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3.7 Meteorology, Climatology and Air Quality

This section describes meteorology, climatology, and air quality in the region where the Permit Area is located. Both regional (long-term) and site-specific (one-year) data are discussed to characterize climatological conditions at the Permit Area. Where site-specific data are not available, data from the closest representative location are presented.

3.7.1 Meteorology and Climatology

The Permit Area is located in the intermountain semi-desert ecoregion (Wyoming State Climate Office, 2005), which has cold winters and short, hot summers (Bailey, 1995). The average annual temperatures range from 40 to 52 degrees Fahrenheit (°F) in this ecoregion. The average annual precipitation ranges from five to 14 inches (Bailey, 1995). Meteorological stations within 50 miles of the Permit Area are shown in **Figure 3.7-1**. The National Weather Service (NWS) meteorological station, closest to the Permit Area, with a long period of record is Muddy Gap, Wyoming (High Plains Regional Climate Center [HPRCC], 2007a). This station is 28 miles northeast of the Permit Area, and temperature, precipitation, snowfall and snow depth data have been collected since 1949.

A meteorological station (Lost Soldier [LS] Station) was installed at a location near Bairoil in April 2006. The LS meteorological station is about 12 miles northeast from the Permit Area (**Figure 3.7-1**). Another meteorological station (Lost Creek [LC] Station) was installed within the Permit Area in May 2007 to collect on-site data (**Figure 3.7-1**).

Information collected from the LS station will be used to describe on-site conditions. All data were measured at a height of 6.6 feet (two meters), with a recovery rate of over 90 percent. The Muddy Gap station is in the same Climate Division as the Permit Area, Climate Division 10 (CLIMAS, 2005), which means that these locations have similar climatic characteristics. At the date of this document, only data through 2005 were available for the Muddy Gap station.

3.7.1.1 Temperature

Based on the Muddy Gap data, July is the warmest month; the average maximum daily temperature is approximately 85°F, and the average minimum daily temperature is approximately 55°F. January is the coldest month; the average daily maximum temperatures are 30 to 35°F, and the average minimum daily temperatures are approximately 10 to 15°F. The maximum temperature on record is 100°F in July, while the minimum temperature on record is -40°F in December. The average monthly temperatures at the LS station, collected in 2006 and 2007, were generally within range of the long-term averages at Muddy Gap. Temperatures from these stations are compared in **Table 3.7-1**.

Dew point temperatures were calculated for the months of April to December; temperatures between January and March showed negative temperatures. The averages ranged from 22.4 to 35.1°F. The highest average dew point temperature occurred in July, while the lowest average dew point temperature occurred in May. The maximum dew point temperatures range from 32.6 to 53.2°F; the minimum dew point temperatures range from -10.2 to 19.7°F. The lowest minimum dew point temperatures occurred in May and November, while the highest maximum dew point temperatures occurred in July and August. **Table 3.7-2** presents the dew point temperature data.

3.7.1.2 Precipitation

The Permit Area is drier than many areas in the State of Wyoming. **Figure 3.7-2** shows the total monthly precipitation in the Project region.

The mean annual precipitation at the Muddy Gap station from 1949 through 2005 was 10.0 inches. Precipitation is distributed throughout the year; the mean monthly precipitation exceeds one inch only in April, May, and June. May is the wettest month, with 1.9 inches of mean precipitation. The actual annual moisture may be somewhat higher, since precipitation gages capture only a small proportion of snowfall under windy conditions.

The precipitation at the LS station from May 2006 to April 2007 showed that precipitation for this period was much lower than normal. Regional data showed the area received 50 to 70 percent less rainfall than average (HPRCC, 2007b). The nearest bodies of water within 50 miles are the Pathfinder and Seminoe Reservoirs (see **Figure 3.7-1**).

3.7.1.3 Humidity

The average relative humidity at the Permit Area is low in the summer, with the lowest average occurring in June (30.2 percent). The relative humidity is elevated during the winter, where the highest average occurred in February (75.6 percent). The monthly maximum and minimum humidity measured at the LS meteorological station is provided in **Table 3.7-3**.

3.7.1.4 Wind

The annual average wind speed at a height of ten meters, measured between May 2006 and April 2007, was 23 feet per second (ft/s) (7.0 meters per second [m/s]) at the LS station. The wind speed is highest in February and November (29.9 and 29.2 ft/s or 9.1 and 8.9 m/s, respectively). The lowest wind speeds occur in July and August (16.4 and 16.7 ft/s or 5.0 and 5.1 m/s, respectively). The wind speed and wind direction from May 2006 to April 2007 is shown in **Figures 3.7-3a, b, c, d, e, f, g, h, i, j, k, l, and m**. The prevailing monthly wind direction is from the west-northwest and west for most of the year, with some variability occurring in the spring.

3.7.1.5 Evaporation

Evaporation from a Class A pan was measured from March to November at the Pathfinder Dam, 56 miles from the Permit Area. This location is in the same climatic zone as the Permit Area (Wyoming State Climate Office, 2007), so potential evaporation would be similar in both locations. Evaporation pan data were not collected during the winter months. Evaporation occurs at a slower rate in lakes than in pans, so empirical equations are generally used to estimate actual lake evaporation. The Kohler-Nordenson-Fox equation uses temperature, wind, humidity, and radiation to predict monthly and annual evaporation, and has been shown to produce reliable results in Wyoming (Pochop et al., 2007). This paper reported the annual estimated lake evaporation at the Pathfinder Dam is 42.5 inches (**Table 3.7-4**). The highest estimated evaporation rates occurred during the summer months, with a peak of 7.5 inches in July. The period of maximum evaporation is consistent with the pan evaporation measurements from the Pathfinder Dam. Evaporation rates were low in the winter, with less than one inch of evaporation predicted for December and January.

3.7.1.6 Severe Weather

Tornadoes are more prevalent in eastern Wyoming than in western Wyoming, because mountain ranges in western Wyoming are barriers to the flow of warm, moist air that causes tornadoes. In Sweetwater County, 19 tornados, none of which caused any injury or death, were reported in a 55-year period. An individual tornado would affect only a portion of Sweetwater County; therefore, the chances are small that the Permit Area would experience a tornado. The Fujita Scale is used to rate the intensity of a tornado by examining the damage caused to man-made structures (The Tornado Project, 2003). The most destructive tornado recorded in Sweetwater County from 1950 to 2004 was an F-1 "moderate" tornado, which would be unlikely to cause extensive damage to the Project.

Figure 3.7-4 presents tornado data collected by the Storm Prediction Center from 1950 to 2004 (Storm Prediction Center, 2005).

July has the highest number of thunderstorm days, as measured over many years at select stations in Wyoming. Wind gusts during thunderstorms are often over 49 mph. The Permit Area is located in an area that has statistically shown a lower density of lightning strikes. The probability of hail is also low, with six occurrences recorded in a 24-year period (Curtis and Grimes, 2007).

3.7.1.7 Local Air Flow Patterns and Characteristics

Atmospheric stability was categorized into six classes according to Pasquill. Calculations were made using wind speed and solar radiation data collected at the Permit Area, and the results are presented in **Table 3.7-5**. The data show that low stability conditions, which contribute to good dispersion conditions, occur 91 percent of the time, making atmospheric inversion conditions unlikely.

3.7.2 Air Quality

National Ambient Air Quality Standards (NAAQS) exist for sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), lead, and particulate matter small enough to move easily into the lower respiratory tract (particles less than ten micrometers in aerodynamic diameter, designated Particulate Matter [PM_{10}]). The NAAQS are expressed as pollutant concentrations that are not to be exceeded in the ambient air, that is, in the outdoor air to which the general public has access (40 CFR Part 50.1(e)). Primary NAAQS are designated to protect human health; secondary NAAQS are designated to protect human welfare by safeguarding environmental resources (such as soils, water, plants, and animals) and manufactured materials. Primary and secondary NAAQS are presented in **Table 3.7-6**.

The air quality in the Project region is good. The area is sparsely populated and is not heavily developed with industrial sources of air pollution. The closest monitoring station to the Permit Area is in Rawlins, and shows that regional air quality is in compliance with the NAAQS and Wyoming Ambient Air Quality Standards (WAAQS) (BLM, 2004c).

In addition to ambient air quality standards, which represent an upper bound on allowable pollutant concentrations, there are national standards for the Prevention of Significant Deterioration (PSD) of air quality (40 CFR § 51.166). The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable concentrations of pollutants, while PSD requirements provide maximum allowable increases in concentrations of pollutants for areas already in compliance with the NAAQS. PSD standards are, therefore, expressed as allowable increments in the atmospheric concentrations of specific pollutants. Allowable PSD increments currently exist for three pollutants: NO_2, SO_2, and PM_{10}. Increments are particularly relevant when a major proposed action (involving either a new source or a major modification to an existing source) may degrade air quality without exceeding the NAAQS, as would be the case, for example, in an area where the ambient air is very clean. One set of allowable increments exists for Class II areas, which cover most of the US; a much more stringent set of allowable increments exists for Class I areas, which are designated areas where the degradation of ambient air quality is severely restricted. Class I areas include certain national parks and monuments, wilderness areas, and other areas as described in 40 CFR § 51.166(e) and 40 CFR Part 81:400-437. Maximum allowable PSD increments for Class I and Class II areas are given in **Table 3.7-7**. Class I areas, as designated in the Rawlins RMP, include the Savage Run Wilderness and Rocky Mountain National Park. PSD Class I areas receive the highest degree of protection from air pollution; only small amounts of particulate, SO_2, and NO_2 air pollutants are allowed in these areas (BLM, 2004c).

Emission air quality data in the EPA database consist of the amount of selected air quality parameters that are released into a particular airshed. Criteria Air Pollutant parameters reported include CO, NO_X (a group of highly reactive gases that contain nitrogen and oxygen in varying amounts), SO_2, volatile organic compounds (VOCs), $PM_{2.5}$, PM_{10} and ammonia (NH_3). Near the Permit Area, reported sources of emissions include that from the Amoco CO_2 Bairoil station, the Northern Gas Bunker Hill compression station and the Sinclair Oil Bairoil station (**Table 3.7-8**). Hazardous Air Pollutants consist of 188 parameters and are also reported in the EPA database; the reported total emissions from the facilities near the Permit Area are presented in **Table 3.7-9**.

Air particulate matter in the Permit Area was sampled using two Mini-Volumetric (MiniVol) samplers with ten micron (PM_{10}) filters. Dust trapped by these filters is the size considered most detrimental to human health. Two samplers were used as a pair, with samples collected concurrently upwind and downwind of the Permit Area, at three locations: Northern (LCAIR9&10), Central (LCAIR13&14), and Southern (LCAIR11&12). The sampling duration was approximately 24 hours; the results were time-adjusted for a 24-hour period. **Figure 3.7-5** shows the sampling locations, and the results are presented in **Table 3.7-10**.

The average PM_{10} concentration in June 2006, including both upwind and downwind sampling locations, was 8.5 micrograms per cubic meter ($\mu g/m^3$). The maximum value was 10.5 $\mu g/m^3$, and the minimum value was 5.4 $\mu g/m^3$. For comparison, the average PM_{10} in Casper Wyoming was 18.8 $\mu g/m^3$ from 1990 through 1994 (Natural Resources Defense Council, 2007). At the northern sampling location, the PM_{10} concentration in the upwind sample was more than 70 percent higher than the downwind sample. At the central and southern sampling locations, the upwind and downwind samples differed by 15 percent or less. The sample collection runs lasted between 21.5 to 28 hours. In February 2007, the PM_{10} concentration at the central sampling location was about one-half of the concentration in June 2006, possibly due to slightly damper soil conditions.

The NAAQS criteria for PM_{10} sets a limit of 150 $\mu g/m^3$ for a 24-hour period, not to be exceeded more than once per year on an average over three years. The data show that for both upwind and downwind locations, this standard was not exceeded. More information on dust and emissions from Project activities are covered in **Section 4.7** of this report.

Passive radon and gamma air sampling for the Project was initiated in November 2006. Sampling locations were established at the closest full-time residence, which is in Bairoil, (URPA1 [Ur-Energy Passive Air 1]), at the western site boundary (URPA7), at the southeastern site boundary (URPA8), at the northeastern site boundary (URPA10), and at the center of the site (URPA9). An additional sampling site was added (URPA13) after the first quarter, to reflect changes to the Permit Area. **Figure 3.7-6** shows passive radiological sampling locations, which represent conditions both upwind (west) and downwind (east) of the Permit Area.

The samplers were retrieved quarterly, and the results are presented in **Table 3.7-11**. The elevated radon measurement at URPA9 during the first quarter may be due to radon retention by snow cover. When retrieved, the sensor was buried in a snow drift; thereafter, the sampler was relocated five feet away. The gamma sensor at URPA10 was missing at the end of the second quarter, but was replaced.

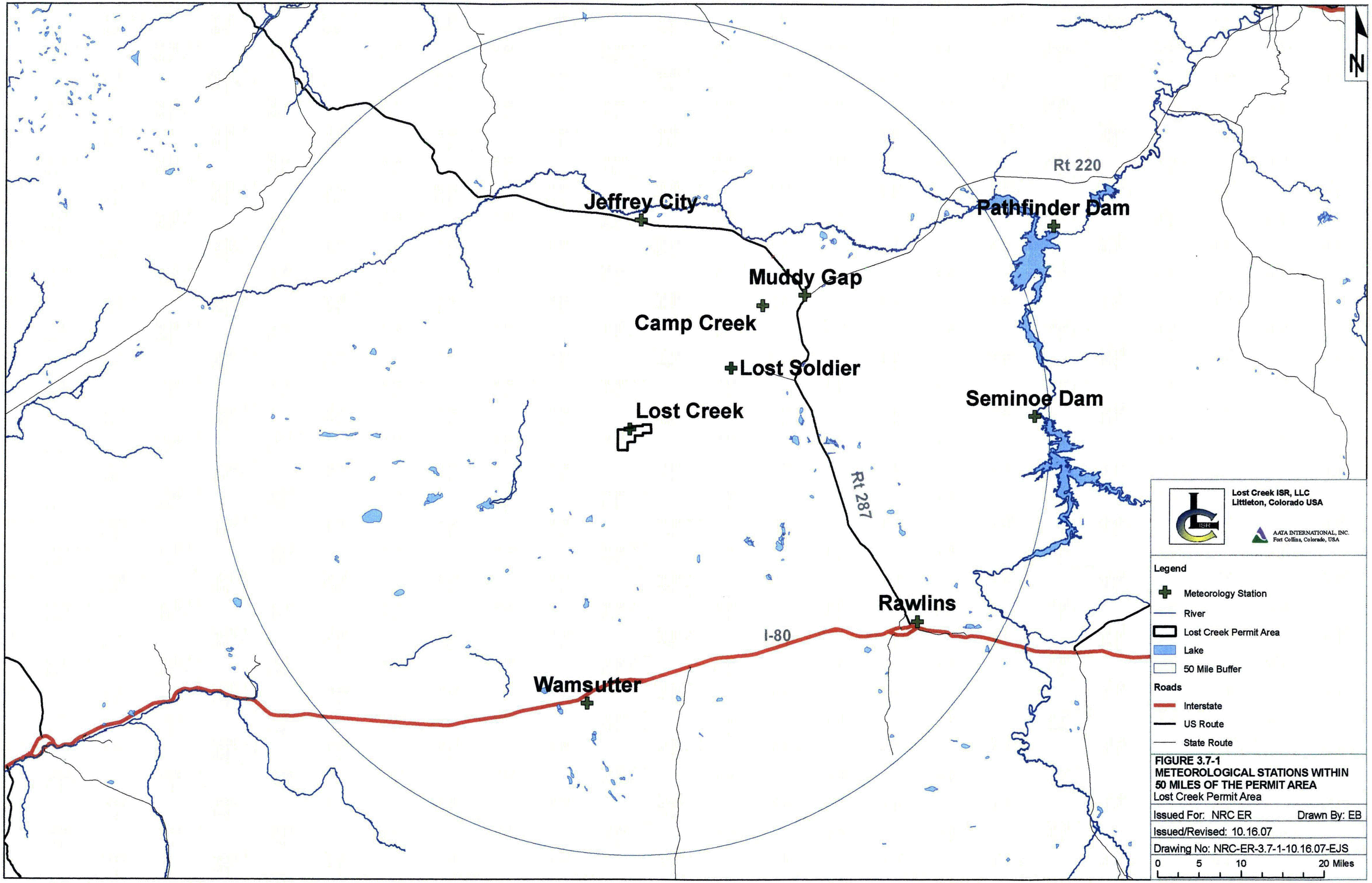


FIGURE 3.7-1
METEOROLOGICAL STATIONS WITHIN 50 MILES OF THE PERMIT AREA
Lost Creek Permit Area

Figure 3.7-2 Monthly Total Precipitation in The Project Region

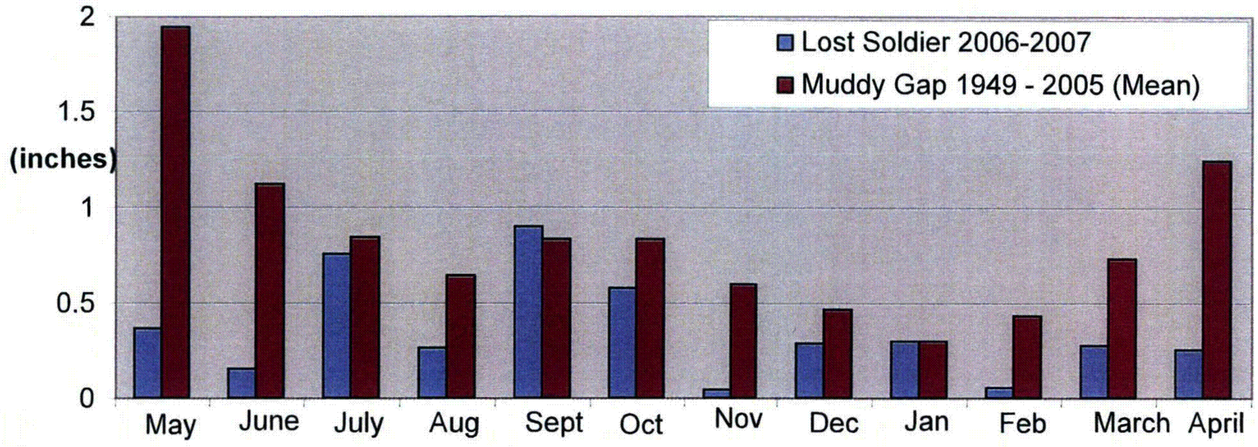
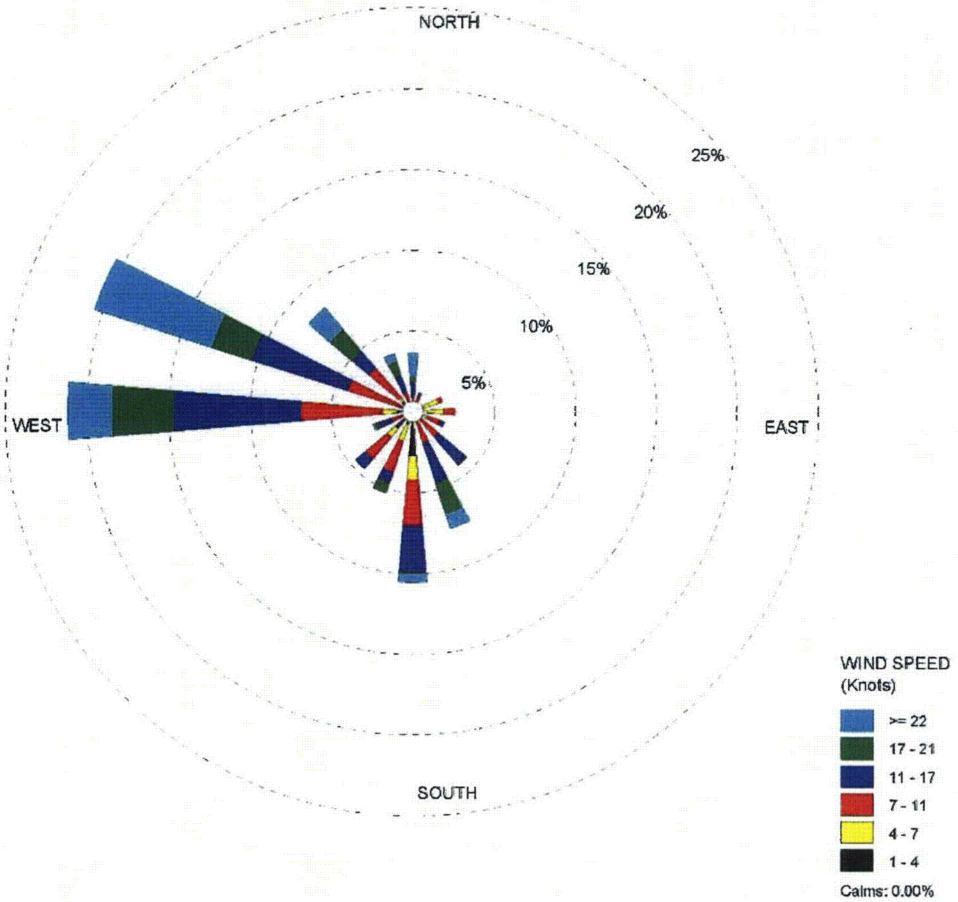


Figure 3.7-3a. Wind Speed and Wind Direction at the LS Met Station – May 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
2006
May 1 - May 31
00:00 - 23:00

COMPANY NAME:
AATA International, Inc.

MODELER:

CALM WINDS:
0.00%

TOTAL COUNT:
744 hrs.

AVG. WIND SPEED:
13.30 Knots

DATE:
5/3/2007

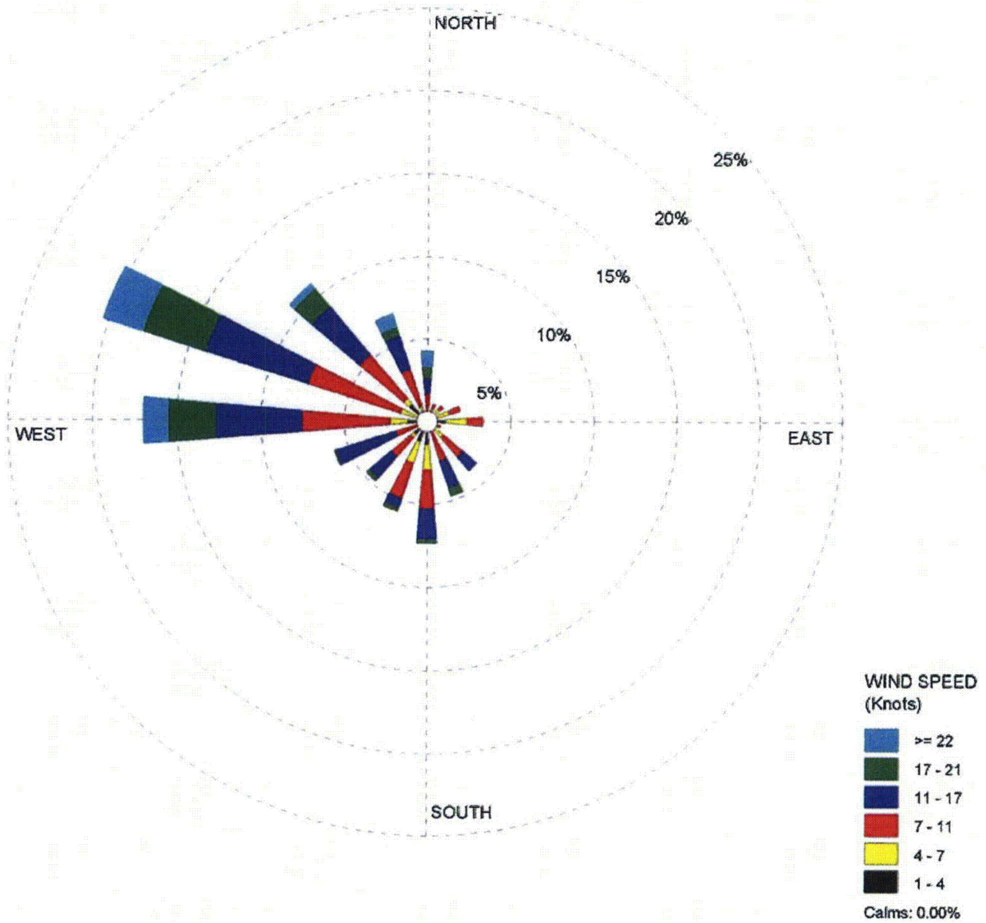
PROJECT NO.

