT. 17, 2007
Contour Interval: 20 FEET
Revision Date: 8-17-2009
Scale: 1"=8000'
Datum: 4901 UTM 13 WYO E



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NICHOLS RANCH ISR PROJECT

FIGURE D11-2

LOCATION OF CITIES WITHIN 80km OF NICHOLS RANCH CENTRAL PROCESSING PLANT

By: S.M.F.	Date: NOV. 8, 2007
Datum: UNKNOWN	Revision Date:
Scale: NOT TO SCALE	Contour Interval:N/A

DWG#: FIGURE D11-2