WRPLOT View - Lakes Environmental Software

Figure 3.7-3b. Wind Speed and Wind Direction at the LS Met Station – June 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



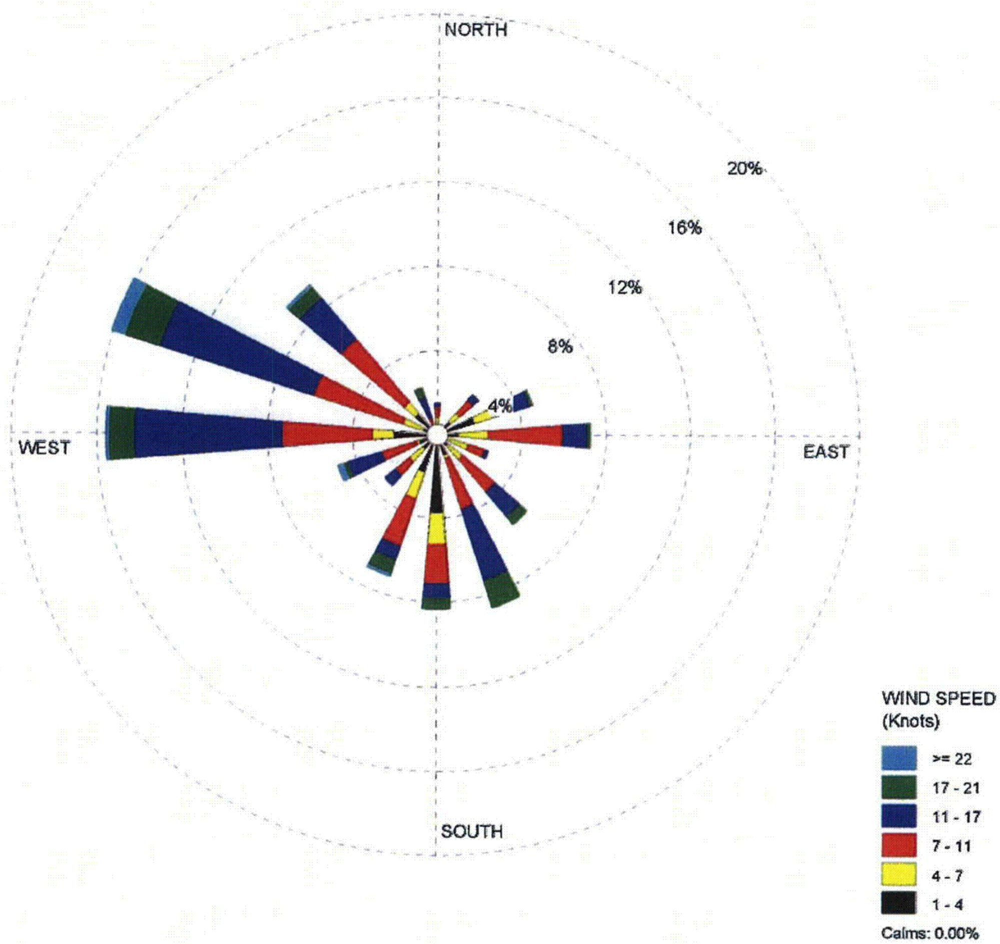
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Jun 1 - Jun 30** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT: **720 hrs.**	
	AVG. WIND SPEED: **11.71 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3c. Wind Speed and Wind Direction at the LS Met Station – July 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



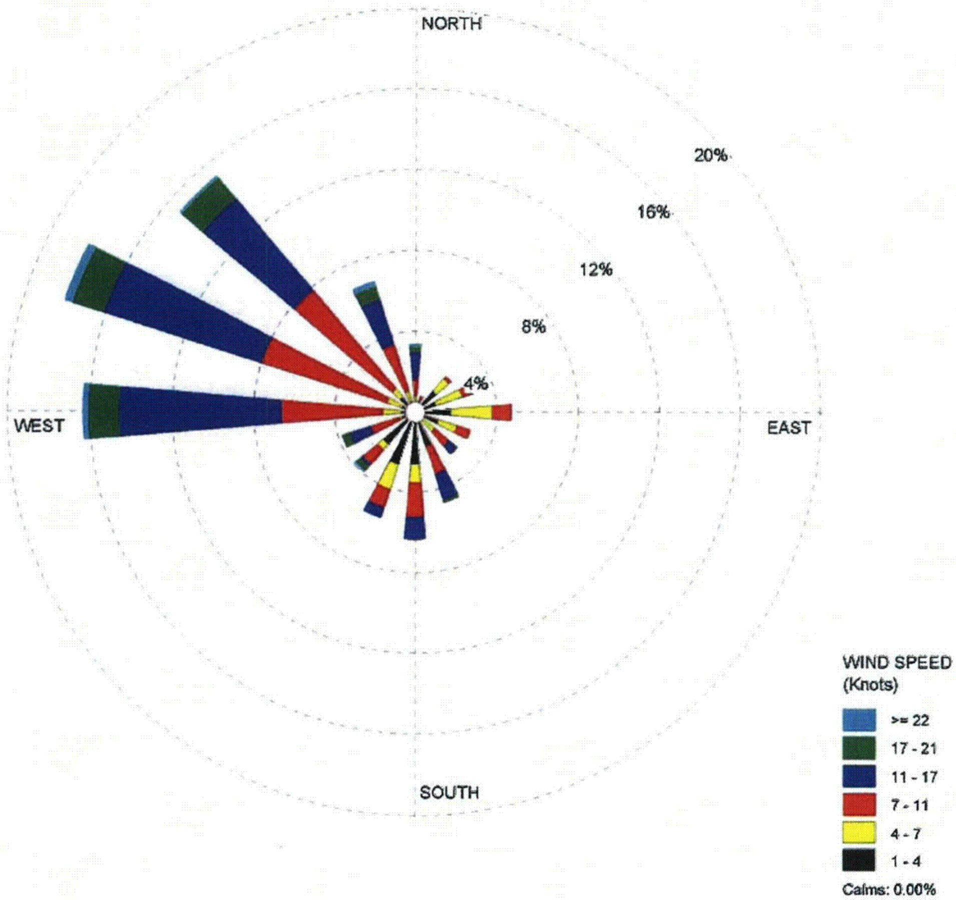
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Jul 1 - Jul 31** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT: **592 hrs.**	
	AVG. WIND SPEED: **9.88 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3d. Wind Speed and Wind Direction at the LS Met Station – August 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



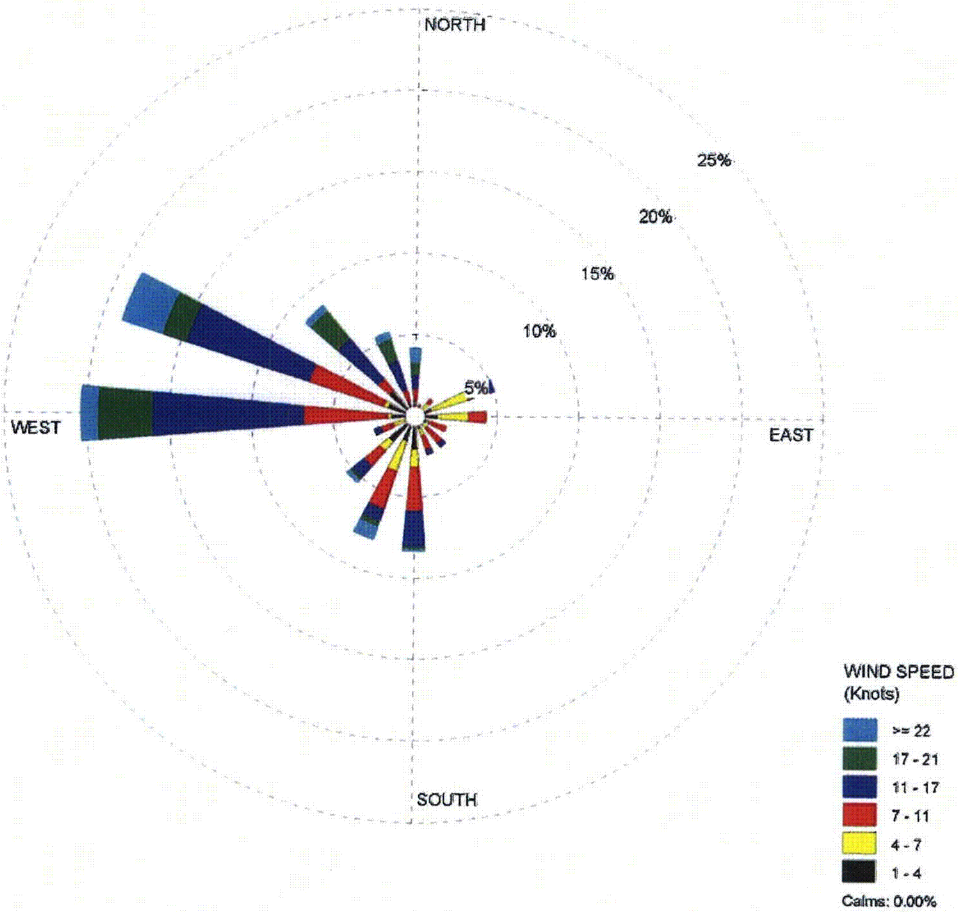
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Aug 1 - Aug 31** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT: **744 hrs.**	
	AVG. WIND SPEED: **9.88 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3e. Wind Speed and Wind Direction at the LS Met Station – September 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)

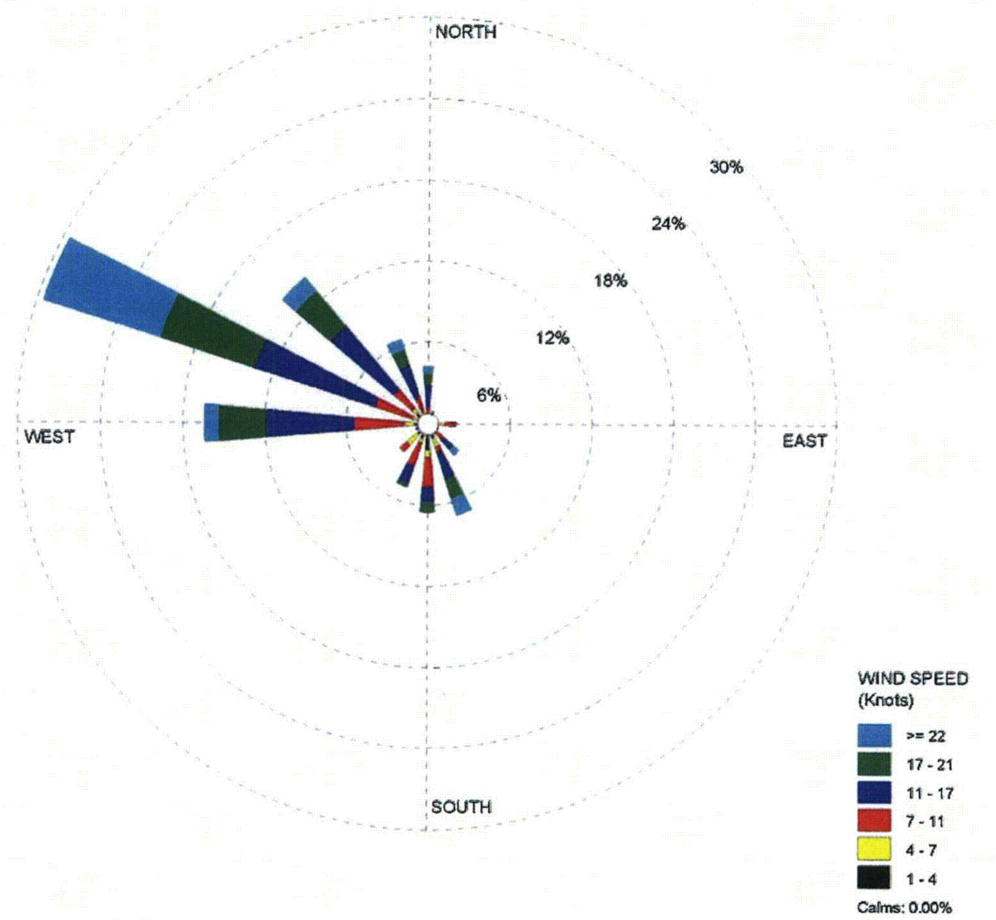


COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Sep 1 - Sep 30** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT: **651 hrs.**	
	AVG. WIND SPEED: **11.10 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3f. Wind Speed and Wind Direction at the LS Met Station – October 2006

WIND ROSE PLOT:	DISPLAY: **Wind Speed** **Direction (blowing from)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Oct 1 - Oct 31** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT: **744 hrs.**	
	AVG. WIND SPEED: **14.16 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3g. Wind Speed and Wind Direction at the LS Met Station – November 2006

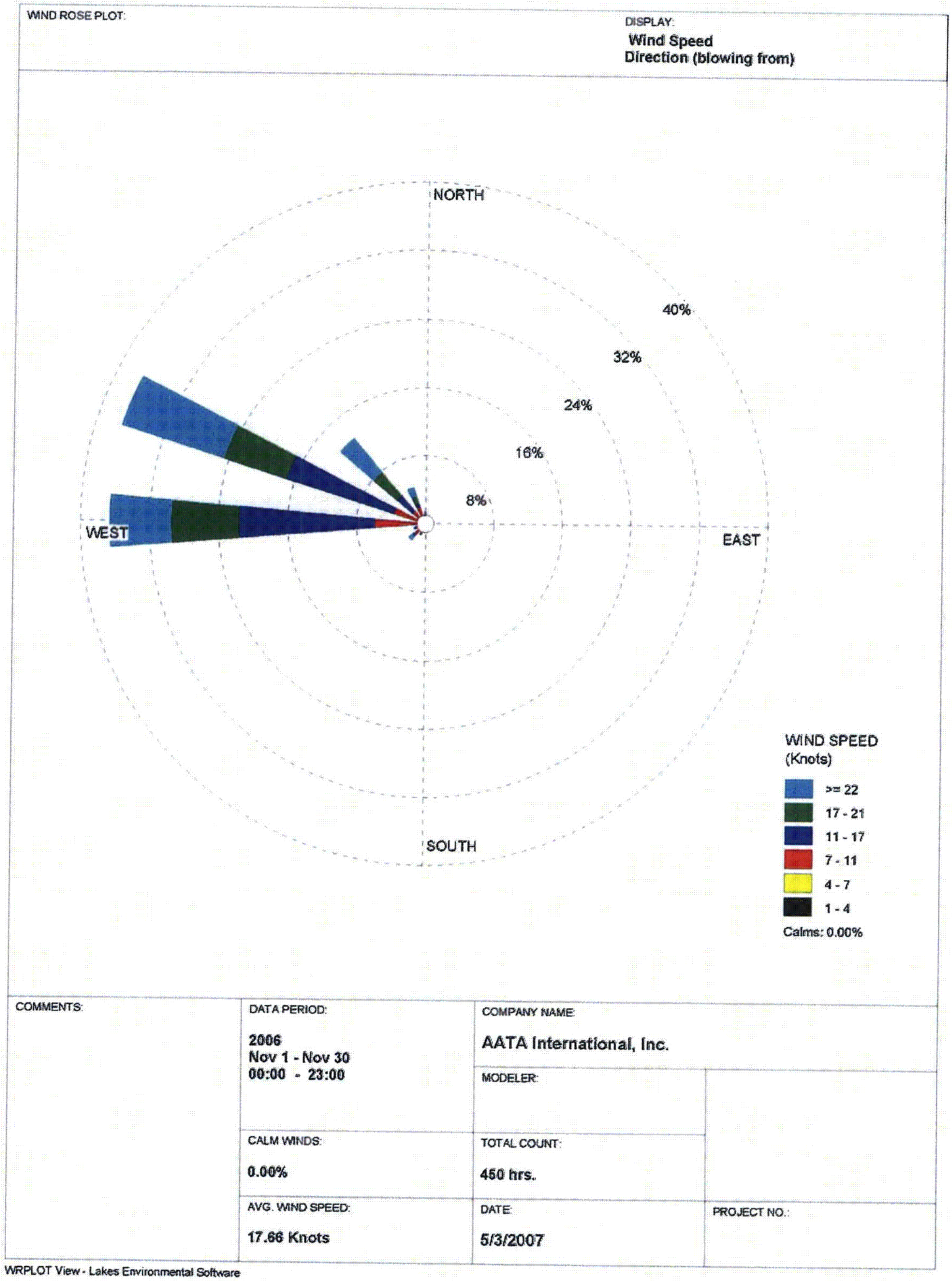
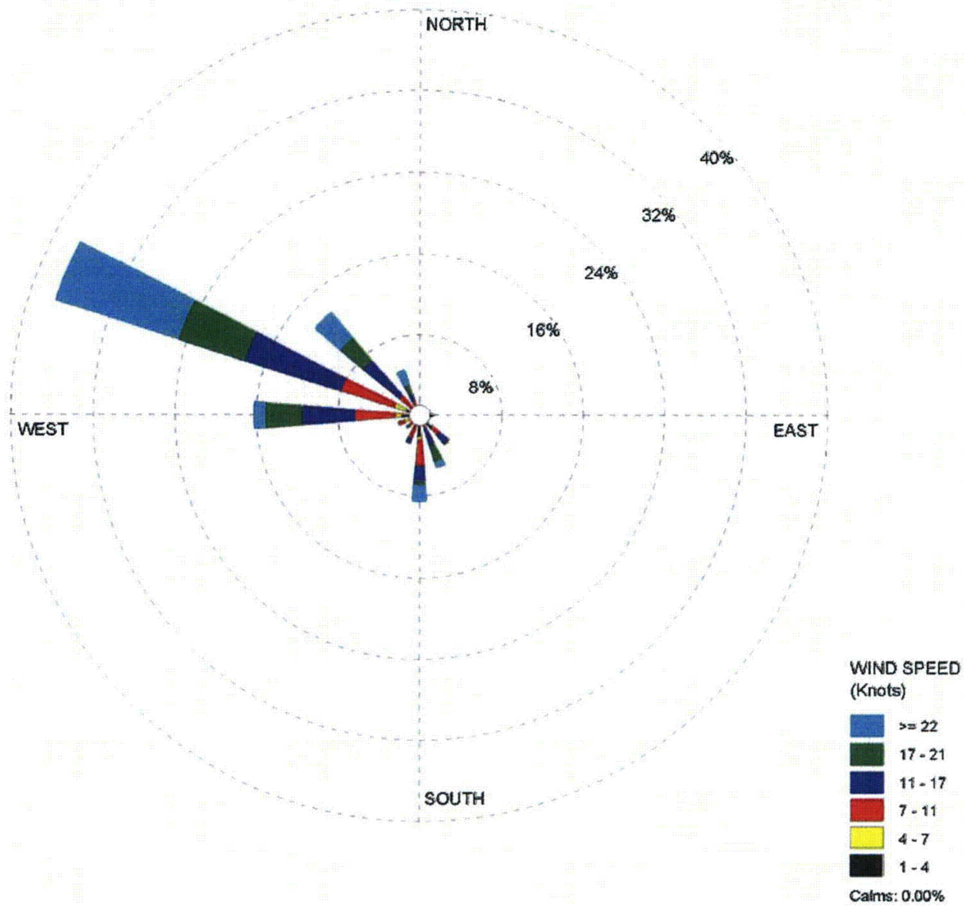


Figure 3.7-3h. Wind Speed and Wind Direction at the LS Met Station – December 2006

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



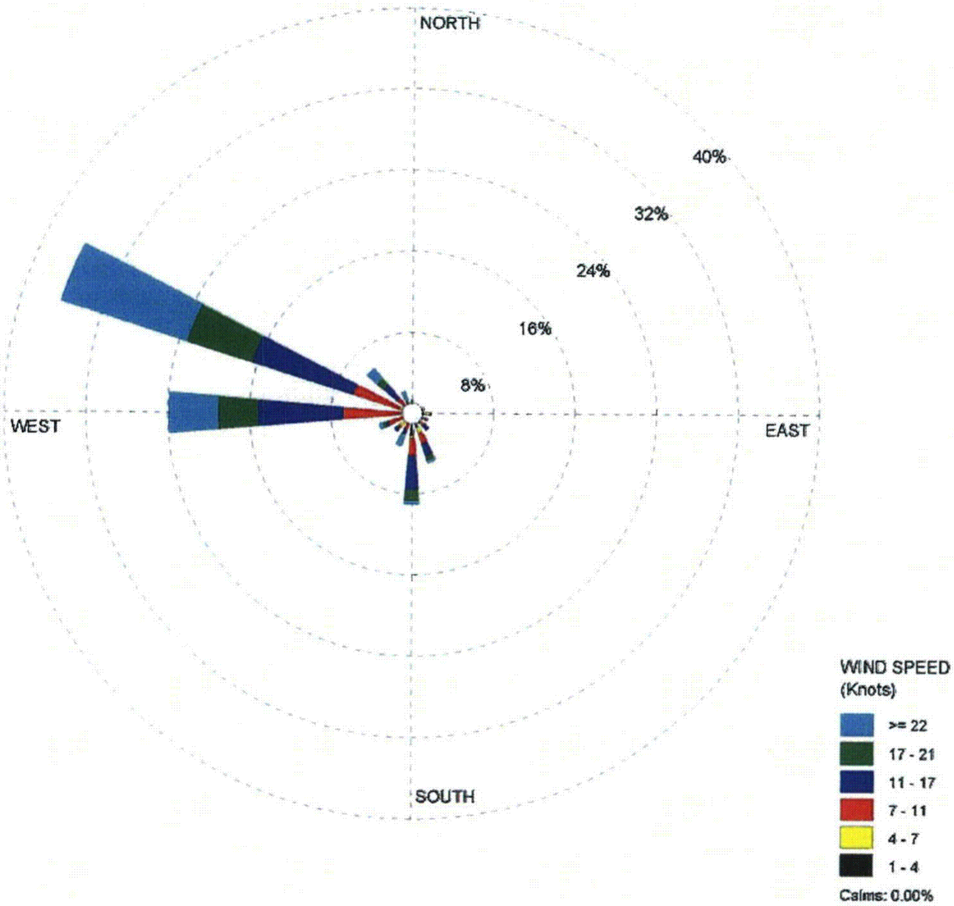
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006 **Dec 1 - Dec 31** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **0.00%**	TOTAL COUNT **587 hrs.**	
	AVG. WIND SPEED: **14.63 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3i. Wind Speed and Wind Direction at the LS Met Station – January 2007

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



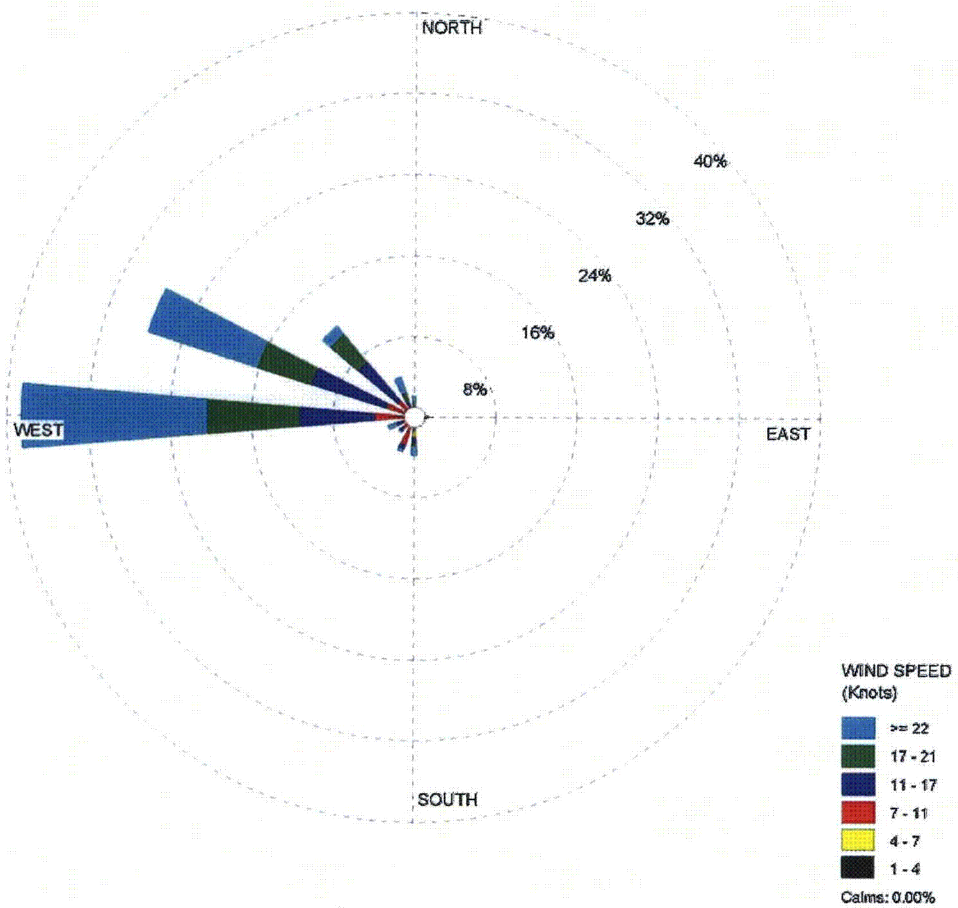
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2007 Jan 1 - Jan 31 00:00 - 23:00	AATA International, Inc.	
		MODELER:	
	CALM WINDS: 0.00%	TOTAL COUNT: 744 hrs.	
	AVG. WIND SPEED: 14.81 Knots	DATE: 5/3/2007	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3j. Wind Speed and Wind Direction at the LS Met Station – February 2007

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



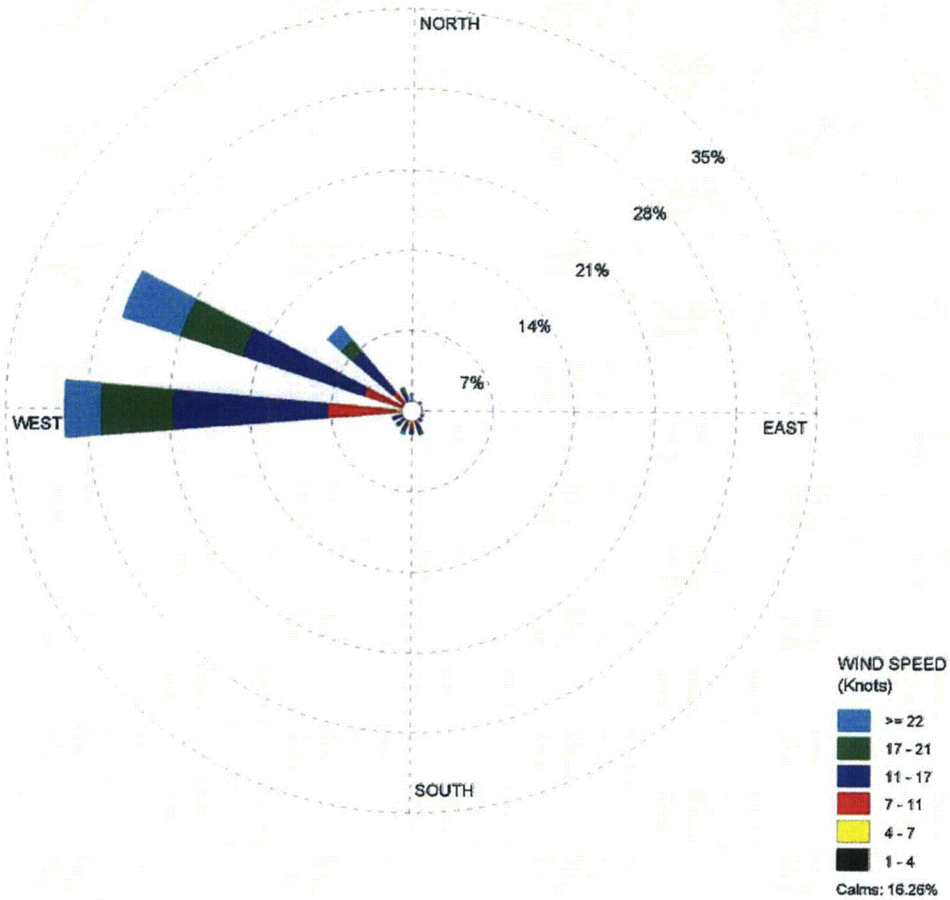
COMMENTS:	DATA PERIOD: 2007 Feb 1 - Feb 28 00:00 - 23:00	COMPANY NAME: AATA International, Inc.	
		MODELER:	
	CALM WINDS: 0.00%	TOTAL COUNT: 671 hrs.	
	AVG. WIND SPEED: 17.70 Knots	DATE: 5/3/2007	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3k. Wind Speed and Wind Direction at the LS Met Station – March 2007

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



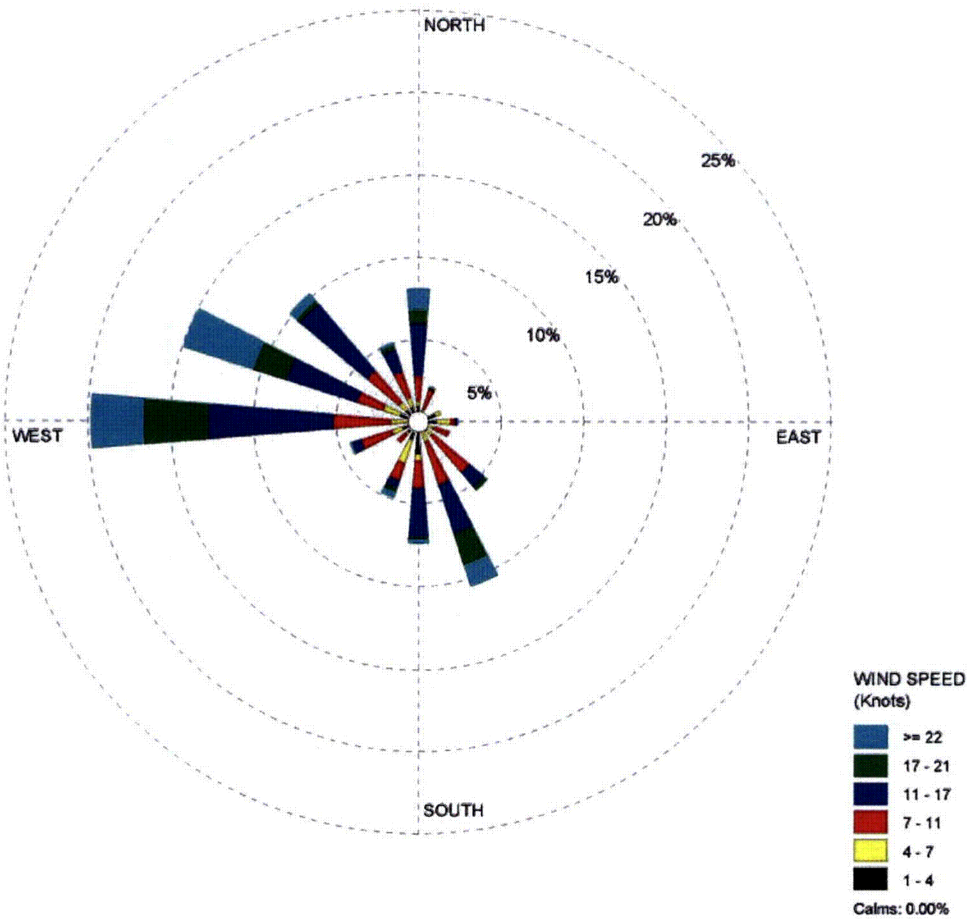
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2007 **Mar 1 - Mar 31** **00:00 - 23:00**	**AATA International, Inc.**	
		MODELER:	
	CALM WINDS: **16.26%**	TOTAL COUNT: **744 hrs.**	
	AVG. WIND SPEED: **12.30 Knots**	DATE: **5/3/2007**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-31. Wind Speed and Wind Direction at the LS Met Station – April 2007

WIND ROSE PLOT:

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
2007
Apr 1 - Apr 30
00:00 - 23:00

COMPANY NAME:
AATA International, Inc.

MODELER:

CALM WINDS:
0.00%

TOTAL COUNT:
719 hrs.

AVG. WIND SPEED:
12.57 Knots

DATE:
9/13/2007

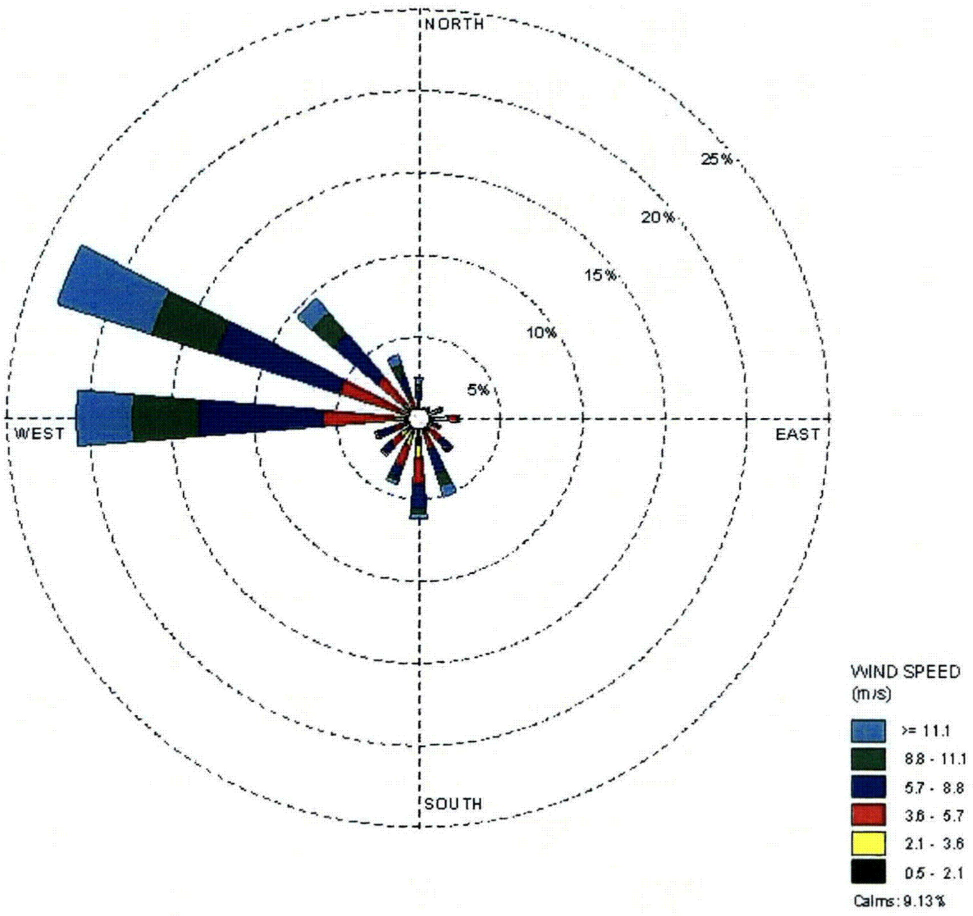
PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-3m. Wind Speed and Wind Direction at the LS Met Station – May 2006 – April 2007

WIND ROSE PLOT:
Windrose Data From the URE Lost Soldier Station

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:
2006-2007
Jan 1 - Dec 31
00:00 - 23:00

COMPANY NAME:
AATA International, Inc.

MODELER:

CALM WINDS:
9.13%

TOTAL COUNT:
8698 hrs.

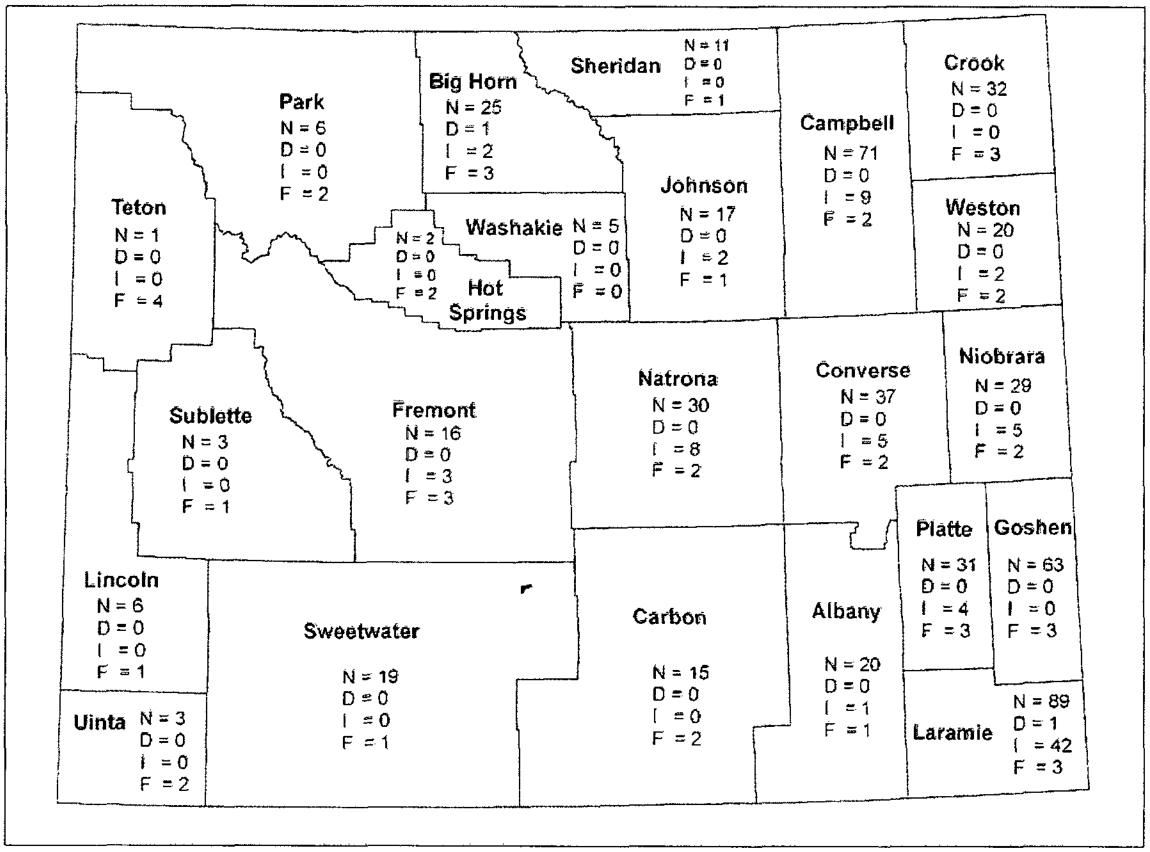
AVG. WIND SPEED:
6.30 m/s

DATE:
6/28/2007

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3.7-4. Tornado Statistics by County (1950–2004)



Source: Storm Prediction Center, 2005
Legend:
N = total number of tornadoes reported
D = deaths
I = injuries
F = Fujita scale index of most destructive storm (0 = gale tornado, 1 = moderate tornado, 2 = significant tornado, 3 = severe tornado, 4 = devastating tornado, 5 = incredible tornado, 6 = inconceivable tornado)

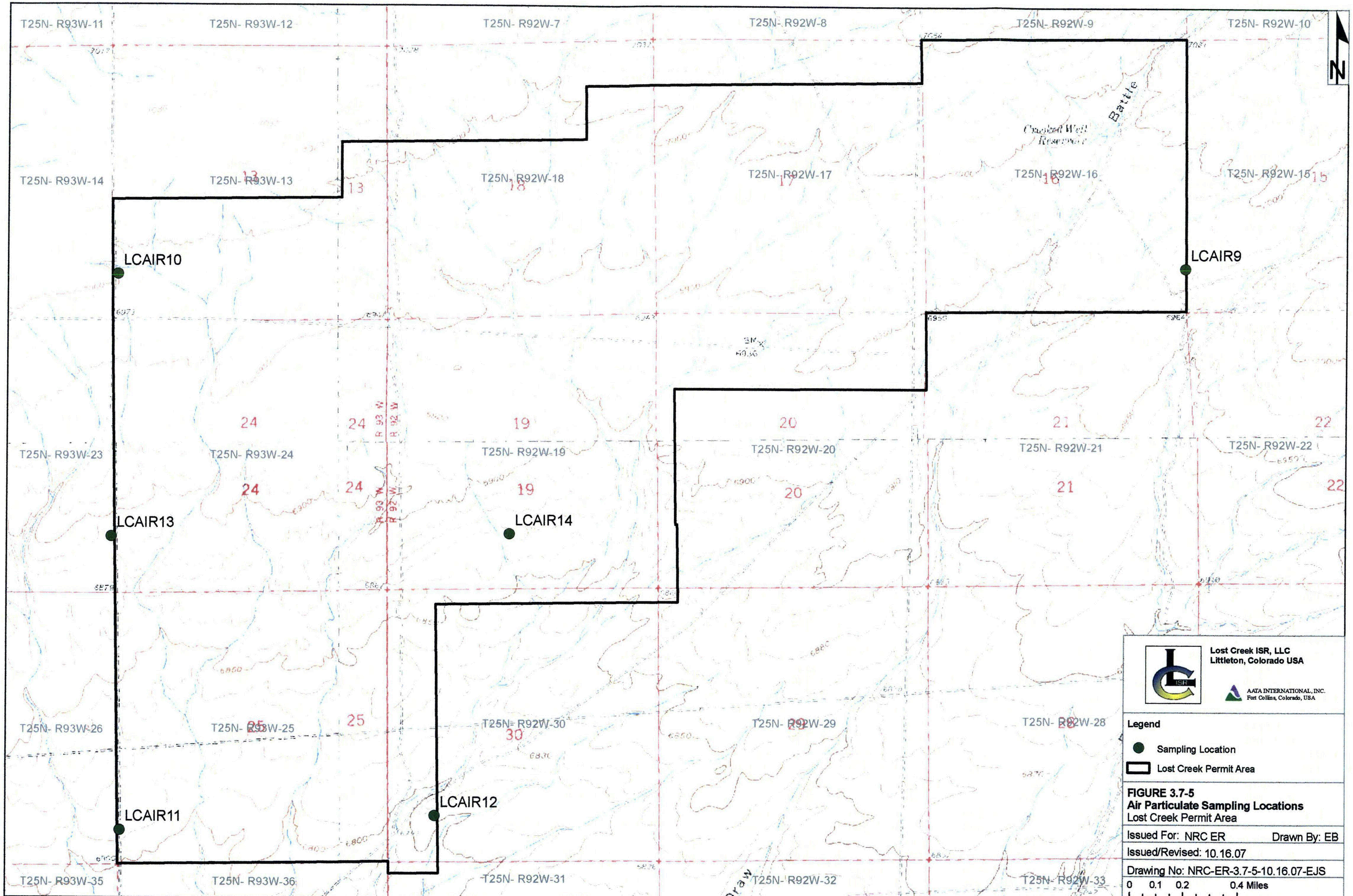


FIGURE 3.7-5
Air Particulate Sampling Locations
Lost Creek Permit Area

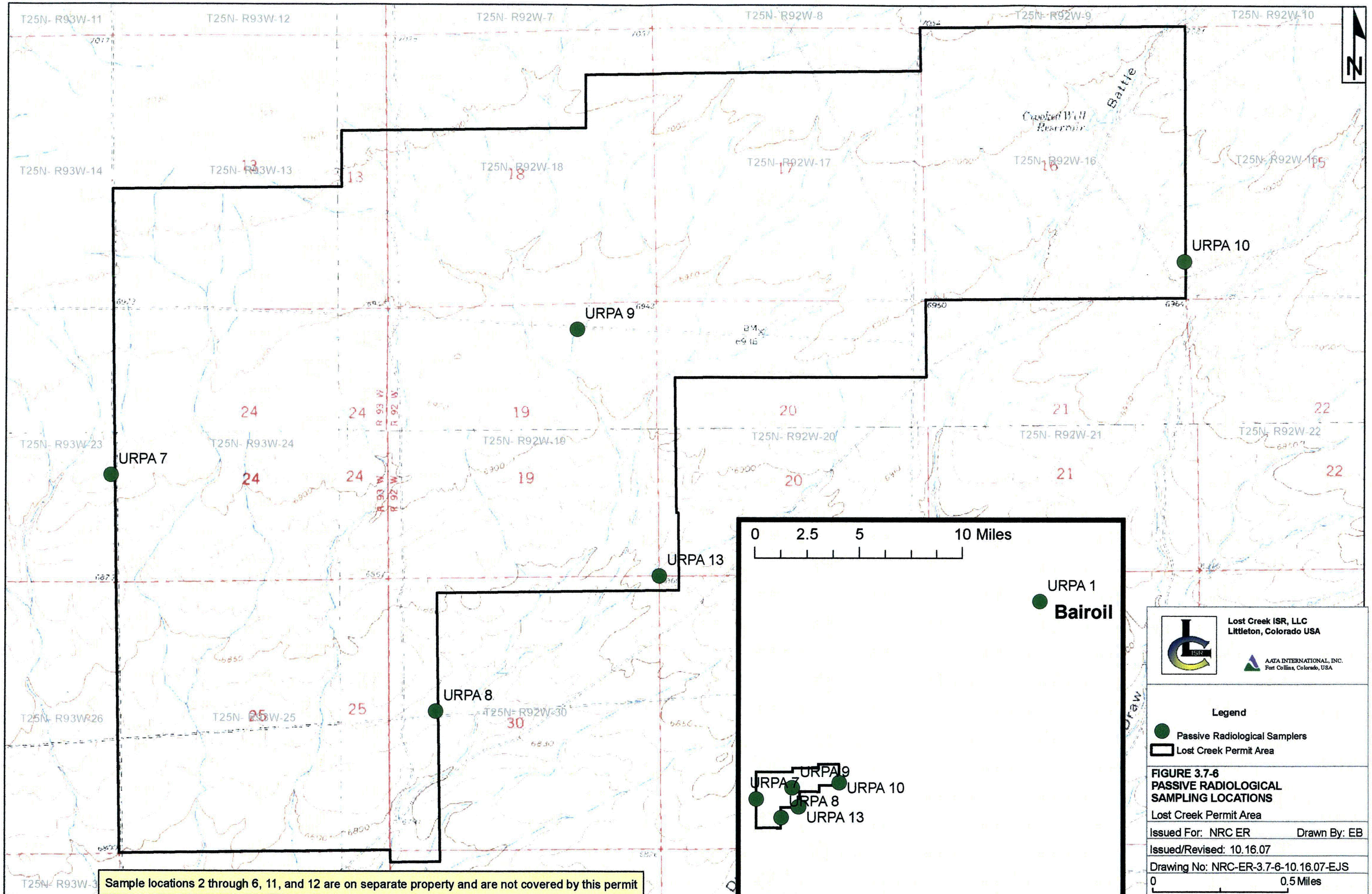


FIGURE 3.7-6 PASSIVE RADIOLOGICAL SAMPLING LOCATIONS

Table 3.7-1 **Comparison of Temperature Data**

Month	Lost Soldier Meteorological Station (2006)			Muddy Gap (1949 through 2005)		
	Average Temperature (° F)	Maximum Temperature (° F)	Minimum Temperature (° F)	Mean Temperature (° F)	Mean Maximum Temperature (° F)	Mean Minimum Temperature (° F)
April [1]	42.1	54.7	30.1	42.6	55.5	29.6
May	51.8	64.0	39.5	52	66	37.9
June	64.2	77.6	50.2	62.5	78	46.9
July	70.0	82.0	57.3	69.6	85.5	53.6
August	65.1	78.4	52.2	68.3	83.9	52.7
September	51.3	61.9	40.7	58.3	73	43.6
October	39.0	49.6	29.8	46.9	60	33.7
November	32.0	40.6	23.3	32.3	41.8	22.8
December	21.9	34.3	49.9	23.8	32.7	14.9
January	12.6	18.7	4.0	22.7	31.4	14
February	23.7	31.6	16.6	26.2	35.5	16.8
March	34.8	45.8	26.4	34.6	45.5	23.7
April [1]	35.1	45.9	23.8	42.6	55.5	29.6
Annual	41.8	52.7	34.1	45	57.4	32.5

[1] partial month

Table 3.7-2 Dew Point Temperature Data (°F)

	Minimum	Maximum	Average
April	19.7	36.4	27.9
May	-7.8	43.2	22.4
June	6.1	49.0	26.8
July	3.7	51.5	35.1
August	9.1	53.2	33.3
September	8.1	47.6	29.6
October	10.9	47.8	29.7
November	-10.2	36.6	25.2
December	11.2	32.6	25.5

Table 3.7-3 Monthly Maximum and Minimum Humidity Measured at the Lost Soldier Meteorological Station

	Maximum Humidity (percent)	Minimum Humidity (percent)
Apr 2006	98.6	9.4
May 2006	97.5	6.8
Jun 2006	87.3	5.8
Jul 2006	98.5	8.1
Aug 2006	94.7	6.3
Sep 2006	98.8	8.9
Oct 2006	98.8	11.7
Nov 2006	98.5	13.3
Dec 2006	97.4	28.9
Jan 2007	97.6	37.7
Feb 2007	99.2	31.0
Mar 2007	98.8	15.9
Apr 2007	98.4	12.6

Table 3.7-4 Monthly Estimated Lake Evaporation at the Pathfinder Dam

1948 to 1991	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	9-month total
PATHFINDER DAM (inches)	---	---	3.2	5.07	6.78	8.78	10.53	9.75	7.17	4.95	2.81	---	59.04

Table 3.7-5 Air Stability Data

Stability Class [1]	Percent [2]
A	0.1
B	5.0
C	8.0
D	77.8
E	3.1
F	6.0

[1] Pasquill Stability Classes
A = very unstable
B = unstable
C = slightly unstable
D = neutral
E = slightly stable
F = stable

[2] Percent Frequency Distribution of Pasquill Stability Classes

Table 3.7-6 Primary and Secondary Limits for National Ambient Air Quality Standards (NAAQS) and the state of Wyoming (EPA, 2007)

Pollutant	National			State of Wyoming		
	Primary Standards	Averaging Times	Secondary Standards	Primary Standards	Averaging Times	Secondary Standards
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [1]	None	9 ppm (10 mg/m^3)	8-hour [1]	None
	35 ppm (40 mg/m^3)	1-hour [1]	None	35 ppm (40 mg/m^3)	1-hour [1]	None
Lead	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary	0.05 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	Revoked [2]	Annual [2] (Arithmetic Mean)		50 $\mu g/m^3$	Annual [2] (Arithmetic Mean)	
	150 $\mu g/m^3$	24-hour [3]		150 $\mu g/m^3$	24-hour [3]	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual [4] (Arithmetic Mean)	Same as Primary	15.0 $\mu g/m^3$	Annual [4] (Arithmetic Mean)	Same as Primary
	35 $\mu g/m^3$	24-hour [5]		65 $\mu g/m^3$	24-hour [5]	
Ozone	0.08 ppm	8-hour [6]	Same as Primary	0.08 ppm	8-hour [6]	Same as Primary
	0.12 ppm	1-hour [7] (Applies only in limited areas)	Same as Primary			
Sulfur Oxides	0.03 ppm	Annual (Arithmetic Mean)	-------	0.02 ppm (60 $\mu g/m^3$)	Annual (Arithmetic Mean)	
	0.14 ppm	24-hour [1]	-------	0.10 ppm (260$\mu g/m^3$)	24-hour [1]	
	-------	3-hour [1]	0.50 ppm (1300$\mu g/m^3$)	0.50 ppm (1300$\mu g/m^3$)	3-hour [1]	

[1] Not to be exceeded more than once per year.

[2] Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM10 standard in 2006 (effective December 17, 2006).

[3] Not to be exceeded more than once per year on average over 3 years.

[4] In this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.

[5] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).

[6] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

[7] a. The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is < 1, as determined by appendix H.

b. As of June 15, 2005 EPA revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonattainment Early Action Compact (EAC) Areas.

Table 3.7-7 Allowable Increments for Prevention of Significant Deterioration of Air Quality

Pollutant	Averaging Time	Prevention of Significant Deterioration Increment					
		Class I			Class II		
		µg/m³	ppm	ppb	µg/m³	ppm	ppb
Nitrogen Dioxide NO_2	Annual	2.5	0.0013	1.3	25	0.013	13
Particulate Matter PM_{10}	24-hour	8			30		
	Annual	4			17		
Sulfur Dioxide SO_2	3-hour	25	0.0096	9.6	512	0.1956	196
	24-hour	5	0.0019	1.9	91	0.0348	35
	Annual	2	0.0008	0.8	20	0.0076	8

Table 3.7-8 **Reported Sources of Emissions near the Permit Area**

Source	Year	CO	NO_x	VOC	SO_2	$PM_{2.5}$	PM_{10}	Total Emission (tons/year)
AMOCO BAIROIL CO_2	1996	24.28	51.53	7.04	28.13	1.48	1.72	112.70
NORTHERN GAS - BUNKER HILL	1996	5.99	26.34	18.14				50.47
COMPRESSION STATION	1999	35.42	15.14	10.43				60.99
SINCLAIR OIL - BAIROIL STATION	1996			87.33				87.33
	1999			102.66				102.66

Table 3.7-9 Reported Total Emissions near the Permit Area (Page 1 of 2) *

Name	Facility ID	Pollutant	Emission (lbs/year)
COLORADO INTERSTATE GAS - MUDDY GAP COMPRESSION STATION	NTIWY2595	Formaldehyde	3,244
SINCLAIR OIL-BAIROIL STATION	NTIWY2593	Ethylbenzene	154
		Hexane	3,143
		Naphthalene	21
		Toluene	281
		Xylenes (Mixed Isomers)	523
		Total	4,122
AMOCO BAIROIL CO_2	NTIWY20140	Acetaldehyde	0.0535
		Arsenic Compounds (Inorganic Including Arsine)	0.0009
		Benzene (Including Benzene From Gasoline)	0.184
		Beryllium Compounds	0.0006
		Cadmium Compounds	0.0006
		Chromium Compounds	0.0006
		Formaldehyde	0.0212
		Lead Compounds	0.0018
		Manganese Compounds	0.0013
		Mercury Compounds	0.0006
		Polycyclic Organic Matter as 7-PAH	0.0854
		Total	0.351
NORTHERN GAS - BUNKER HILL COMPRESSION STATION	NTIWY0071269	Acetaldehyde	11
		Acrolein	10
		Benzene (Including Benzene From Gasoline)	0.0081
		Ethylbenzene	522
		Formaldehyde	285
		Hexane	111
		Methanol	57
		Naphthalene	1
		Polycyclic Organic Matter as 7-PAH	0.0005
		Toluene	1,118
		Xylenes (Mixed Isomers)	8,173
		Total	10288

Table 3.7-9 Reported Total Emissions near the Permit Area (Page 2 of 2)

Name	Facility ID	Pollutant	Emission (lbs/year)
BAIROIL #2 LANDFILL	NTIWYLF1132	1,1,2,2-Tetrachloroethane	3.75
		1,4-Dichlorobenzene	0.621
		Acrylonitrile	6.76
		Benzene (Including Benzene From Gasoline)	17.4
		Carbon Disulfide	0.888
		Carbon Tetrachloride	0.0124
		Carbonyl Sulfide	0.592
		Chlorobenzene	0.566
		Chloroform	0.0721
		Ethyl Chloride (Chloroethane)	1.62
		Ethylbenzene	9.85
		Ethylene Dibromide (Dibromoethane)	0.0038
		Ethylene Dichloride (1,2-Dichloroethane)	0.816
		Ethylidene Dichloride (1,1-Dichloroethane)	4.68
		Hexane	11.4
		Mercury Compounds	0.0012
		Methyl Chloride (Chloromethane)	1.23
		Methyl Chloroform (1,1,1-Trichloroethane)	1.29
		Methyl Ethyl Ketone (2-Butanone)	10.3
		Methyl Isobutyl Ketone (Hexone)	3.77
		Methylene Chloride (Dichloromethane)	24.4
		Propylene Dichloride (1,2-Dichloropropane)	0.409
		Tetrachloroethylene (Perchloroethylene)	12.4
		Toluene	306
		Trichloroethylene	7.45
		Vinyl Chloride	9.23
		Vinylidene Chloride (1,1-Dichloroethylene)	0.39
		Xylenes (Mixed Isomers)	25.8
		Total	462

* Source: EPA, 2007b.

Table 3.7-10 PM_{10} Concentrations at Lost Creek

Location	Date	Wind Speed (mi/hr)	Upwind Sample	Concentration (μg/m³)	Downwind Sample	Concentration (μg/m³)
Northern	6/24/2006	10.1	LCAIR10	9.3	LCAIR9	5.4
Central	6/26/2006	10.3	LCAIR13	10.5	LCAIR14	9.1
Southern	6/25/2006	n/a	LCAIR11	8.0	LCAIR12	8.9
Central	2/7/2007	7.2	LCAIR16	4.7	LCAIR15	3.7

Table 3.7-11 Analytical Results for Passive Radon and Gamma Sampling

Location	Period	Radon pCi/l-days	Gamma millirems	Gamma millirems/ day
URPA1 (Bairoil)	Q1	50.30	11.30	0.12
	Q2	22.50	16.90	0.20
	Q3	90.50	18.60	0.19
URPA7 (West Boundary of LC)	Q1	147.60	33.00	0.34
	Q2	56.30	23.20	0.28
	Q3	153.70	41.70	0.43
URPA8 (Southeast Boundary of LC)	Q1	258.40	13.60	0.14
	Q2	108.10	23.40	0.28
	Q3	203.10	38.20	0.39
URPA9 (North - Central LC)	Q1	370.60	23.70	0.24
	Q2	67.50	18.00	0.21
	Q3	148.80	42.10	0.43
URPA10 (Northeast boundary of LC)	Q1	201.70	24.40	0.25
	Q2	100.70	NA [1]	NA
	Q3	173.20	50.40	0.52
URPA13 (South - Central near boundary of LC)	Q1	#	#	#
	Q2	167.20	25.60	0.30
	Q3	146.80	24.80	0.26

No data available for first quarter due to later sampler installation.
[1] NA = sensor missing; a new undamaged sensor was installed for the next quarter.

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3.8 Noise

Background noise in the Permit Area is representative of a quiet rural area. In the afternoon of June 13, 2007, field measurements of noise in the Permit Area were below the instrument detection limit of 40 decibels. Thirty to 35 decibels is considered the normal range for background noise in a quiet rural area, according to a government study (Federal Interagency Committee on Urban Noise, 1980). There are no sensitive receptors near the Permit Area. The closest residence is in Bairoil, about 15 miles northeast from the Permit Area.

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3.9 Existing Historic and Cultural Resources

Requesting NRC confidentiality. Section submitted separately.

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3.10 Visual/Scenic Resources

Visual resources consist of landforms, vegetation, rock and water features and cultural modifications that create the visual character and sensitivity of landscapes. Important visual resources are areas that have landscape qualities of unusual or intrinsic scenic value and areas of human and cultural use that are valued for their visual settings. Factors considered in evaluating the importance of visual resources include the following (BLM, 1984).

"Visual quality" is defined as the overall visual impression or attractiveness of an area, considering the variety, vividness, coherence, harmony or pattern of landscape features. Visual quality is defined according to three levels: distinctive resources that are unique or exemplary in quality; representative resources that are typical of the physiographic region and commonly encountered; and indistinctive resources that are landscape or cultural areas that either lack visual resource amenities or have been degraded.

"Visual sensitivity" is defined as a measure of an area's potential sensitivity to visual change, considering types of viewers and viewer exposure. Visual sensitivity considers viewer types and numbers, as well as viewing distance zones. Areas and associated viewer types considered to be potentially sensitive to visual changes include: park, recreation and wilderness study areas, major travel routes, and residential areas.

Distance zones also influence the potential impact of scenery changes on receptors. Potentially sensitive view areas are discussed with respect to three distance zones: foreground (within 0.5 mile), middle-ground (0.5 to 2.0 miles) and background (beyond 2.0 miles).

The BLM Visual Resource Inventory process consists of a scenic quality evaluation, a sensitivity level analysis, and a delineation of distance zones. Together, these evaluations are used to group areas into Visual Resource Management (VRM) classes, which provide guidance for management decisions. Areas are classified on a four-level scale, with Class I being the most protective of visual and scenic resources, and Class IV being the least restrictive (BLM, 1984).

The objectives of each class are:

- Class I: to preserve the existing character of the landscape. The class provides for natural ecological changes. The level of change to the characteristic landscape should be very low and must not attract attention.
- Class II: to retain the existing character of the landscape. The level of visual change should be low. Management activities may be seen, but should not attract the attention of the casual observer.

- Class III: to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer.
- Class IV: to provide for management activities that require major modification to the existing character of the landscape. The level of change to the characteristic landscape can be high.

3.10.1 Visual/Scenic Quality

The study area for visual resources includes the Permit Area, access roads, and a two-mile buffer area outside of the Permit Area. Beyond this distance, any changes to the landscape would be in the background distance zone, and either unobtrusive or imperceptible to viewers.

The Permit Area is characterized by low-relief, sagebrush-dominated plains, dissected by small ephemeral drainage networks. The scenery is characteristic of surrounding areas in the Great Divide Basin, though less visually appealing than many other locations. Few intermittent meandering streams, creeks and associated riparian vegetation cross the open steppe, providing localized visual diversity to the otherwise homogeneous landscapes. More rugged mountainous landscapes can be seen in the background. Previous modifications to the natural environment of the Permit Area include fencing, power lines, and four-wheel drive roads. Drilling rigs can currently be seen in the Permit Area; and these impacts are temporary. The site scenery is characterized by **Figures 3.10-1 (a, b, c, d, e, f, g, h)**, which are photographs taken from the center of the Permit Area, facing eight compass directions. The scenic quality field inventory score according to BLM methodology was seven out of a possible 32. The associated scenic quality classification was "C", the lowest possible.

3.10.2 Visual/Scenic Sensitivity

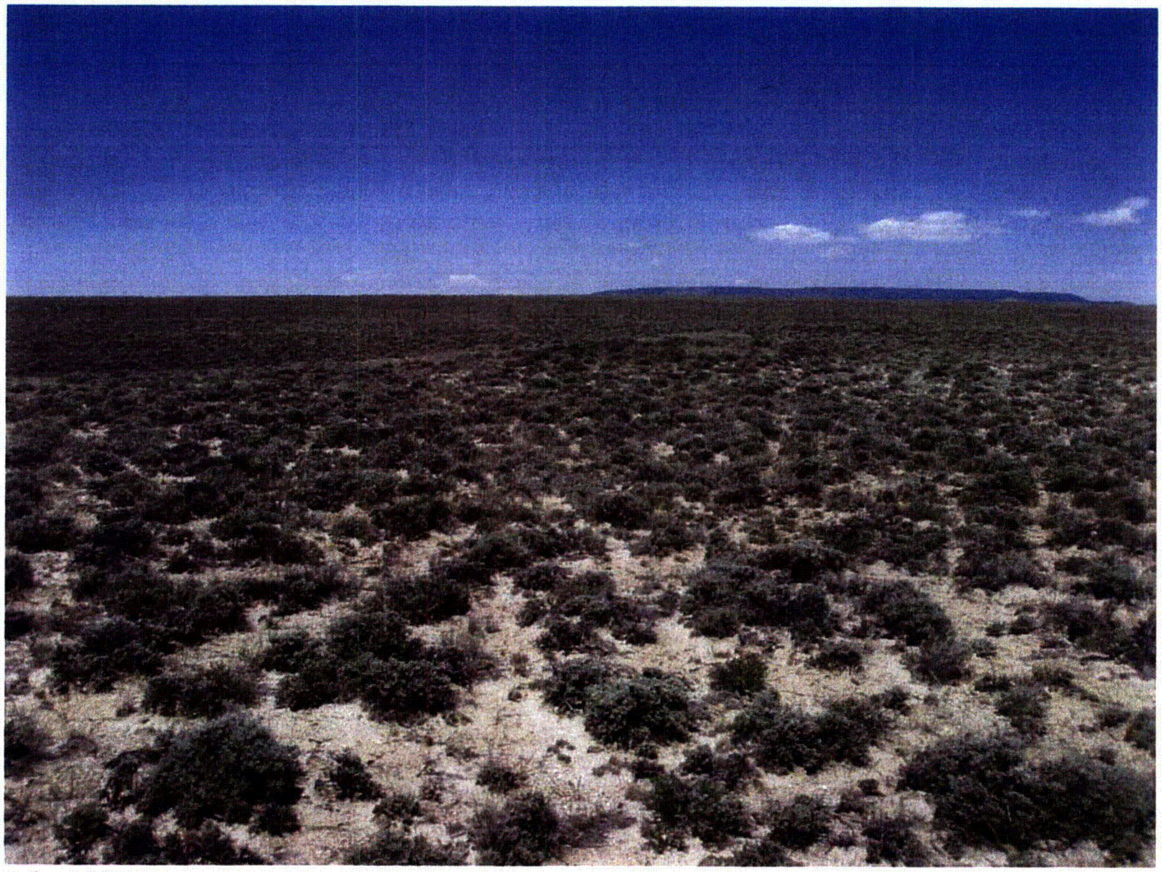
Visually sensitive areas include: parks, recreation and natural areas; major travel routes; and residential areas within two miles of the Permit Area. Potentially sensitive areas located two miles or more from the Permit Area are not considered in this study since beyond this distance the Project changes would be indistinct compared to the existing conditions. The viewer groups and use areas described below are considered to be moderately or highly sensitive to visual impacts when in the foreground or middle-ground distance.

No developed parks or recreation areas are located within the visual resources study area. Travel routes in the visual resources study area include CR 63, CR 23N, and BLM 3215. The Permit Area cannot be seen from any of these transportation corridors from viewpoints within the visual resources study area. There are no residences within the visual resources study area.

The Project is approximately 30 miles from the Ferris Mountain Wilderness Study Area, but no Wilderness Areas or Areas of Critical Environmental Concern are located within the visual resources study area. The Permit Area is within proximity of recreation areas, but these activities, such as hiking, sight-seeing, antler collecting, OHV use, hunting, and wild horse viewing are dispersed.

The Permit Area is not visually pristine or of special visual interest. The sole visually sensitive receptors within the visual resources study area are a small number of dispersed recreationists. The Permit Area has been designated VRM Class III by the BLM (BLM, 2004c; Rau, P. Recreation Specialist, BLM Rawlins Field Office. Personal communication. 2007), and the Project would be compatible with this use.

Figure 3.10-1a View from center of Lost Creek Permit Area facing north



July, 2007

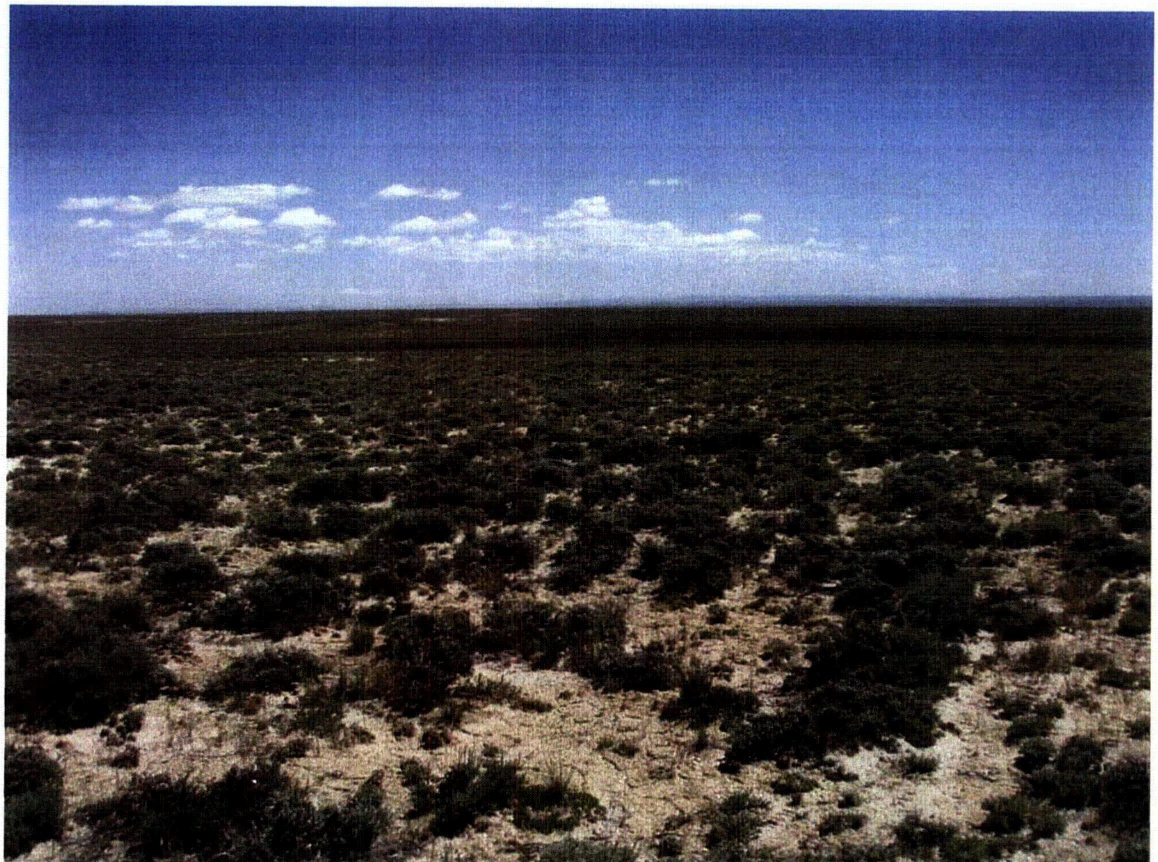
Figure 3.10-1b View from center of Lost Creek Permit Area facing northeast

July, 2007

Figure 3.10-1c View from center of Lost Creek Permit Area facing east

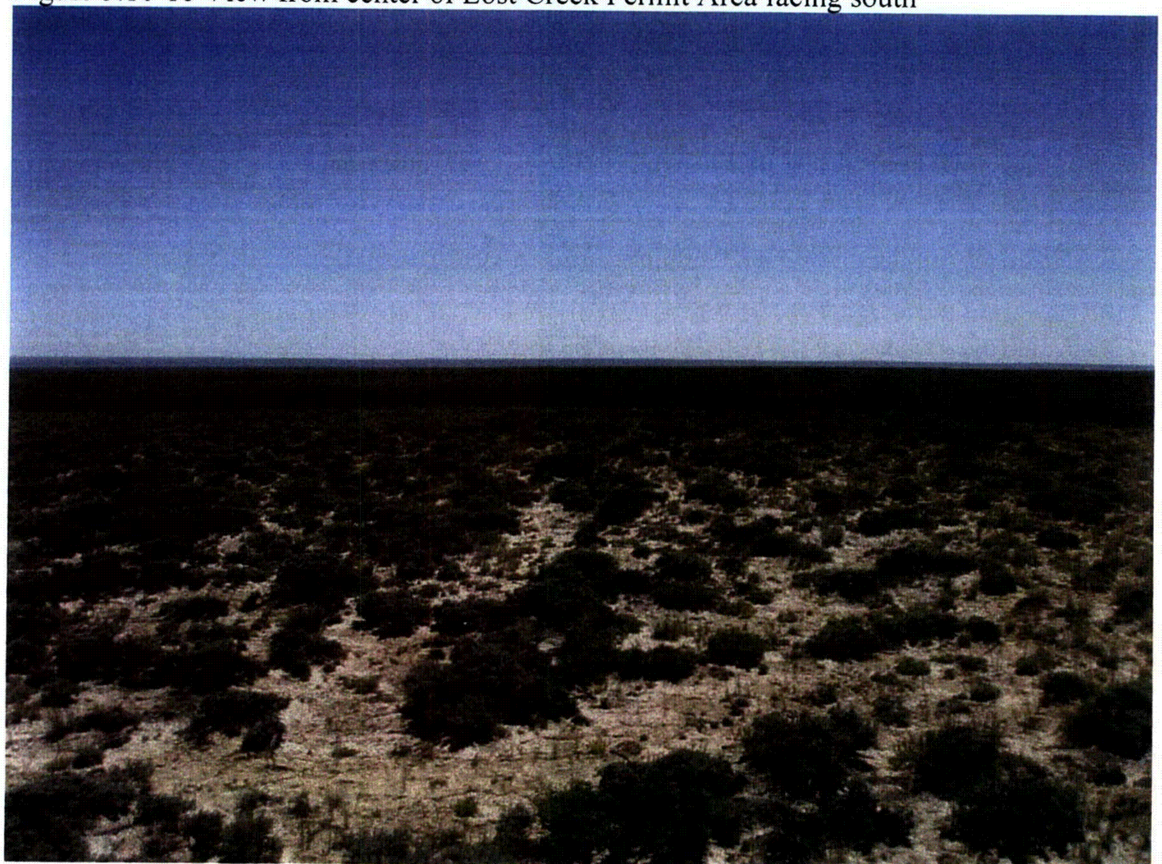
July, 2007

Figure 3.10-1d View from center of Lost Creek Permit Area facing southeast



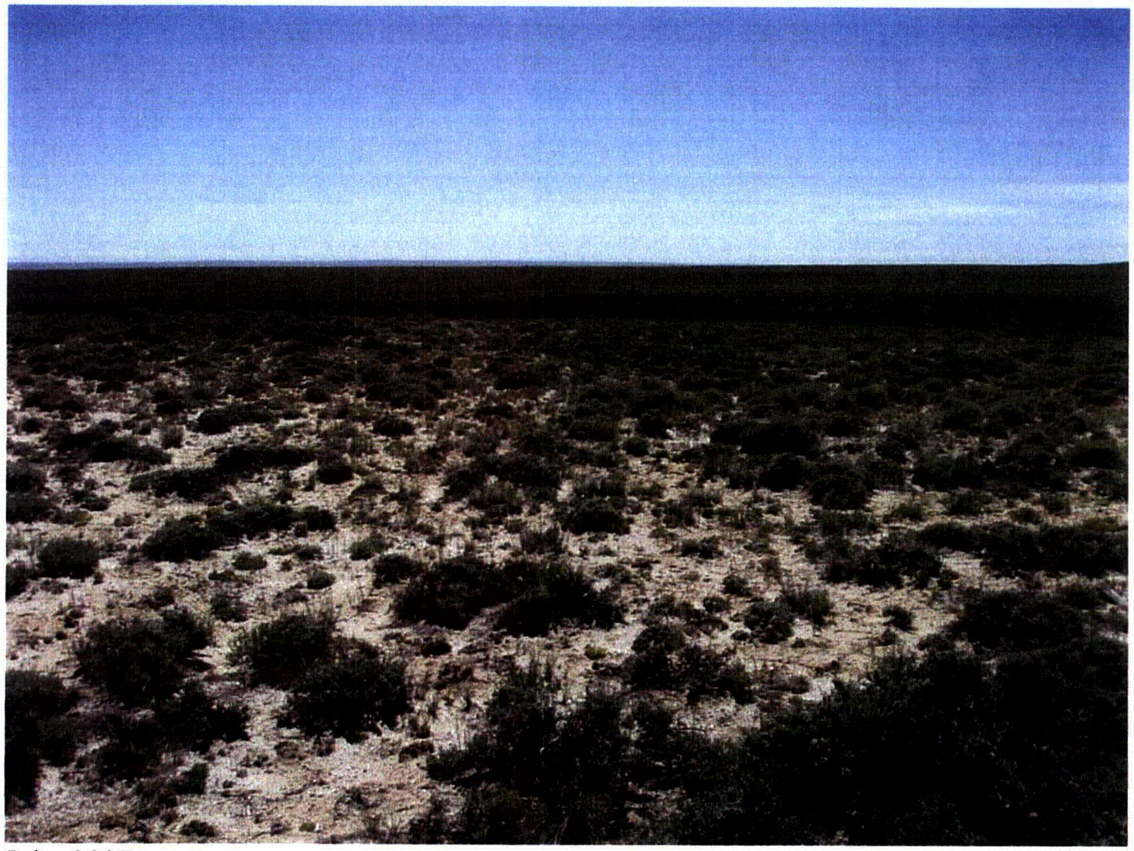
July, 2007

Figure 3.10-1e View from center of Lost Creek Permit Area facing south



July, 2007

Figure 3.10-1f View from center of Lost Creek Permit Area facing southwest

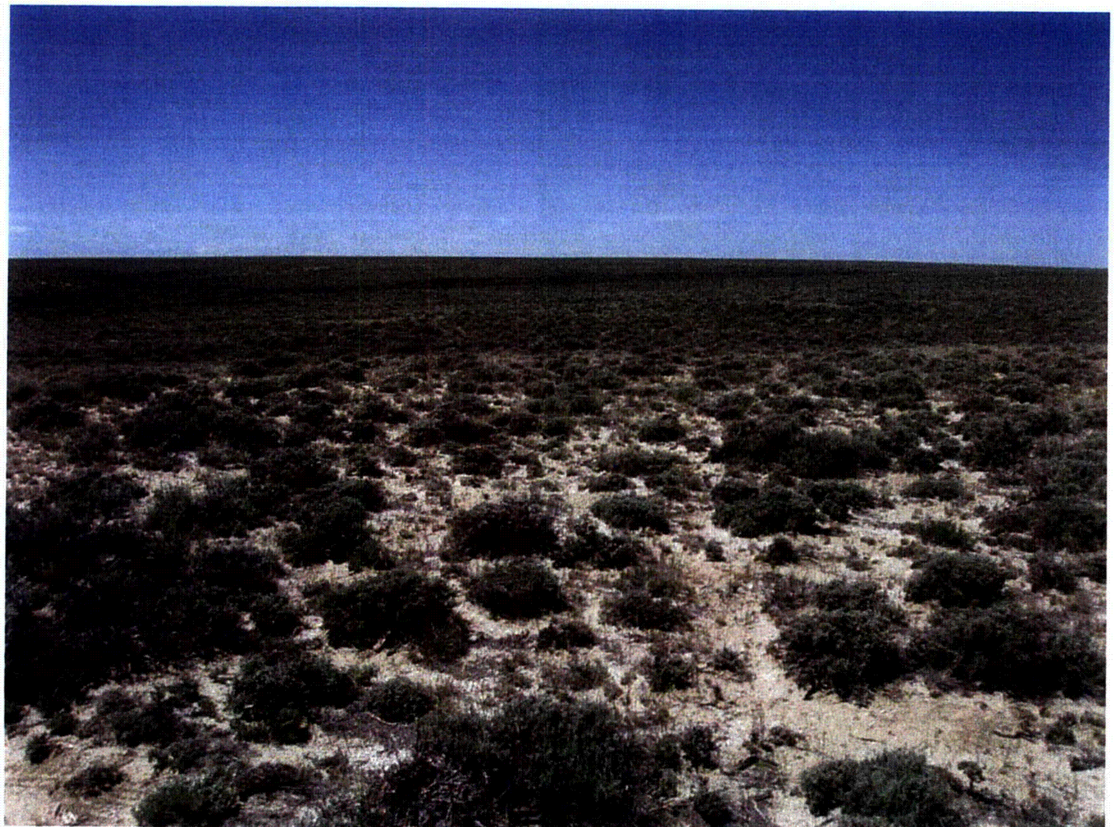


July, 2007

Figure 3.10-1g View from center of Lost Creek Permit Area facing west

July, 2007

Figure 3.10-1h View from center of Lost Creek Permit Area facing northwest



July, 2007

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3.11 Socioeconomic Conditions

This section provides a description of the existing population and economy of the Permit Area and nearby regions within 50 miles (80 kilometers [km]) of the Permit Area, which includes the potentially affected communities of Rawlins, Sinclair, Bairoil, and other outlying towns in Carbon and Sweetwater Counties, Wyoming.

3.11.1 Demographics

Table 3.11-1 presents the demographic information for Sweetwater and Carbon Counties and **Figure 3.11-1** shows the population centers within a 50-mile (80-km) radius from the center of the Permit Area. The information for Jeffrey City is from the 2000 census, and may not reflect the current condition. As seen in the figure, the Project is located in a remote area in the Great Divide Basin, with Bairoil being the closest town to the Permit Area. There are no population centers within two miles of the Permit Area.

Table 3.11-2 shows the population distribution by race for the environmental justice analysis, which is discussed in detail in **Section 4.11**. Minority populations within the study area, will not be disproportionately affected.

3.11.1.1 Sweetwater County

As shown in **Table 3.11-1**, the Sweetwater County population in 2000 was 37,613 people, down (-3.1 percent) from 38,823 in 1990. According to US Census Bureau estimates, the population of Sweetwater County increased slightly (0.4 percent) between 2000 and 2004 (US Census Bureau, 2005a).

According to the 2000 Census, Sweetwater County had a population density of 3.6 people per square mile and 89.1 percent (33,512 people) of the population lived in urban clusters. Of the 4,101 rural residents, only 416 (10.1 percent of rural residents, 1.1 percent of county residents) resided on farms. Bairoil is the community in Sweetwater County nearest to the Permit Area.

In January 2006, the Sweetwater Economic Development Association (SWEDA) estimated the population of several communities, including Bairoil and Wamsutter, using Pacific Power electrical hook-ups (SWEDA, 2006) in order to get a more accurate estimate of the current population. For Bairoil, including incorporated and unincorporated areas, the estimated population was 162 and 643 people, respectively, based on 2.57 persons per household. Conversations with the Bairoil Mayor and Police Chief indicate that the population is currently 97 people. Bairoil is an example of an oil and gas boom-and-bust town. The population of Bairoil was estimated around 240 people in the 1980s and early 1990s. Subsequently, with the rise and fall of oil and gas prices and the sale of oil properties to Merit Energy Company, many people have moved from Bairoil. Amoco Production Company once required all employees who worked in Bairoil to live in the town.

3.11.1.2 Carbon County

As shown in **Table 3.11-1**, the Carbon County population declined by 6.1 percent between 1990 and 2000. the Carbon County population declined by 6.1 percent between 1990 and 2000. The Wyoming census population estimates for 2005 show that Carbon County continues to decline in population. However, recent economic activity related to pipeline and construction projects has caused the transient population to grow. The actual number of residents in Carbon County may be higher than the estimated 2005 population of 15,331 people.

Rawlins and Sinclair are the Carbon County communities that are most likely to be affected by the Project. As summarized in **Table 3.11-1**, growth in Rawlins is on the upswing. The population of Rawlins has increased by 1.4 percent from 2000 to 2005 to a population estimate of 8,658 people. The estimated 2005 population in Sinclair was 406 people. Population forecasts for Sweetwater and Carbon Counties are shown in **Table 3.11-3**.

3.11.2 Economic Trends and Characteristics

The economy in Carbon and Sweetwater Counties has historically depended on industrialized activities, including mining, oil and gas development, power generation, related services, and agricultural activity, including grazing and farmland. Recently, the service and trade sectors have become increasingly important in providing services to the growing population. Many of the service sector jobs are directly and indirectly associated with oil and gas development. Employment growth has fluctuated in some sectors of the economy since 1990 due to the recession from 2001 to 2003. However, recent activity in the past two to three years shows significant increases in oil and gas development and production, which will be reflected in the mining and service sectors.

3.11.2.1 Employment Sectors and Industry Income

In 2003, the mining sector employment (including oil and gas) was not disclosed for Sweetwater County, but represented 1.9 percent of the 9,580-person workforce in Carbon County. Besides retail trade, other important sectors in Sweetwater County included services (21 percent) and government (17 percent). In Carbon County, services represented 28 percent, retail represented 12 percent and government represented 23 percent of the total employment. Many of the employment sectors have shown growth during the 13-year period between 1990 and 2003 for the counties included within the study area. Much of the increase in employment in the mining and service sectors has been filled by workers who have moved into the area either from other parts of Wyoming or from outside of the State of Wyoming. For every direct mining sector job created, additional service jobs are also created. Jobs in the mining and related gas service sectors are competing for workers in the lower paying jobs. Many government, retail, and other service workers are leaving the lower paying jobs to work in the mining sector. All cities and towns are having a hard time finding minimum-wage workers or workers for the lower paying jobs, including police, sheriff, and public works departments (Allen, D. Business Development Specialist, City of Rawlins. Personal communication. March, 2006).

Wyoming's mining and minerals sector contributes more to Gross State Product (GSP) than any other sector of the economy (Coupal et al., 2003). Minerals (including oil and gas) accounted for 23.7 percent of Wyoming's GSP, or over $4.5 billion in 2000, and supported approximately 19,387 full-time wage earners, or 5.9 percent of Wyoming's employment base (US Bureau of Economic Analysis, 2003a). In 2000, government-led industry income provided 23.4 percent of income, followed by services (20.0 percent), retail trade (9.3 percent), construction (8.5 percent), and transportation, communication, and public utilities (8.3 percent). In real terms, based on Year-2000 dollars, for the 20-year period (1980 to 2000), the Wyoming industry income fell in farm, mining, oil and gas, construction, transportation, communication, public utilities, wholesale trade, and retail trade. The most industry-income growth occurred in non-farm agricultural services (156.4 percent; 4.8 percent average annual growth) and government (27.5 percent; 1.2 percent average annual growth) (US Bureau of Economic Analysis, 2003a).

In 2004, figures were not available in the mining, utilities, and wholesale trade sectors for Sweetwater County. The sectors contributing the most to the Sweetwater County economy included government (13 percent), manufacturing (eight percent), construction (seven percent), and retail trade, transportation, and warehousing (five percent). The only sector showing a decline in income generation from 2001 to 2004 was manufacturing.

In 2004, Carbon County's income generated by the government sector led other industries (20 percent of the total). Total mineral extractions provided three percent of the industry income. Transportation and warehousing (six percent) and retail trade (four percent) were also important sectors in income generation. Data from 2004 were not available for construction and manufacturing, which generated substantial income in 2001. Over the three year study period (2001 through 2004), slight losses occurred in total mining and transportation and warehousing.

3.11.2.2 Labor

Both labor force and employment have increased in Sweetwater and Carbon Counties from 1990 to 2004, as seen in **Table 3.11-4**. Labor force statistics reflect employment by residence, unlike employment by sector statistics, which reflect employment by work location. The State of Wyoming labor force increased from 236,043 to 284,538 laborers, a 20.5 percent increase throughout the period (Wyoming Department of Employment, Research, and Planning, 2005).

The labor force in Sweetwater County increased from 20,354 to 22,732 laborers, an 11.7 percent increase from 1990 to 2005. In recent years, the unemployment rate throughout the region may have fluctuated due to seasonal employment. The months with highest unemployment are typically December through March. The average annual unemployment rate in 2005 in Sweetwater County was 3.0 percent, compared to 5.3 percent in 1990 and 4.0 percent in 2000.

From 1990 to 2004, Carbon County showed a decrease in the labor force (8,825 to 7,841 laborers) of 11.2 percent compared to an 11 percent increase in Sweetwater County (**Table 3.11-4**). The most recent unemployment rate in Carbon County was 4.0 percent in 2005, compared to 5.2 percent in 1990 and 4.2 percent in 2000.

3.11.2.3 Personal Income

Income levels throughout the study area are diverse. The most recent estimate of per capita personal income was $28,438 in Carbon County and $34,656 in Sweetwater County in 2004. Median income in 2004 was $40,750 in Carbon County and $54,700 in Sweetwater County. These numbers are fairly consistent with the economic base of the area, which is mineral resource and agriculturally driven. The most recent poverty status statistics are from 2003 census data. These data showed a poverty rate of 11.8 percent in Carbon County and 8.6 percent in Sweetwater County (US Census Bureau, 2003a). Since the economic base of the study area is largely rural-agriculture and resource-extraction based, low income areas are dispersed within the study area.

3.11.3 Other Resources

3.11.3.1 Housing

The existing housing situation is difficult to characterize quantitatively with any degree of certainty since the status of the housing market and availability is changing constantly. The effect on housing demand from the oil and gas industry has had a significant impact on the availability and price of both owner-occupied and rental units. The housing situation is a major issue for the two-county region. Lack of affordable housing has contributed to social problems in the area and has created a transitory workforce that has little invested in the local communities. Because some of the LC ISR, LLC employees may reside in Casper, discussion of housing in Natrona County is included.

According to the Wyoming Housing Database Partnership (WHDP), there were seven out of 298 total rental units available for rent in Carbon County in July 2006, 24 out of 1,290 rental units available for rent in Sweetwater County, and 49 out of 3,118 rental units available for rent in Natrona County (WHDP, 2006). The vacancy rates were 2.4 percent in Carbon County, 1.9 percent in Sweetwater County, and 1.6 percent in Natrona County. The average rents are shown in **Table 3.11-5** for Carbon, Sweetwater, and Natrona Counties for 2005 and 2006 (WHDP, 2006). The average single-family sale price in 2005 was lowest in Carbon County ($96,200) and highest in Sweetwater County ($179,000). The average sales price in Natrona County was $156,281 (WHDP, 2006). Some vacant units can be attributable to second-home growth in the State of Wyoming.

Sweetwater County

According to a November 4, 2005 Casper Star Tribune article, housing in Sweetwater County is inadequate for the current demand for two reasons: 1) housing in the Sweetwater County is not readily available; and 2) housing currently on the market is expensive (Gearino, 2005). To help meet the demand for new housing, the SWEDA has made housing development a priority for the county; it is anticipated that 500 new housing units will be constructed in Sweetwater County by next year (Gearino, 2005).

Temporary housing resources in Wamsutter include three mobile home parks. One has 26 spaces, the second has 70 spaces, and the third has 52 spaces. Most of these parks have units that are equipped to serve RVs. There has recently been a limited amount of subdivision activity and housing construction in Wamsutter. A local developer/mobile home park owner is in the process of applying for a permit to develop additional RV spaces (BLM, 2006).

Carbon County

According to the community Development Director for Rawlins, the housing market has become exceedingly tight in the past year. Sales prices have escalated by 25 percent in 2006 with sales prices ranging from $200,000 to $390,000. Very few homes are in the $100,000 to $130,000 range. Rawlins is proactively involved in bringing affordable owner-occupied and rental housing to Rawlins. Rawlins is currently working on a project with a developer to build 150 to 300 affordable units on a 50-acre parcel of infill land. Other development projects are also being discussed for long-term residential, commercial, and industrial development just outside of Rawlins (Allen, D. Business Development Specialist, City of Rawlins. Personal communication. March, 2007).

Temporary lodging is also being built. Two new motels have been built in the past year and two are slated for development in 2007. One-hundred-forty rooms have been added to the total of approximately 700 existing rooms (19 motels and four RV parks). Motels are at capacity, but with the two planned motels, temporary demand should be met. In addition to the estimated 900 motel rooms, approximately 450 campsites are available for RVs in the local area.

For longer-term housing, there are 18 mobile home parks with over 550 pads (Allen, D. Business Development Specialist, City of Rawlins. Personal communication. March, 2007), about half of which were vacant during the fall of 2005. The 2000 census listed 285 units in two- to four-unit housing structures in Rawlins and 467 units in structures with over five units (US Census Bureau, 2000b); there are rarely vacancies in these housing types. Although Rawlins has some vacant single-family houses, most of the affordable units are substandard and would require some rehabilitation to make them attractive to buyers (BLM, 2006).

3.11.3.2 Public Facilities and Services

Bairoil and Wamsutter are the two nearest towns in Sweetwater County to the Permit Area. Sweetwater County provides the typical county government services, including county assessor, county attorney, county commissioners, treasurer, road and bridge, engineering, planning, landfill, emergency management, health and human services, sheriff, search and rescue, parks and recreation, museum, libraries, and community arts center. Bairoil and Wamsutter provide similar municipal services, including administration, public works, police, fire, and parks and recreation services. The landfill is located in Wamsutter.

In Carbon County, the communities of Rawlins, Sinclair, and other outlying areas would potentially be affected by the Project. Carbon County provides the typical county government services, including county assessor, county attorney, county commissioners, treasurer, road and bridge, planning, emergency management, public health, and sheriff.

Law Enforcement and Fire Protection

The Carbon County Sheriff has an office and 74 jail beds in Rawlins, a substation in Medicine Bow, a deputy in Baggs, and a part-time deputy in Saratoga. The sheriff's office has 17 patrol officers, 23 detention deputies, seven full-time and three part-time dispatchers, and 11 other employees. The sheriff covers a service area of 8,000 square miles. The sheriff's department is adequately staffed and will possibly add a patrol officer this year to handle the slight increase in calls caused by the increases in oil and gas activity in the area (Colson, J. Sheriff, Carbon County Sheriff's Office. Personal communication. March, 2007; Morris, M. Deputy Sheriff, Carbon County Sheriff's Office. Personal communication. March, 2007). Rawlins has a police department with one chief, two detectives, 12 patrol officers, and 19 additional staff employees. All law enforcement offices have 911 emergency telephone services. Fire protection is provided by Rawlins Fire Department, which has eight paid staff and 15 volunteers in the area. The fire department has two fire stations, a training center, five engines, a wildland engine, and a rescue truck.

Law enforcement near the Project Area is primarily provided by the Bairoil Police Department, which consists of a police chief, one sergeant, and one part-time police officer. The department provides law enforcement for Bairoil and the surrounding unincorporated area of the Sweetwater County Sheriff's Department. This area is 165 square miles and extends 20 miles west and 15 miles south of Bairoil. Fire protection is provided by the Bairoil Volunteer Fire Department, with a station in Bairoil.

Law enforcement in Wamsutter area is currently provided by the Sweetwater County Sheriff's Department; a deputy patrols the town daily. Two Wyoming Highway Patrol officers also live in Wamsutter. Wamsutter has positions for two part-time police officers, but the positions are currently vacant; and the town has not been able to hire officers for the positions (BLM, 2006). Emergency response services are provided by 15 volunteer emergency medical technicians (EMTs) operating one ambulance and ten volunteer firefighters operating two fire trucks.

The volunteer fire and ambulance services provide coverage to surrounding oil and gas operations, and both services may have difficulty responding to more than one emergency at the same time. BP America recently provided a $68,000 grant toward the purchase of a new ambulance; other energy and pipeline companies have also contributed funds. Wamsutter has an ongoing effort to recruit new volunteers for both the fire and ambulance service.

Health Services

Medical services within Carbon County are provided by the Memorial Hospital in Rawlins, a 35-bed acute care facility served by a 24-hour ambulance service. The hospital has five physicians and 105 full-time equivalent employees. Rawlins also has a Public Health Department, Senior Citizens Center, the South Central Wyoming Health Care and Rehabilitation, Senior Citizens apartment complex, and various private health care providers. No medical care is available in either Bairoil or Wamsutter. Sweetwater County is served primarily by the Memorial Hospital of Sweetwater County in Rock Springs, which has 99 beds. The study area is served by Memorial Hospital in Rawlins.

Education

Sweetwater School District Number One serves Wamsutter. Wamsutter has one elementary school and one middle school with an enrollment of 42 students in the elementary school and 15 students in the middle school (Desert Elementary School, 2007). Carbon County School District Number One provides educational services to the Rawlins and Bairoil area. The total enrollment in the district is currently estimated at 1,727 students (2006). This enrollment has fluctuated over the years with a previous high enrollment of 2,420 students in 1991 and 2,076 students in 1997. There are currently three elementary schools in Rawlins, a middle school, and a high school. Bairoil and Sinclair have elementary schools (Wyoming Department of Education, 2006). Bairoil has one elementary school with five students. Rawlins has the Carbon County Higher Education Center, which provides continued and extended education courses on-line. Some school capacities are being met, and additional school capacity may be required if economic activity in the area brings in more families.

Utilities

Rawlins provides water, sewer, landfill, and recycling services for its residents and businesses. Rocky Mountain Power provides electric service to all areas, and KN Energy provides natural gas to the community. The infrastructure in Rawlins has a capacity for increased population, as well as commercial and industrial growth. Bairoil provides water service for residents and businesses. The landfill is located in Wamsutter, but has a transfer station in Bairoil.

Qwest is the local provider of telephone services. Long-distance carriers include ATT, MCI, Sprint, and others. Digital switching and fiber-optic systems are available. Local internet access is provided by Qwest and Bresnan.

Other

Other services in Carbon County include a public library, senior services, daycares, and recreation facilities, and services including a recreation center in Rawlins, golf courses, parks, ball fields, bike trails, and an airport. Other community services in Wamsutter consist of a town attorney and engineer, library, recreation center, and city park. Wamsutter is developing a new library and has identified a variety of street and infrastructure improvements (BLM, 2006). Although the transient drilling and field development population in Wamsutter can be substantial from time to time, their demands on local government facilities and services have generally been minor (Wyoming Business Council et al., 2002).

Transportation infrastructure is discussed in **Section 3.2** of this report.

3.11.3.3 Taxes and Revenues

Financial resources of the study area refer to government revenue sources from local and state taxes on the production of natural resources in Carbon and Sweetwater Counties. These statistics are useful in helping to determine the financial impacts of industrial development on the counties potentially affected. Both counties will directly benefit from the increased tax base provided by the Project. Both counties also could be financially impacted by secondary growth from residential development, increased retail sales, and increased demands on public services and facilities.

The minerals industry accounts for a substantial share of revenues to the state and to local governments in Wyoming. Produced minerals are classified as personal property, and mineral producers pay two types of taxes: 1) the county property (ad valorem-gross products) tax on production and 2) the state severance tax. Producers pay county property (ad valorem) taxes on plants, refineries, mining and well head equipment, pipelines, and other facilities used in the mineral production and transportation operations. A severance tax is an excise tax imposed on the present and continued privilege of removing, extracting, severing, or producing any mineral in Wyoming. Severance taxes are distributed according to Wyoming Statute (WS) 39-14-801. The Permanent Wyoming Mineral Trust Fund (PWMTF) is a fund that holds 25 percent of all severance taxes currently received by the State of Wyoming, functioning like a savings account. The fund balance was $4.5 billion in December 2006 (Wyoming State Treasurer's Office, 2006).

Local and state government fiscal conditions that would be affected by development of the Project include: ad valorem property tax revenues of Sweetwater and Carbon Counties, Sweetwater County School District Number One, and certain special districts;

sales and use tax revenues of the state, county, and municipalities; state severance taxes; and state gross products tax.

Both Sweetwater and Carbon Counties show an increase in valuation from natural resources development (Coupal et al., 2003). It is believed that mineral revenues will continue to rise and that gas production, particularly, will drive future revenues higher for the foreseeable future. Wyoming Department of Revenue reports indicate that in 2002, natural gas production contributed the greatest proportion of taxable value to the state (34.8 percent), followed by residential land and improvements (18.5 percent), mining production (15.9 percent), and oil production (9.7 percent). In 2004, natural gas production continued to contribute the greatest proportion of taxable value to the state (38.5 percent), again followed by residential land and improvements (17.8 percent), mining production (15.4 percent), and oil production (9.1 percent).

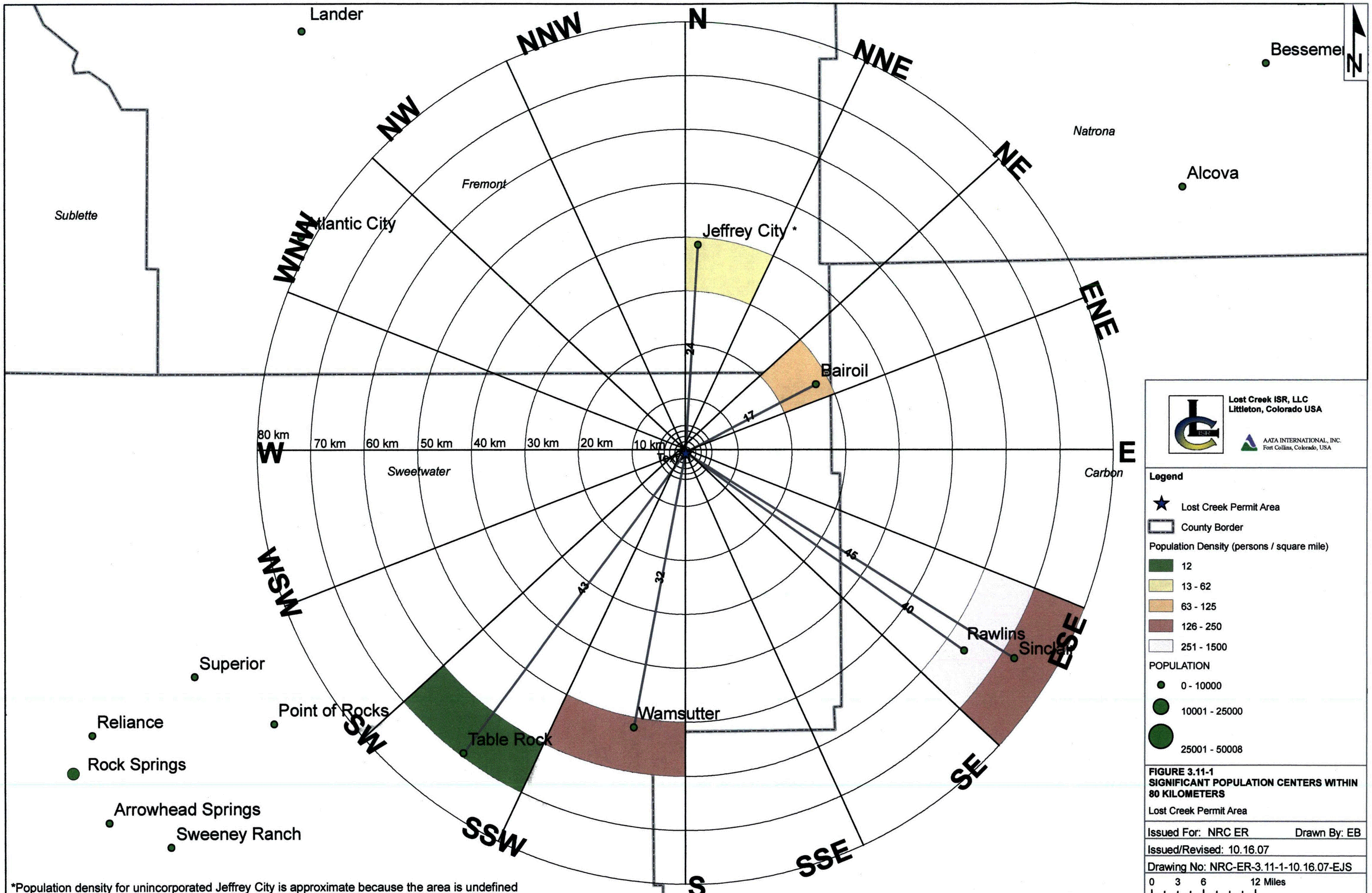

FIGURE 3.11-1
SIGNIFICANT POPULATION CENTERS WITHIN 80 KILOMETERS

*Population density for unincorporated Jeffrey City is approximate because the area is undefined

Table 3.11-1 Demographic Information

Location	Population [1]			Change in Population (Percent)		Projected Population		
	1990 [2,3]	2000 [3]	2005 [1,4,5]	1990 to 2000	2000 to 2005	2010 [6,7,8]	2015 [6,7,8]	2020 [6,7,8]
US (thousands)	248,709	281,421	296,410	13.2	4.3	308,935	322,365	335,804
Wyoming	453,588	493,782	509,294	8.9	2.6	519,595	529,352	533,534
Sweetwater County	38,823	37,613	37,975	- 3.1	0.4	41,620	42,810	43,990
Bairoil	228	97	96	- 57.5	0	106	109	112
Wamsutter	NA	261	265	NA	1.5	291	300	308
Carbon County	16,659	15,639	15,331	- 6.1	- 2.0	15,730	15,590	15,440
Rawlins	9,380	8,538	8,658	- 9.0	1.4	8,912	8,833	8,748
Sinclair	500	423	406	- 15.4	- 4.0	421	417	413
Other								
Casper	46,765	49,644	51,738	6.2	4.2	53,903	56,107	58,369

[1] NA = Not available
[2] (Wyoming Department of Administration and Information (WDAI), 2000)
[3] (WDAI, 2001)
[4] (Census Bureau (US), 2005a)
[5] (Census Bureau (US), 2005b)
[6] (Census Bureau (US), 2005c)
[7] (WDAI, 2004)
[8] (WDAI, 2006)

Table 3.11-2 Population Distribution *

	Minority Group	Carbon County	Sweetwater County
Income	Persons Below Poverty Level (2005)	1,808	3,266
	Percent Below Poverty (2003)	11.8 percent	8.6 percent
Race [1]	White (2004)	96.3 percent	95.7 percent
	Black (2004)	1.0 percent	1.0 percent
	American Indian (2004)	1.2 percent	1.1 percent
	Asian (2004)	0.9 percent	0.9 percent
	Native Hawaiian or Pacific Islander (2004)	0.0 percent	0.1 percent
	Other Race (2004)	0.5 percent	1.3 percent
Other	Hispanic Origin (of any race) (2004)	13.0 percent	10.2 percent

* (Census Bureau (US), 2000a)
[1] Does not equal 100 percent due to rounding errors

Table 3.11-3 Population Forecasts for the Study Area *

	2007	2010	2015	2020	Percent change 2007 to 2020
Sweetwater County	39,540	41,620	42,810	43,990	0.82
Bairoil	101	106	109	112	0.79
Wamsutter	277	291	300	308	0.82
Carbon County	15,450	15,730	15,590	15,440	- .005
Rawlins	8,754	8,912	8,833	8,748	- .005
Sinclair	413	421	417	413	0

* (Wyoming Department of Administration and Information, 2006)

Table 3.11-4 Labor Force Statistics *

Location/Year	Labor Force	Employment	Unemployment	Unemployment Rate (percent)
Carbon County				
1990	8,825	8,366	459	5.2
2000	8,094	7,757	337	4.2
2005	7,841	7,530	311	4.0
Sweetwater County				
1990	20,354	19,281	1,073	5.3
2000	20,714	19,890	824	4.0
2005	22,732	22,044	688	3.0

* (Wyoming Department of Employment, Research and Planning, 2006)

Table 3.11-5 **Average Rental Rates ***

County	Apartments [1]			Mobile Home Lot [2]			House [3]			Mobile Home [4]		
	2005	2006	Percent Change	2005	2006	Percent Change	2005	2006	Percent Change	2005	2006	Percent Change
Carbon	$507	$619	22.2	$128	$138	7.8	$546	$625	14.5	$396	$564	42.3
Sweetwater	$512	$684	33.6	$214	$238	11.2	$673	$816	21.1	$594	$669	12.7
Natrona	$441	$508	15.2	$189	$203	12.5	$719	$767	6.7	$527	$581	10.2
Statewide Average	$504	$549	8.9	$203	$210	3.5	$693	$748	8.0	$505	$547	8.4

* (Wyoming Housing Database Partnership, 2006)

[1] Two-bedroom, unfurnished, excluding gas and electric.

[2] Single-wide, including water.

[3] Two or three-bedroom, single family, excluding gas and electric.

[4] This price reflects total monthly rental expense, including lot rent.

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3.12 Background Radiological Characteristics

A baseline radiological survey was performed within the Permit Area to establish and document the pre-operation radiological environment. The primary goals were to: detect surface areas having anomalously high radiological activity; establish preliminary surface background radiological levels in water resources; and provide source data for MILDOS radiation dispersion and dose calculation modeling.

To detect areas of anomalously high radiological activity, sodium iodide (NaI) detectors linked to data loggers and a GPS were used to take hundreds of thousands of gamma measurements throughout the Permit Area. These measurements were correlated with radiation levels in soil samples, and with gamma levels measured by High-Pressure Ionization Chambers (HPICs). Radiological analysis was completed on quarterly groundwater and stormwater samples; and the results are presented in **Section 3.5** of this report. Passive air samplers were used to measure natural gamma and Rn-222 at multiple locations within and outside of the Permit Area; and these results are presented in **Section 3.7.2** of this report.

The Project will not directly produce particulate emissions because the end-product is yellowcake slurry. Therefore, there will be no radiological impact on vegetation; and baseline characterization of vegetation radiological characteristics was not conducted. Because there is no perennial surface water in the Permit Area, sediment sampling was not conducted.

3.12.1 Background Gamma Radiation Survey and Soils Sampling

Baseline environmental studies in the Permit Area began in January 2006. As part of the overall baseline study, a radiological baseline survey of naturally occurring gamma exposure rates and soil radionuclide concentrations was performed. Radiological baseline surveys in the Permit Area began in late August 2006.

Basic guidance for radiological baseline surveys at uranium recovery sites can be found in Regulatory Guide 4.14 (NRC, 1980a). This regulatory guide, intended for conventional uranium mill recovery facilities, includes a pre-operational radial gamma survey design that covers a maximum area of 1,750 acres with up to 80 individual gamma exposure rate measurements. The recommended sampling design calls for a higher density of measurements near the mill location, and more dispersed measurements in a radial pattern at greater distances from the mill location.

Although Regulatory Guide 4.14 does not address special considerations associated with uranium ISR sites, NRC and WDEQ LQD (WDEQ-LQD, 2007) currently recommend following Regulatory Guide 4.14 for conducting radiological baseline surveys of ISR uranium projects. Consistent with ISR permit application guidelines described in Regulatory Guide 3.46 (NRC, 1982) and NUREG-1569 (NRC, 2003), as well as with decommissioning considerations outlined in MARSSIM, the Multi-Agency Radiation Survey and Site Investigation Manual (NRC, 2000), Tetra Tech proposed using state-of-the-art GPS-based scanning technologies capable of providing uniform, high-density gamma measurements across very large areas. This scanning system can be mounted in various configurations including in backpacks, OHVs, or trucks, and has been used in the US and abroad for remedial support at multiple uranium mill site decommissioning projects as well as for other site characterization applications.

During a site visit at the beginning of gamma survey activities (August 30, 2006), discussions between Tetra Tech; LC ISR, LLC; AATA International, Inc.; and NRC resulted in a general consensus that using an OHV-mounted version of this scanning system for baseline radiological surveys would meet or exceed minimum guidelines outlined in Regulatory Guide 4.14 and would provide more detailed information on baseline radiological conditions in the Permit Area.

3.12.1.1 Methods

The background radiation survey of the Permit Area consisted of a number of methods including high density gamma scanning with Sodium Iodide (NaI) detectors, measurements with a HPIC, and soil sampling as described below.

Gamma Surveys and Mapping

Although various GPS-based scanning system configurations used previously by Tetra Tech were well developed and extensively field tested prior to the Project, unique aspects and challenges of scanning the Permit Area presented the need for different vehicles and mounting systems. Given the rugged terrain, sagebrush vegetation and the large Permit Area, two-seater OHVs with roll-bar cages and conventional driver control systems with steering wheel, and gas and brake pedals were best suited for the Project. The OHV models selected were Yamaha Rhinos. Equipped with extra-wide tires, these Rhino OHVs were well suited to safely negotiate the Permit Area while minimizing environmental impacts.

Roll-bar cages on the Rhino OHVs addressed safety considerations and provided a support system for adjustable outriggers. Three Ludlum 44-10 NaI gamma detectors and paired GPS receivers were mounted on the outriggers of each OHV (**Figure 3.12-1**). The detectors were coupled to Ludlum 2350 rate meters housed in a cooler carried in the OHV cargo bed. Simultaneous GPS and gamma exposure rate data were recorded using an onboard personal computer (PC) with data acquisition software developed by Tetra Tech.

After several days of field testing, site scanning, and mounting system modifications, a final system design was achieved that proved stable, reliable, and practical for the terrain. The final system configuration was about ten-foot spacing between detectors (measured perpendicular to the direction of travel), with each detector positioned 4.5 feet above the ground surface. A three-foot detector height is generally accepted, but not mandated, by NRC. This height was impractical in the Permit Area given the tall brush, ravines, and fence gate crossings. A detector height of 4.5 feet was the lowest practical height for the system under the conditions. Experimental measurements were later performed to statistically quantify any measurement difference between the three-foot and 4.5-foot detector heights.

Based on previous experiments conducted under similar scanning geometries, lateral detector response to significantly elevated planar (non-point) gamma sources at the ground surface is about five feet, giving each detector an estimated "field of view" of about ten feet in diameter at the ground surface. This does not imply that a system detector can pick up readings from a small point source five feet away, but does suggest that scattered photons from larger elevated source areas (e.g., 1,076 square feet or 100 square meters [m^2]) are likely to be detected at that distance. Within this conceptual framework, the scanning track width for each vehicle's scanning system is estimated to be about 30 feet across, perpendicular to the direction of travel. The vehicle speed while scanning ranged between two and eight mph, depending on the roughness of the terrain, with an average speed of four to five mph.

Data were downloaded daily into a Project database and mapped using Gamma Viewer software (Tetra Tech Inc., 2006). In addition to daily quality control (QC) measurements used to evaluate instrument performance and insure data quality (discussed later), daily scan results were evaluated in terms of general agreement between onboard detectors to help identify any problems that may have occurred during data acquisition throughout the day. Evaluation of updated gamma maps each day also helped in planning the next day's scanning activities.

Initial results indicated that spatial variability in gamma exposure rates across the Permit Area was higher than expected. In areas near orebodies or proposed operational facilities, attempts were made to achieve scanning coverage close to 100 percent. After assessment of initial scanning results for these areas, a distance of 15 to 30 feet between the adjacent detectors in both vehicles was deemed practical and sufficient to resolve smaller-scale variability in the areas targeted for higher-density scanning coverage. This vehicle spacing provided an estimated effective ground scan coverage of 75 to 90 percent. In other portions of the Permit Area, five to ten percent was the initial target coverage, though practical considerations such as safety, terrain, and natural obstructions often dictated actual distances maintained between vehicles. For most areas of the Permit Area, a target distance of 300 feet between vehicles was a conservative goal employed during scanning, as this provides an estimated scan coverage of about 15 percent.

Cross-calibration between NaI Detectors and the HPIC

Gamma exposure rates measured by NaI detectors are only relative measurements, as response characteristics of NaI detectors are energy dependent. True gamma exposure rates are best measured with an energy independent system such as an HPIC. Depending on the radiological characteristics of a given site, NaI detectors can have measurement values significantly higher than corresponding HPIC measurement values. NaI systems are useful for ISR sites; because they can quickly and effectively demonstrate relative differences between pre- and post-ISR gamma exposure rate conditions. Unless the exact same equipment is used for both surveys; however, it is necessary to normalize the data to a common basis of comparison. This is the purpose of performing NaI/HPIC cross-calibration measurements. Cross-calibration insures that the results of future gamma scans, which are likely to use different detectors (and perhaps different detector models or technologies), can be meaningfully compared against the results of the pre-ISR baseline gamma surveys.

To perform NaI/HPIC cross-calibrations, static measurements were taken at various discrete locations covering a range of exposure rates representative of the Permit Area. Many locations were selectively chosen to be at or near earlier soil sampling grids for verification purposes. At each cross-calibration measurement location, ten to 20 individual HPIC readings were recorded and averaged. The center of the HPIC is positioned about three feet above the ground surface. A pin flag was pushed into the ground directly below the center of the HPIC to mark the exact spot for subsequent NaI measurements. The OHVs were then systematically positioned, such that each NaI detector was located directly above the pin flag, when taking measurements. For each NaI detector, 20 individual NaI readings at both three-foot and 4.5-foot detector heights were automatically collected and averaged using a special data acquisition software program.. Mean values were recorded.

Soil Sampling and Gamma Correlation Grids

Regulatory Guide 4.14 specifies that baseline soil sampling be conducted in a radial pattern originating at the center of the milling area, with samples collected at 984-foot (300-meter) intervals in eight compass directions. At the time of this portion of baseline survey activities, the exact location and types of ISR processing facilities to be employed were uncertain. This, coupled with the expected high density of gamma survey information, resulted in a decision to initially focus on developing a correlation between soil Ra-226 concentrations and gamma exposure rates. Depending on the statistical strength of any such relationship, the resulting correlation can be used to infer approximate Ra-226 concentrations across the Permit Area based on the gamma survey results.

Other radiological soil sample analyses were also conducted per Regulatory Guide 4.14 recommendations. Those recommendations indicate that, in addition to Ra-226 analysis for all soil samples, ten percent of samples should be analyzed for natural uranium (U-nat), thorium-230 (Th-230), and lead-210 (Pb-210). In this case, all ten correlation grid samples were analyzed for these additional radionuclides, providing a reasonably representative characterization across the Permit Area.

Soil sampling was conducted as composite sampling over 33-by-33 foot (ten-by-ten meter) grids. Within each grid, ten soil sub-samples were collected to a depth of six inches (15 centimeters) then composited into a single sample. GPS coordinates were taken at the center of each sampling grid and recorded. Samples were sent to Energy Laboratories Incorporated (ELI) in Casper, Wyoming for analysis of Ra-226 and other select radionuclide concentrations, as stated above. Samples were dried, crushed, and thoroughly homogenized prior to analysis to insure a representative average radionuclide concentration over each 1,076 square foot (100 m^2) grid. For high-purity germanium (HPGe) gamma spectroscopy analyses (method E901.1), samples were first canned, sealed, and held 21 days prior to counting to allow sufficient ingrowth of radon and short-lived progeny. Separate aliquots of homogenized samples were used for analyses requiring wet radiochemistry methods.

Each 1,076 square foot (100 m^2) soil sampling grid was also scanned to determine the average gamma exposure rate over the same area, following methods described in Johnson et al. (2006). A diagram depicting the sampling design for correlation grid measurements is shown in **Figure 3.12-2**.

This Project does not include a yellowcake dryer in the Permit Area. As such, the correlation soil samples and related estimates of Ra-226 concentrations across the Permit Area (discussed later), along with the other recommended radiological parameters at representative correlation grid locations, provides sufficient information on baseline soil radionuclide concentrations for the proposed operations which are described in **Section 1.2** of this report.

3.12.1.2 Data Quality Assurance and Quality Control

Sources of gamma measurement uncertainty include instrument variability, spatial variability in gamma exposure rates (differences in readings due to small differences in the measurement location or geometry), and temporal variability in gamma exposure rates (differences over time due to changes in soil moisture, barometric pressure, etc. that can affect ambient radon levels and/or photon attenuation characteristics of the soil profile).

Data quality assurance (QA) and QC issues for the radiological surveys in the Permit Area are addressed in various ways. In general, QA includes qualitative factors that provide confidence in the results, while QC includes quantitative evidence that supports the accuracy and precision of results.

Data QA factors for this project include the following.

- The investigators have extensive qualifications and over 100 years worth of combined experience for performing radiological measurements and site assessments (curriculum vitaes [CVs] provided in **Attachment 3.12-1**).
- Scanning system methodologies and technology are published in peer-reviewed radiation protection and measurement research publications (Johnson et al., 2006; Meyer et al. 2005a; Meyer et al. 2005b; Whicker et al., 2006).
- All NaI and HPIC gamma detectors were calibrated by the manufacturer within one year prior to use on the Project (calibration certificates are provided in **Attachment 3.12-1**).
- Chain-of-custody protocols were followed for soil sampling and contract laboratory analyses (relevant forms are provided in **Attachment 3.12-1**).
- Soil samples were analyzed by ELI. ELI is certified by EPA as well as by seven different states, including Wyoming. The laboratory follows chain-of-custody protocols, uses certified standards of the National Institute of Standards and Technology (NIST) for instrument calibrations, and performs measurements on EPA or other certified reference material standards with each set of client samples to provide information on measurement accuracy.

A detailed field log book of daily activities was maintained and is provided in **Attachment 3.12-2**.

Quantification of data QC for the Project included the following:

- Daily QC measurements were performed for each NaI detector used in gamma scanning; and results were plotted on system instrument control charts. Background as well as cesium-137 (Cs-137) check-source QC measurements were taken each day. Detectors performed within acceptable limits throughout the Project (instrument control charts are provided in **Attachment 3.12-2**).

- Daily scan results for each vehicle were reviewed for consistency along track paths for all onboard detectors. Obvious inconsistencies prompted further investigation. On the few occasions where this occurred, technical problems were discovered and the affected data were removed from the Project database. Affected scanning systems were not used again until technical problems were resolved.
- NaI detectors were cross-calibrated in the field at each site against an HPIC. Results were consistent with cross-calibrations at other uranium sites as well as with the literature in terms of the energy dependence of NaI detectors (Ludlum, 2006; Schiager, 1972).
- One or more days at the Permit Area were used for re-scans of areas previously scanned. As part of this effort, certain higher activity locations of particular interest were targeted for static or mobile re-scanning measurements. Re-scanning demonstrated that measurements were reproducible, generally showing good agreement with the original scans.
- ELI performs duplicate analyses on ten percent of all samples to provide information on measurement variability. The results of all duplicate sample analyses, blanks, laboratory control samples, and sample matrix spikes were within acceptable QC limits, as reported in the ELI QA/QC Summary Report (provided in **Attachment 3.12-2**).

3.12.1.3 Results

Baseline Gamma Survey

The gamma survey results in the Permit Area are shown in **Figure 3.12-3**. There is an unexpected degree of variability in gamma exposure rates at the Permit Area. Even within regions of five-to-ten-percent scanning coverage, localized trends or "pockets" of higher gamma activity are evident across the Permit Area. The area of higher-density scanning covers an approximate region of primary subsurface ore deposits and is a probable area of future operational facilities. The smaller bordered area to the south of that region was an additional Permit Area added after initial survey activities had commenced.

Some areas with slightly elevated background radiation occurred near Permit Area boundaries. Commonly, there was no visible evidence of certain landscape features in these areas that might help explain such findings (e.g., exposed bedrock outcrops or unusual soil layers). Subsequent correlation sampling, re-scanning, and HPIC cross-calibration activities were selectively conducted along some of these boundary areas.

Those investigations generally confirmed the original readings (**Figures 3.12-4** and **3.12-5**). The evidence indicates that some portions of Permit Area boundaries fall on areas where natural terrestrial radioactivity is slightly elevated at the soil surface.

Baseline Soil Sampling

Soil sampling was conducted in a roughly radial pattern with the origin located near a potential general area of operational facilities. Sample locations were generally selected to try and cover the range of gamma values found across the Permit Area rather than to employ a rigidly fixed spatial pattern. Overlays of soil sampling locations and baseline gamma survey results are shown in **Figure 3.12-6**. The soil sampling results represent the mean Ra-226 concentrations of the 1,076 square foot (100-m^2) sampling grids; and concentric circles have been added to illustrate the approximate radial pattern of the sampling locations.

A general relationship between gamma exposure rates and Ra-226 concentrations at the soil surface is visually apparent in **Figure 3.12-6**. Statistical analysis demonstrated a significant linear relationship (**Figure 3.12-7**) between the mean Ra-226 soil concentration and the mean gamma exposure rate across all of the sampling grids (**Table 3.12-1**). In general, uranium and Ra-226 in these soils do not appear to be in equilibrium (**Figure 3.12-8**). On average, the uranium concentration was less than 45 percent of the Ra-226 concentration, suggesting a considerable degree of uranium mobility in the surface soil environments in the Permit Area.

HPIC / NaI Cross-Calibration

The results of the cross-calibration between the HPIC and NaI detectors positioned at both three-foot and 4.5-foot detector heights are shown in **Figure 3.12-9**. Regression coefficients for both curves are similar to those measured by Tetra Tech at other uranium recovery sites and to other reported values (Ludlum, 2006; Schiager, 1972). Initial OHV scanning at the Permit Area was conducted with the detectors set three feet above the ground surface until problems with the detector clearance necessitated a change to 4.5 feet. All areas scanned at three-foot detector heights are shown in **Figure 3.12-10**.

Numerical differences between the three-foot and 4.5-foot NaI detector height readings are shown in **Table 3.12-2**. The relationship between the two detector heights is shown in **Figure 3.12-11**. For measured gamma values less than 25 microRoentgens per hour (μR/hr), there was no evidence that readings from the two detector heights were different. For areas with measured values greater than 25 μR/hr, the difference is proportional to the magnitude of exposure rate being measured.

Three-Foot HPIC Equivalent Gamma Exposure Rate Mapping

All final gamma survey data presented have been normalized to a three-foot HPIC equivalent to create a uniform final gamma baseline survey dataset of the Permit Area. The appropriate regressions from **Figure 3.12-9** were used for the data conversions.

A final map of official results, showing Permit Area boundaries and the three-foot HPIC equivalent gamma exposure rate data, is presented in **Figure 3.12-12**, with an E-sized version included in **Attachment 3.12-3**. Note that the legend scale increments in **Figure 3.12-12** differ from the maps in previous figures because the raw NaI scan data have been normalized to an HPIC equivalent.

A kriging program in ArcGIS was used to develop continuous estimates of three-foot-HPIC-equivalent gamma exposure rates throughout the Permit Area. Kriging is a geostatistical interpolation procedure that fits a mathematical function to a specified number of nearest points within a defined radius to determine an output value for each location. A given "location" is represented by a cell of specified dimensions that may or may not include any measured data points. Values closer to the cell are given more weight than values further away; and distances, directions, and overall variability in the data set are all considered in the predictive semivariogram model. The input parameters used for this application were as follows.

- cell size: ten feet by ten feet;
- maximum search radius: 350 feet;
- semivariogram model: exponential; and
- number of nearest data points: ten.

A map of the estimated three-foot-HPIC-equivalent gamma exposure rates throughout the Permit Area is presented in **Figure 3.12-12**, with a larger version included in **Attachment 3.12-3**. Note that for the central area of the highest-density scan coverage shown in **Figure 3.12-12**, there is an apparent difference in distribution between the scan track data and the corresponding kriged region in **Figure 3.12-13**. This is because the scan data symbol sizes in **Figure 3.12-12** have been somewhat enlarged for illustrative purposes, and higher values prevail where adjacent data symbols overlap. In such cases, the kriged map is believed to provide a more accurate representation of the actual distribution. The larger version of **Figure 3.12-12** (**Attachment 3.12-3**) or the raw electronic dataset (**Attachment 3.12-4**) should be used to identify values at individual locations.

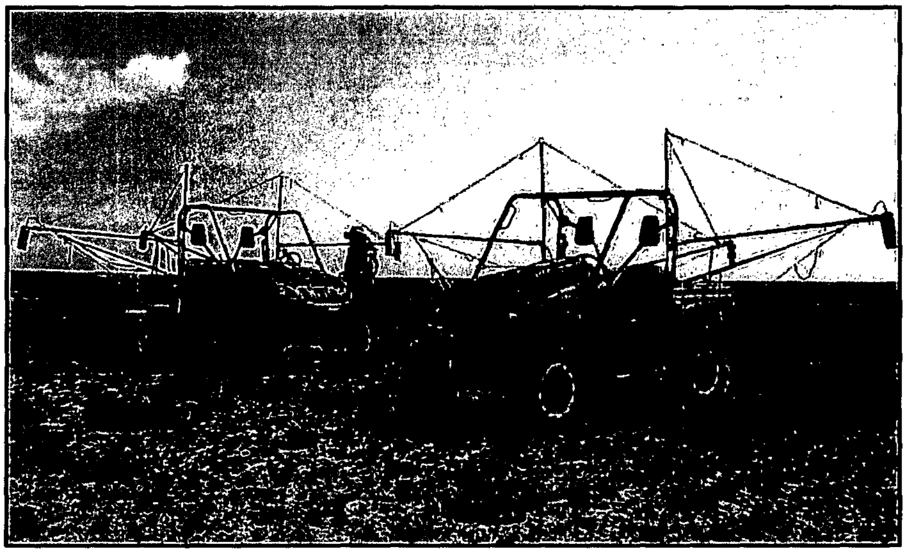
Soil Ra-226 Concentration Mapping

Using the NaI /HPIC cross-calibration results, along with the gamma/Ra-226 correlation data, raw NaI scan data were also converted into estimates of soil Ra-226 concentrations. The regression associated with the Lost Creek data shown in **Figure 3.12-14** was used for this conversion. Also shown in **Figure 3.12-14** is another correlation developed for the nearby Lost Soldier study area that shares similar geophysical and geochemical soil characteristics. One data point for the Lost Creek correlation appears to be a mild outlier that increases the slope of the regression relative to that of the Lost Soldier site. Without this data point, the two regressions are nearly identical, suggesting that the basic relationship between the gamma reading and the Ra-226 concentration is reasonably consistent in this region of Wyoming.

Using the regression for the Lost Creek data shown in **Figure 3.12-14**, kriging was performed to produce continuous estimates of soil Ra-226 concentrations across the Permit Area as shown in **Figure 3.12-15**, with an E-sized version included in **Attachment 3.12-3**.

QC measurements performed each day at the field staging area indicated that instrument variability for background readings was generally on the order of plus or minus one μR/hr (based on the standard deviations of 20 successive readings). OHVs were parked overnight in the same general locations; but the exact location of detectors for daily QC measurements varied by five to ten meters. Day-to-day variability in background QC measurements at the field staging area thus provides an indication of respective small-scale spatial variability, as well as temporal variability over successive days. Based on the instrument control charts, these sources of variability approached plus or minus three μR/hr. Thus, the total amount of potential uncertainty in measurements at the staging area approached plus or minus four μR/hr. The staging area had measured background gamma readings in the range of 17 to 27 μR/hr, which is at the lower end of the range of values found in the Permit Area. In areas of higher gamma exposure rates, the degree of uncertainty in measurements may be higher.

Figure 3.12-1 Scanning System Equipment and Configuration Used at the Lost Creek Site



September, 2006

Figure 3.12-2 Correlation Grid Sampling Design

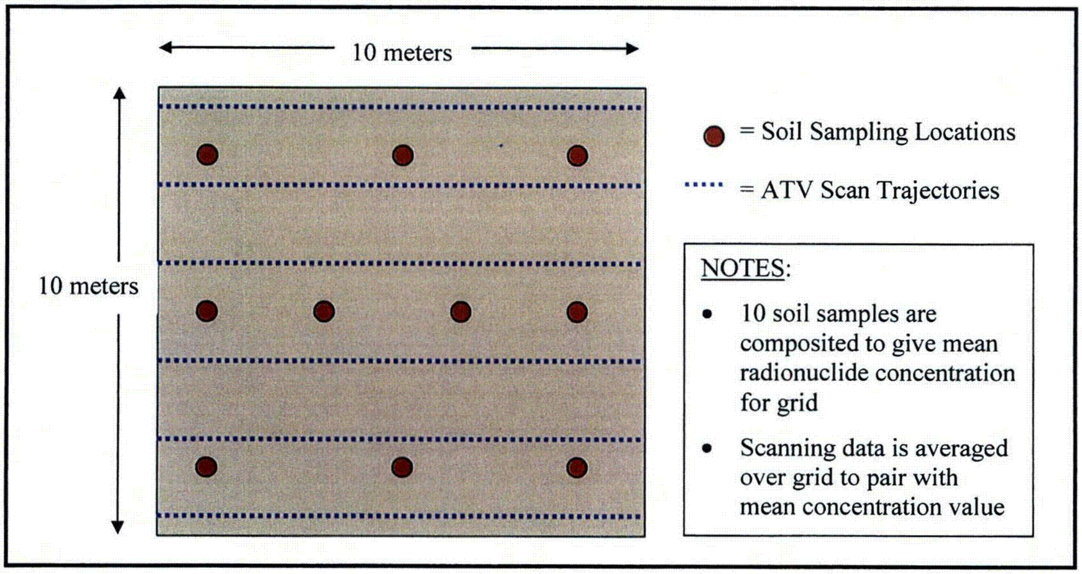


FIGURE 3.12-3
NAI-BASED GAMMA SURVEY RESULTS
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EJS
Issued/Revised: 10.18.07
Drawing No: NRC-ER-3.12-3-10.18.07-EJS

Lost Creek ISR, LLC
Littleton, Colorado USA

AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA

Legend

Lost Creek Permit Area

Gamma Scan (uR/hr)

- <25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- >45

FIGURE 3.12-4
NAI GAMMA SURVEY RESULTS AND HPIC MEASUREMENT LOCATIONS

Lost Creek Permit Area

Issued For: NRC ER Drawn By: EJS

Issued/Revised: 10.18.07

Drawing No: NRC-ER-3.12-4-10.18.07-EJS

0 0.125 0.25 0.5 Miles

FIGURE 3.12-5
OHV RE-SCAN RESULTS

FIGURE 3.12-6
SOIL SAMPLING AND GAMMA SURVEY RESULTS
Lost Creek Permit Area

Figure 3.12-7: Ra-226 Soil Concentration and Gamma Exposure Rate Correlation

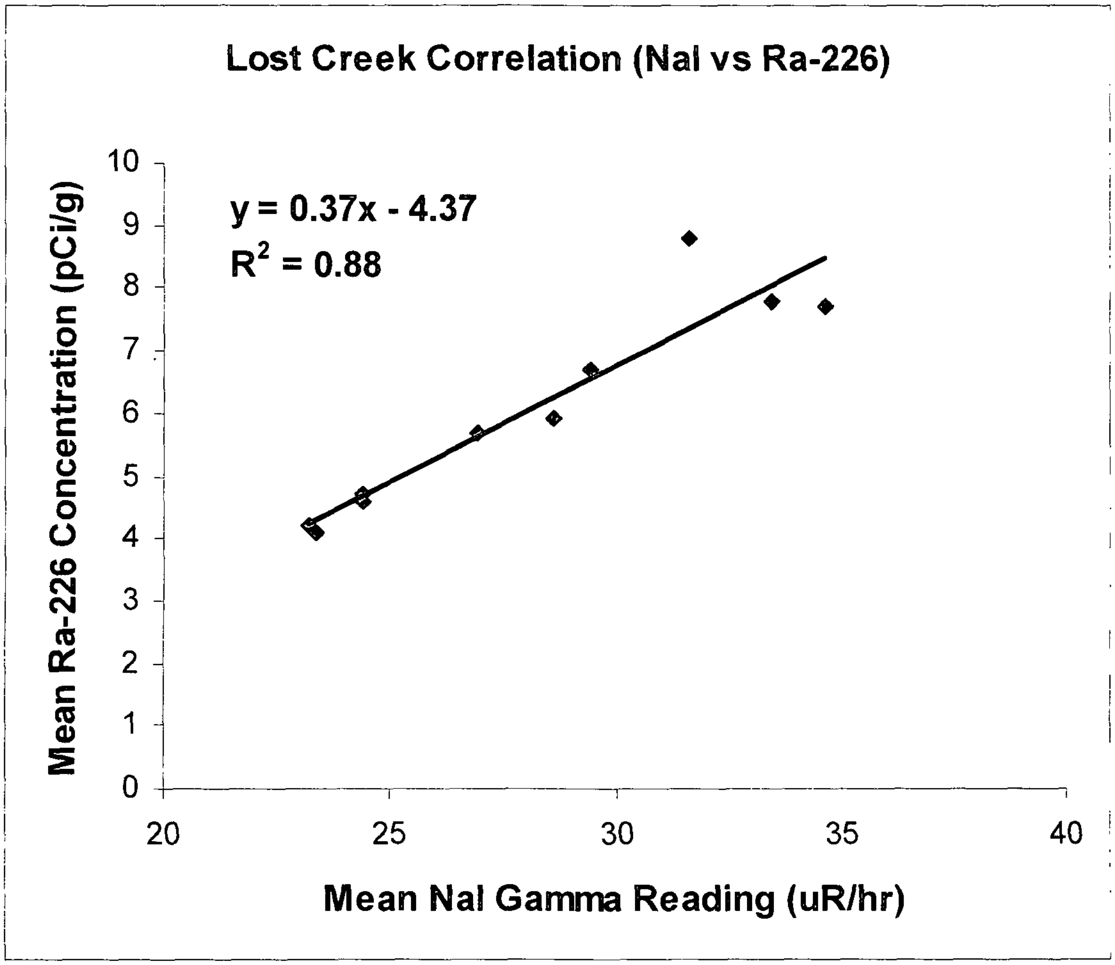


Figure 3.12-8: Ra-226 and Uranium Soil Concentration Correlation

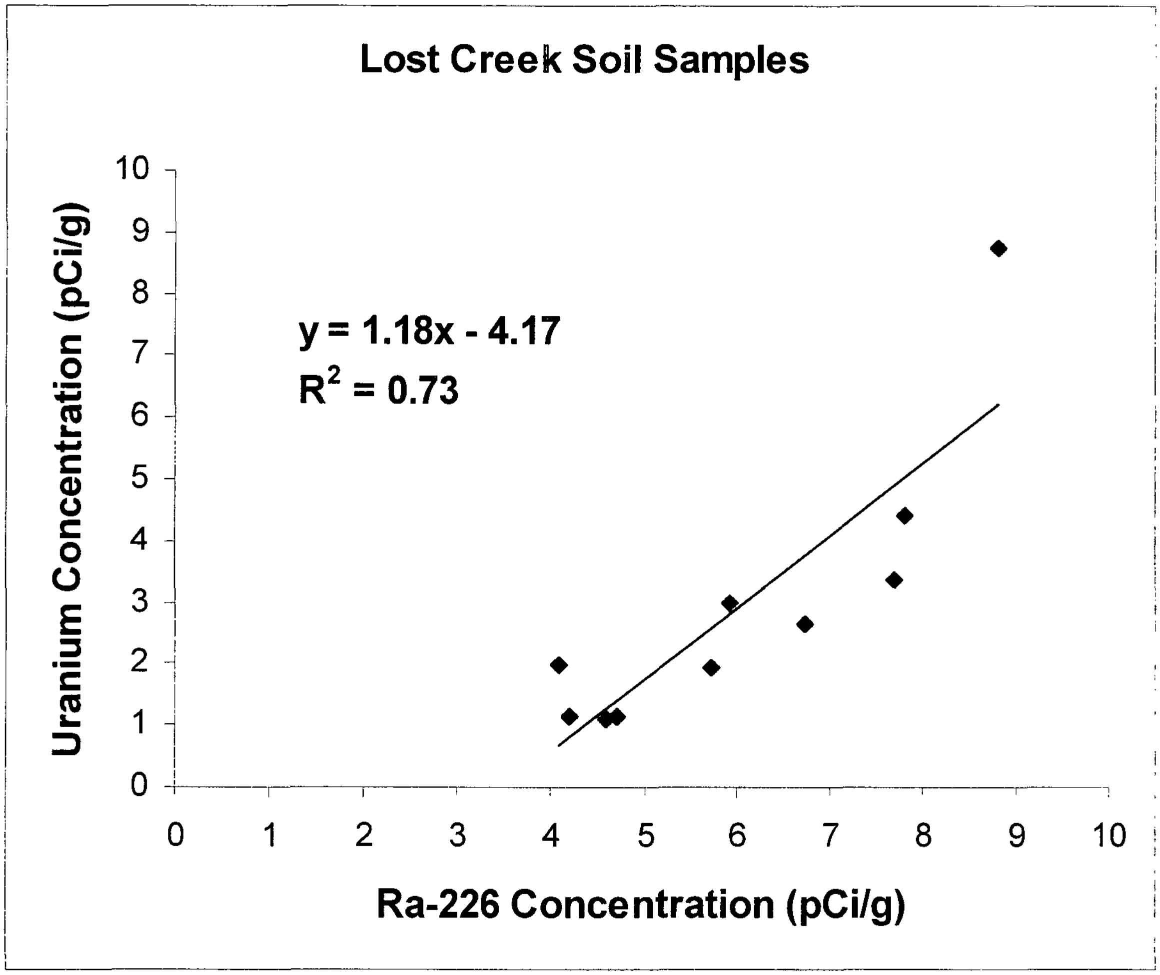


Figure 3.12-9: Calibration Curves for HPIC versus NaI Detectors

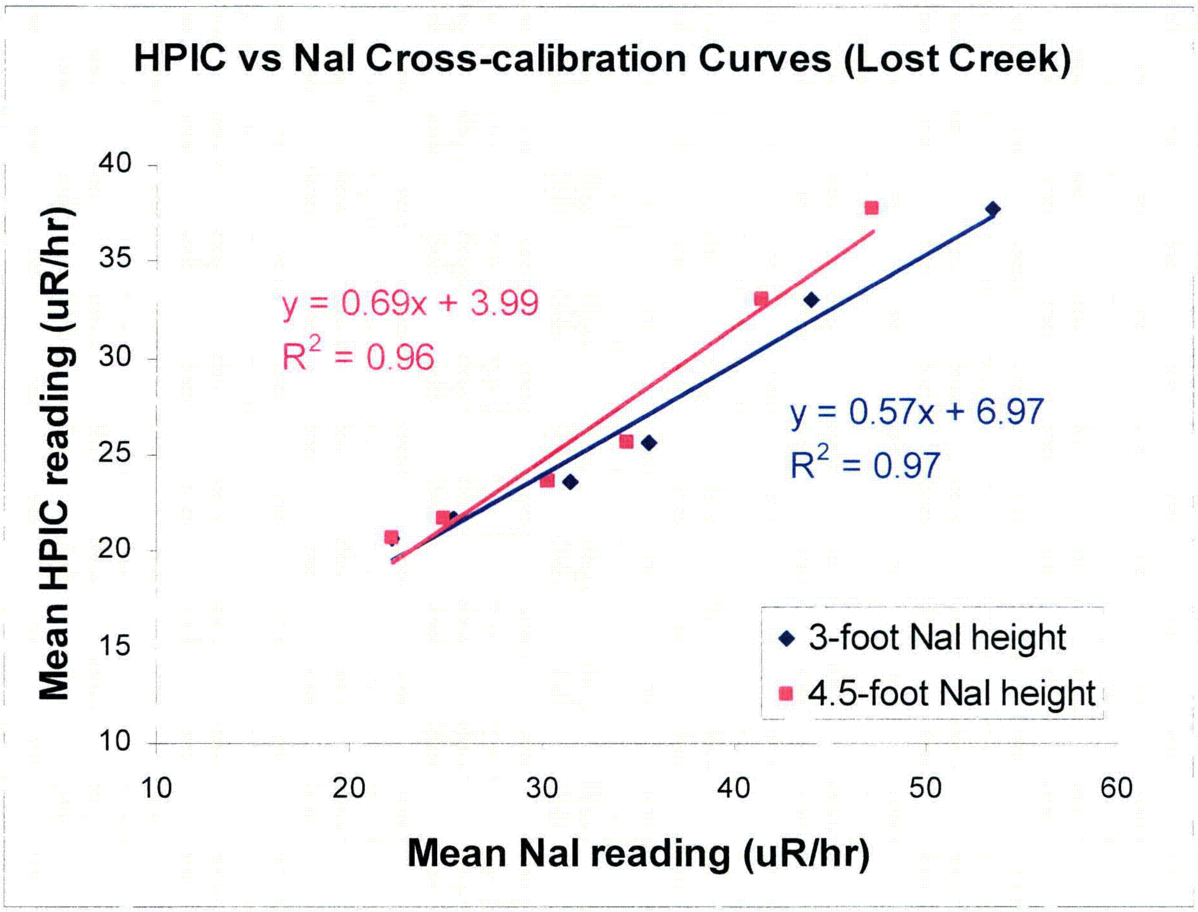


FIGURE 3.12-10
THREE-FOOT NAI DETECTOR HEIGHT DATA
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EJS
Issued/Revised: 10.18.07
Drawing No: NRC-ER-3.12-10-10.18.07-EJS

Figure 3.12-11: Three-Foot and 4.5-Foot NaI Detector Height Readings Correlation

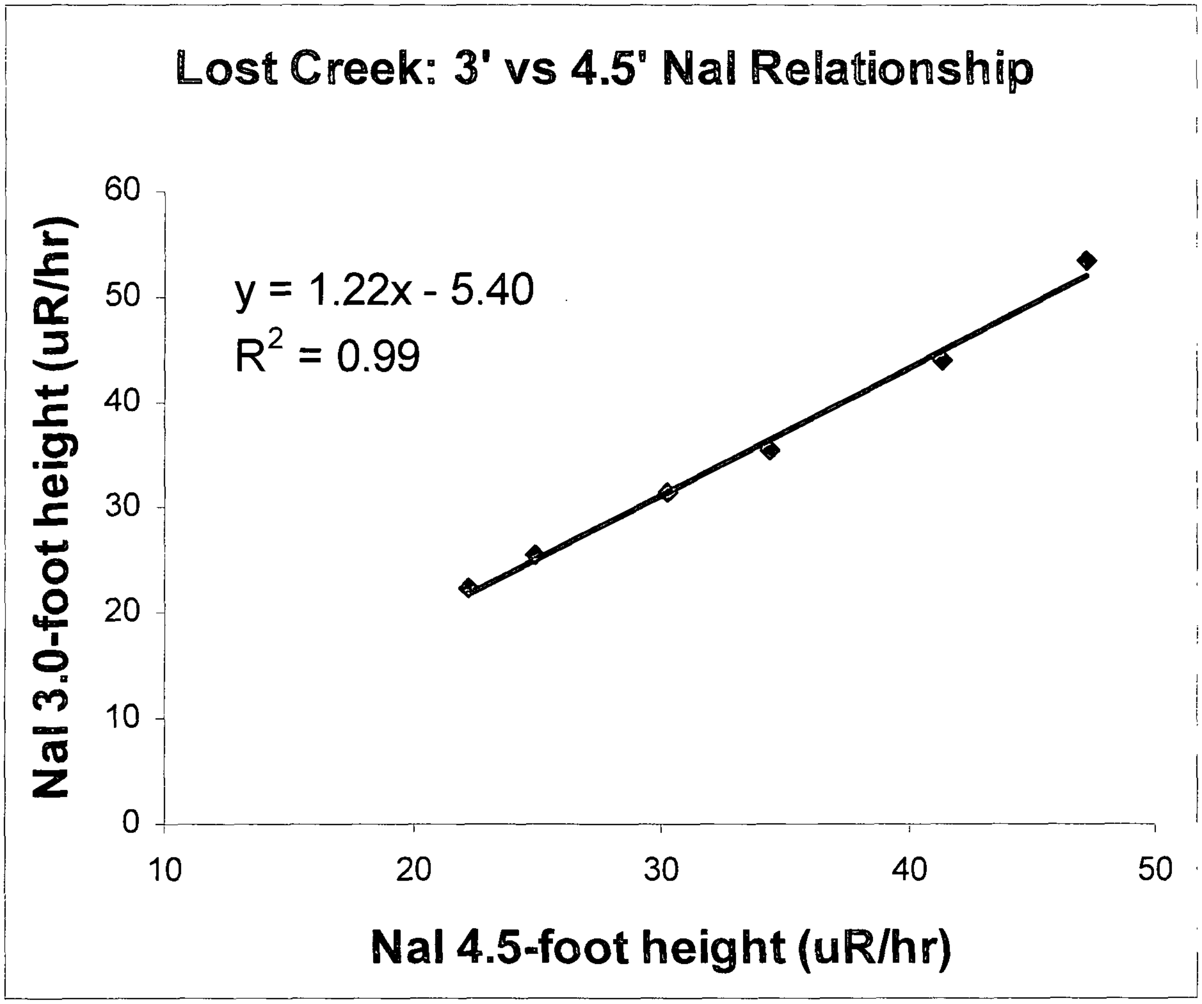
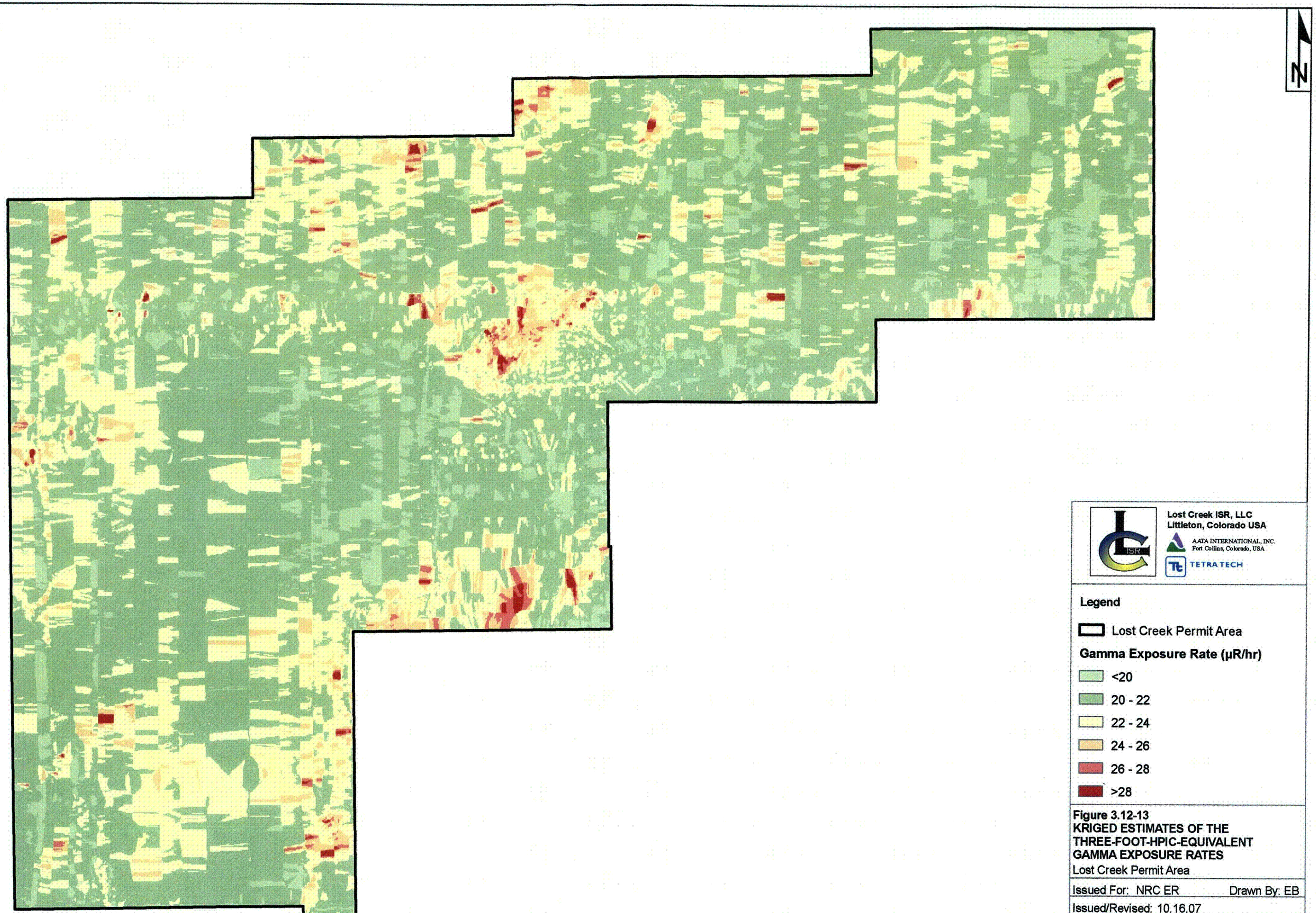


FIGURE 3.12-12
CALCULATED THREE-FOOT HPIC EQUIVILANT GAMMA EXPOSURE RATES
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EJS
Issued/Revised: 10.18.07
Drawing No: NRC-ER-3.12-12-10.18.07-EJS



Lost Creek ISR, LLC
Littleton, Colorado USA

AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA

TETRA TECH

Legend

Lost Creek Permit Area

Gamma Exposure Rate (μR/hr)

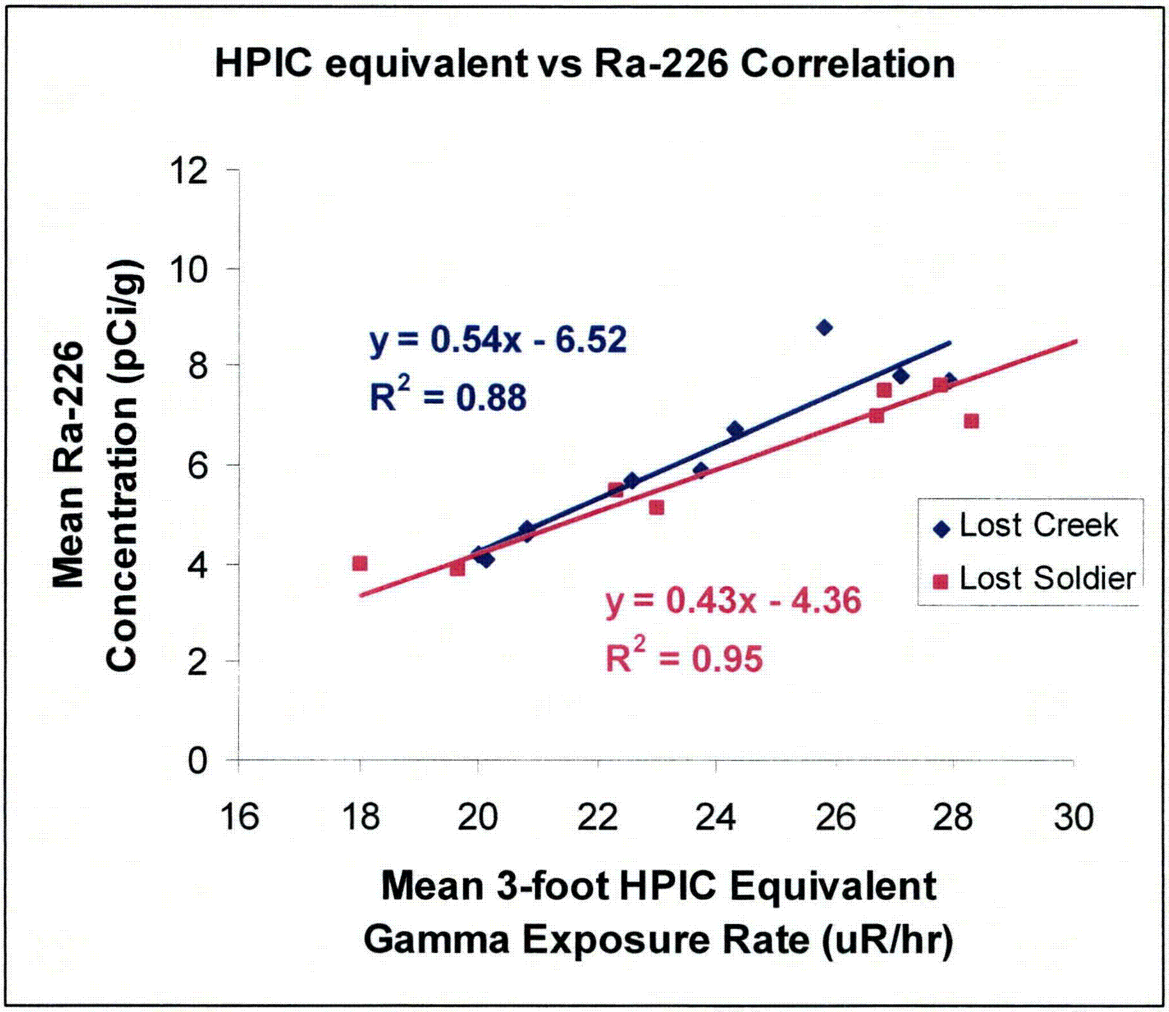
- <20
- 20 - 22
- 22 - 24
- 24 - 26
- 26 - 28
- >28

Figure 3.12-13
KRIGED ESTIMATES OF THE THREE-FOOT-HPIC-EQUIVALENT GAMMA EXPOSURE RATES
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EB
Issued/Revised: 10.16.07
Drawing No: NRC-ER-3.12-13-10.16.07-EJS

0 0.125 0.25 0.5 Miles

Figure 3.12-14: Regression Used to Predict Soil Ra-226 Concentrations



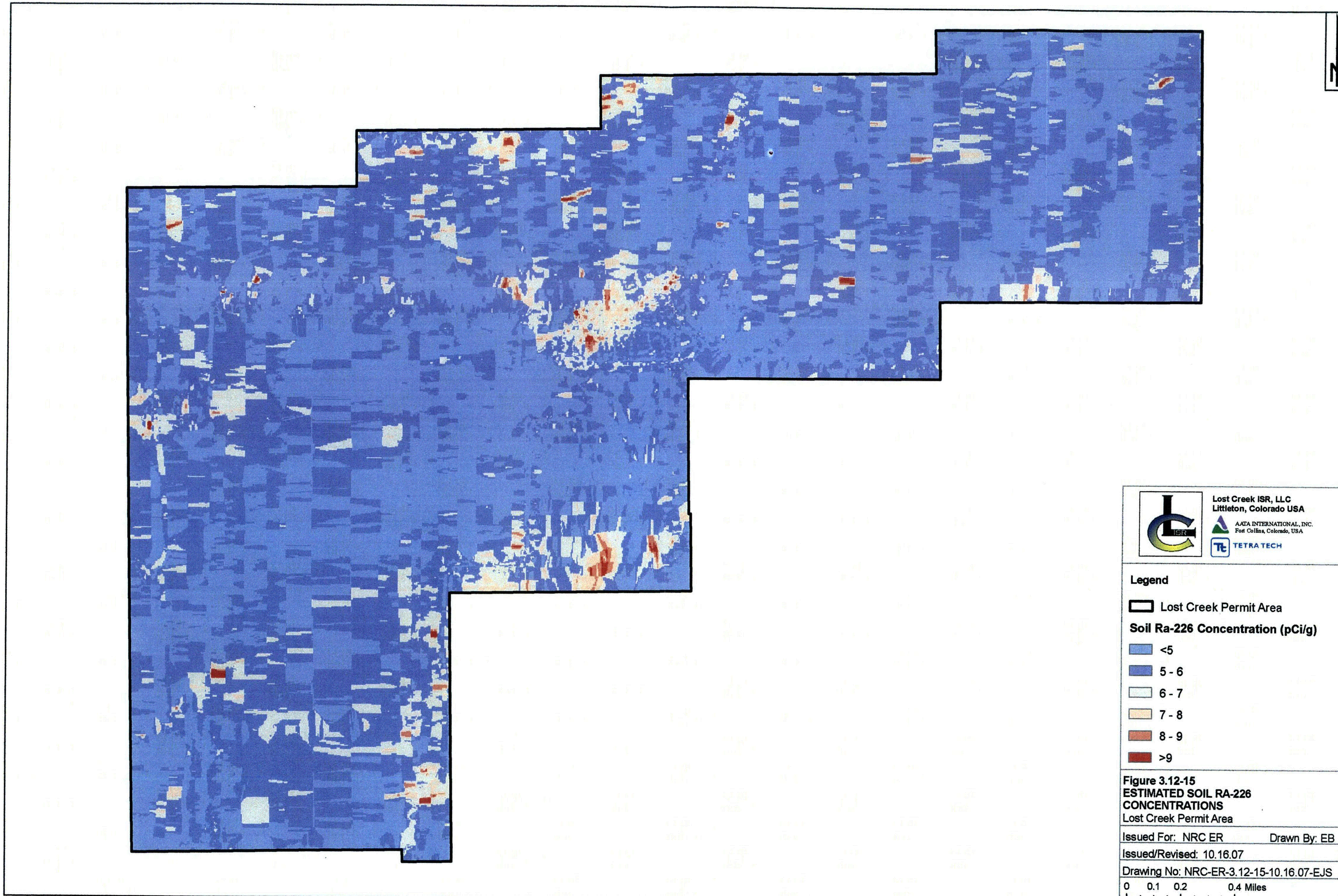


Figure 3.12-15
ESTIMATED SOIL RA-226 CONCENTRATIONS
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EB
Issued/Revised: 10.16.07
Drawing No: NRC-ER-3.12-15-10.16.07-EJS

Table 3.12-1 **Soil Sampling and Correlation Grid Results**

Sample ID	Latitude dd North	Longitude dd West	Mean Ra-226 (pCi/g)	Ra-226 Precision (±pCi/g)	Uranium (mg/kg)	Uranium (pCi/g)	Mean Th-230 (pCi/g)	Th-230 Precision (±pCi/g)	Mean Pb-210 (pCi/g)	Pb-210 Precision (±pCi/g)	Mean Gamma Exposure Rate (μR/hr)
LC-1	42.14155	107.88055	8.8	1.4	12.9	8.7	2.1	0.6	4.9	0.5	31.6
LC-2	42.11874	107.88639	4.1	1.1	2.9	2.0	1.0	0.4	0.6	0.1	23.4
LC-3	42.10628	107.87012	6.7	1.5	3.9	2.6	1.9	0.6	1.1	0.2	29.4
LC-4	42.11892	107.86263	5.9	1.1	4.4	3.0	0.8	0.4	0.4	0.2	28.6
LC-5	42.13146	107.87123	4.2	1.1	1.7	1.1	0.3	0.3	0	-	23.2
LC-6	42.14215	107.85717	7.7	1.3	5.0	3.4	0.7	0.4	0.4	0.2	34.6
LC-7	42.13118	107.85932	7.8	1.2	6.5	4.4	1.5	0.5	0.4	0.1	33.4
LC-8	42.13024	107.85688	5.7	1.1	2.9	1.9	0.6	0.4	1.0	0.2	26.9
LC-9	42.13038	107.84396	4.6	1.1	1.6	1.1	0.4	0.3	0	-	24.4
LC-10	42.13951	107.82803	4.7	1.1	1.7	1.1	0	-	0	-	24.4
LC-10	*Duplicate Analysis*		4.8	1.1	-	-	-	-	-	-	-

Table 3.12-2 Gamma Exposure Rate Differences of Two NaI Detector Heights

Three-Foot NaI Exposure Rate (μR/hr)	Corresponding Predicted 4.5-Foot NaI Exposure Rate (μR/hr)	Difference Between the Three-Foot and 4.5-Foot NaI Exposure Rates	
		(μR/hr)	(Percent)
25	24.9	0.10	0.4
30	29.0	1.0	3.3
35	33.1	1.9	5.4
40	37.2	2.8	7.0
45	41.3	3.7	8.2
50	45.4	4.6	9.2

Attachment 3.12-1 Data Quality Assurance Documentation

H. Robert Meyer, Ph.D.
Tetra Tech Inc. (formerly MFG Inc.), Suite 100
3801 Automation Way
Fort Collins, Colorado 80525
Telephone: (970) 227 8578
Fax: 801 991 7019
Email: robert.meyer@mfgenv.com

Education

Ph.D., Radiation Biology, Colorado State University, Fort Collins, Colorado, 1977
M.S., Health Physics, Colorado State University, Fort Collins, Colorado, 1973
Former Line Officer, U.S. Naval Reserve
U.S. Navy Officer Candidate School, Newport, Rhode Island, 1969
B.A., Physics, St. Olaf College, Northfield, Minnesota, 1967

Specialties

Human health risk assessment
Radiation protection and measurement
Public involvement

Professional Experience

MFG Inc.

Senior Scientist and Project Manager, Fort Collins, Colorado (5/2000-present)

Managing the radiation protection and measurements group, including a large set of gamma, alpha and beta monitoring systems. MARSSIM experience in the context of pre- and post-remedial action surveys. Co-developer of MFG Inc.'s global positioning system-based field gamma scanning hardware/software systems. Currently Radiation Safety Officer (RSO) for the Highlands former uranium mill site (Wyoming) and the Felder Ray Point former uranium mill site (Texas). Co-editor and author of 900-page graduate textbook, "Radiological Assessment, A Textbook on Environmental Risk Analysis". MFG project leader on National Institutes of Occupational Safety and Health Atomic Energy Worker Compensation Project. Performing radiation measurements, human health risk and regulatory assessments of various facilities, including scanning, sampling and analysis. License-related assistance for uranium and related mine/mill facilities in western U.S. ASTM environmental site assessment professional. Environmental Impact Statement and related support. Accreditation Board on Engineering Technology, Health Physics Society university program evaluator. National Council on Radiation Protection and Measurements committee on radioactive metals recycling. Guest lecturer at Colorado State University.

Keystone Scientific, Inc.

President, Fort Collins, Colorado (1992–5/2000)

Performed radiation and chemical dose evaluation/reconstruction analyses at weapons complex facilities as a private consultant to the Centers for Disease Control and Prevention. Included research at Idaho National Engineering and Environment Laboratory, and the Savannah River Site near Aiken, South Carolina. Performed similar research for the Colorado Department of Public Health and Environment at the Rocky Flats Environmental Technology Site (Rocky Flats

Plant) near Denver, Colorado. Primary project-related public speaker at numerous risk-related meetings in South Carolina, Georgia and Colorado. Uranium mill tailings facility radiation protection licensing, environmental transport modeling and procedures development. NCRP committee member. Member, National Academy of Sciences Board on Radioactive Waste Management. Invited graduate school lecturer at Colorado State University.

Chem-Nuclear Systems, Inc.

Vice President, Harrisburg, Pennsylvania (1990–1992)

Responsible for initiation and management of a contract with the Commonwealth of Pennsylvania to site, design, construct, and operate a low-level radioactive waste facility. On-site reviews of all power reactor operations in the Compact region. Located and staffed a new office in Harrisburg, negotiated prime contract with State health department, and subcontracts with individual companies, developed and negotiated technical work plans including emergency preparedness plan, led the public involvement effort as primary project speaker for numerous presentations throughout the Appalachian Compact region; directed the project's first two years. Member, U.S. Environmental Protection Agency's Science Advisory Board. Guest lecturer, Harvard School of Public Health.

Chem-Nuclear Systems, Inc.

Executive Director, Albuquerque, New Mexico (1983–1990)

Developed and managed all aspects of environmental monitoring, dosimetry, radiation protection, verification, radiological emergency response and quality assurance programs for the U.S. Department of Energy's Uranium Mill Tailings Project (UMTRA Project, under subcontract to MK-Ferguson, Inc.). Responsible for uranium, radium, thorium-related radioactivity/radiation measurements at up to eight field sites simultaneously, managed 138 health physics field staff. Negotiated regulatory requirements and compliance specifics with USDOE, USNRC, USEPA, State health departments. Primary UMTRA project speaker at numerous public meetings in eight states. Consultant, International Atomic Energy Agency, Vienna, Austria. Guest lecturer, Harvard School of Public Health.

Oak Ridge National Laboratory

Research Staff Member, Oak Ridge, Tennessee (1976–1983)

Performed radionuclide and chemical environmental risk assessments of: proposed uranium and thorium ore mining, milling, and refining; fuel reprocessing and refabrication facilities; power reactor operations; breeder reactor fuel cycle; and high temperature gas-cooled reactor fuel recycling. Research also included assessments of non-nuclear energy sources, including toxics released during wood combustion, coal liquefaction, and coal gasification. Responsible for regular professional presentations related to research and publications.

Colorado State University

Graduate Research Assistant, Fort Collins, Colorado (1972–1976)

Prepared and presented laboratory and classroom lectures. Conducted Ph.D. research on plutonium uptake characteristics of bacteria immobilized on a polymer matrix.

U.S. Navy

Line Officer, Little Creek, Virginia (1969–1972)

Three years active duty. Shipboard experience: qualification as Command Duty Officer, Officer of the Deck, Engineering Watch Officer, Electrical Division Officer. Training in radiation contamination emergency response at Naval Damage Control Training Center, Camden NJ.

Patent

RTRAK autolocating mobile gamma scanning system, U.S. Patent #5,025,150, J. Oldham, R. Meyer, C. Begley, and C. Spencer, 1991.

Professional Activities

Accreditation Board for Engineering and Technology (ABETS) University Program Evaluation Team Leader, 2001 – present

National Council on Radiation Protection and Measurements, Subcommittee on Radioactive Metals Recycling, 1999 – 2002.

RESRAD model, training course at Argonne National Laboratory, 2001.

Certified Environmental Site Assessment Professional, ASTM training course, 2000.

Lecturer (occasional), Colorado State University, 1993-present.

National Academy of Sciences, Member, Board on Radioactive Waste Management (1992-1998)

National Academy of Sciences, Subcommittees: Review of the New York State Low Level Waste Siting Project, 1996; DOE Site Decommissioning, 1997; the National Low Level Waste Problem, 1998.

U.S. Environmental Protection Agency Science Advisory Board, Radiation Advisory Committee Member, 1990–1992.

High intensity training: "Dealing with the Media", interactive 6-student, 3-day course directed by Dr. Leonard Roller, 1989.

Invited lecturer, Harvard School of Public Health, 1988-1994.

Consultant to the International Atomic Energy Agency, Vienna. Co-authored IAEA Technical Report STI/DOC/10/327, "Planning for Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident," 1988.

Consultant to the US EPA Science Advisory Board, technical review of National Emissions Standards for Hazardous Air Pollutants, 1988.

Consultant to the Centers for Disease Control, Fernald Dose Assessment Project, 1987.

Invited participant, "European Seminar on the Risks from Tritium Exposure," Mol, Belgium, November 1982.

Invited participant, "Light Water Reactor Accident Mitigation Workshop," West Germany, April 1981.

Faculty Affiliate, Colorado State University Ph.D. committee member, 1980–1982.

Governor's Planning Committee for the Management of Radioactive and Hazardous Wastes for the State of Tennessee, 1979–1980.

Health Physics Society, Environmental Section, Education and Training Committee.

Expert Testimony

"Review of the Radiological Hazard Associated with the Durango Uranium Mill Tailings Pile." Court testimony for the *State of Colorado vs. HECLA.* Durango, Colorado, April 20–22, 1987.

Honors and Awards

Society for Technical Communications 1985 Award for "Radiological Assessment–A Textbook on Environmental Dose Analysis," edited by John E. Till and H. Robert Meyer, NUREG/CR-3332.

Society for Technical Communications 1980 Award for "Radiological Impact of Thorium Mining and Milling," H.R. Meyer et al., *Nuclear Safety* 20 (3).

American Nuclear Society's P.W. Jacoe Award–outstanding nuclear science student, 1976.

Phi Kappa Phi Graduate Honor Society, 1976.

Distinguished Naval Graduate, Officer Candidate School, 1969.

NASA Summer Fellowship, 1966.

Selected Publications

Emery, R.M., M.L. Warner, **H.R. Meyer**, C.A. Little and J.E. Till. 1977. Environmental Assessment Strategies in Support of the Nonproliferation Alternative Systems Assessment Program (NASAP). PNL-2415. Battelle Pacific Northwest Laboratories. October.

Meyer, H.R., and J.E. Till. 1978. "Global/Generic Studies." In HTGR Fuel Recycle Development Program Annual Report. ORNL-5423. Oak Ridge National Laboratory.

Meyer, H.R., J.E. Till, E.A. Bondietti, D.E. Dunning, C.S. Fore, C.T. Garten, Jr., and S.V. Kaye. 1978. Nonproliferative Alternative Systems Assessment Program - Preliminary Environmental Assessment of Thorium/Uranium Fuel Cycle Systems. ORNL/TM-6069. Oak Ridge National Laboratory. June.

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Carnes, S.A., E.D. Copenhaver, L. Martin-Bronfman, **H.R. Meyer**, T.W. Oakes, D.C. Parzyck, L.W. Rickert, E.G. St. Clair, C.W. Tevepaugh, L.F. Willis, and D.W. Weeter. 1979. Report of the UCC-ND Task Force on Waste Management in Tennessee. September.

Dunning, D.E. and **H.R. Meyer**. 1979. "An Evaluation of Thorium-232 Dose Conversion Factors." In The Validation of Selected Predictive Models and Parameters for the Environmental

Transport and Dosimetry of Radionuclides. ORNL/TN-6663. Edited by C.W. Miller. Oak Ridge National Laboratory. July.

Faust, R.A., C.S. Fore, M.V. Cone, **H.R. Meyer** and J.E. Till. 1979. Biomedical and Environmental Aspects of the Thorium Fuel Cycle. ORNL/EIS-111. Oak Ridge National Laboratory. July.

Meyer, H.R. and D.E. Dunning. 1979. "Reevaluation of Dose Equivalent per Unit Intake for Th232." Health Physics 37 (4): 595–598. October.

Meyer, H.R. and J.E. Till. 1979. "Anticipated Radiological Impacts of the Mining and Milling of Thorium for the Nonproliferative Fuels." Proceedings of the Symposium–Radioactivity and Environment. Edited by W. Feldt. German-Swiss Society for Radiation Protection, Norderney, Federal Republic of Germany, October 2–6, 1978, IRPA.

Meyer, H.R, J.E. Johnson, R.P. Tengerdy, and P.M. Goldman. 1979. "Use of a Bacteria-Polymer Composite to Concentrate Plutonium from Aqueous Media." Health Physics 37 (3): 359–363. September.

Meyer, H.R, C.A. Little, J.P. Witherspoon and J.E. Till. 1979. "A Comparison of Potential Radiological Impacts of U233 and Pu239 Fuel Cycles." Transactions of the American Nuclear Society, Winter Meeting, November 12–16, 1979.

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Meyer, H.R, J.E. Till and E.L. Etnier. 1980. "Reprocessing Thorium-Based Fuels." and "Tritium Doses and Dosimetry." HASRD Technical Progress Report. ORNL-5595. Oak Ridge National Laboratory. January.

Meyer, H.R, D.E. Dunning, D.C. Kocher and K.K. Kanak. 1980. "Dose Conversion Factors." In Recommendations Concerning Models and Parameters. Best Suited to Breeder Reactor Environmental Radiological Assessments. Edited by C.W. Miller. ORNL-5529. Oak Ridge National Laboratory. May.

Miller, C.W., D.E. Dunning, E.L. Etnier, D.C. Kocher, L.M. McDowell-Boyer, **H.R. Meyer** and P.S. Rohwer. 1980. Recommendations Concerning Research and Model Evaluation Needs to Support Breeder Reactor Environmental Radiological Assessments. ORNL/TM-7491. Oak Ridge National Laboratory. December.

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Till, J.E., **H.R. Meyer**, E.L. Etnier, E.S. Bomar, R.D. Gentry, G.G. Killough, P.S. Rohwer, V.J. Tennery, and C.C. Travis. 1980/ "Tritium—An Analysis of Key Environmental and Dosimetric Questions. ORNL/TM-6990. Oak Ridge National Laboratory. May.

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Yalcintas, M.G., T. D. Jones, **H.R. Meyer**, H. Ozer, and S Unsal. 1980. "Estimation of Dose Due to Accidental Exposure to a Cobalt 60 Therapy Source." Health Physics 38 (2): 187–191. February.

Meyer, H.R. 1981. "Radiological Assessment of an Alternate Breeder Reactor Fuel Cycle." In Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment. Edited by C.W. Miller, S.J. Cotter and S.R. Hanna. U.S. Department of Energy CONF-801064. October.

Meyer, H.R. 1981. "The Contribution of Residential Wood Combustion to Local Airshed Pollutant Concentrations." Proceedings of the International Conference on Residential Solid Fuels. Portland, Oregon, December.

Miller, C.W. and **H.R. Meyer**. 1981. Breeder Reactor Program Summary. HASRD Technical Progress Report. ORNL-5750. Oak Ridge National Laboratory. October.

Till, J.E., E.L. Etnier, and **H.R. Meyer**. 1981. "Methodologies for Calculating the Radiation Dose from Environmental Releases of Tritium." Nuclear Safety 22(2): 205–213. March–April.

Meyer, H.R. 1982. "Health and Environmental Effects." In Life Sciences Synthetic Fuels Semi-Annual Progress Report. Edited by K.E. Cowser. ORNL/TM-8229. Oak Ridge National Laboratory. May.

Meyer, H.R. 1982. "Coal Liquefaction: Health and Environmental Risk Analysis Program." Proceedings of the Third Annual Contractor's Meeting. Alexandria, Virginia, U.S. Department of Energy Document No. CONF-820250. July.

Meyer, H.R and F. O'Donnell. 1982. "University of Minnesota—Duluth Coal Gasification Project." In Life Sciences Synthetic Fuels Semi-Annual Progress Report. Edited by K.E. Cowser. ORNL/TM-8441. Oak Ridge National Laboratory. November.

Meyer, H.R., J.P. Witherspoon, J.P. McBride, and E.J. Frederick. 1982. Comparison of the Radiological Impacts of Thorium and Uranium Nuclear Fuel Cycles. NUREG/CR-2184. U.S. Nuclear Regulatory Commission. April.

Smith, W.J., F.W. Whicker, and **H.R. Meyer**. 1982. "A Review and Categorization of Saltation, Suspension, and Resuspension Models." Nuclear Safety 23 (6). November–December.

DesRosiers, A.E., **H.R. Meyer**, R.E. Swaja, and K. Brusserman. 1983. "Emergency Planning for Accident Mitigation." In Report of the Workshop on the Evaluation and Mitigation of the Consequences of Accidental Releases of Radioactivity: Identification of Uncertainties. Bad Munstereifel, Federal Republic of Germany.

Killough, G.G., **H.R. Meyer**, and D.E. Dunning. "Radionuclide Dosimetry." In Models and Parameters for Environmental Radiological Assessments. Edited by C.W. Miller. U.S. Department of Energy Critical Review Series.

Meyer, H.R, and G. Holton, "Modeling the Potential Public Health Impacts of Airborne Releases." In Proceedings of the Health and Environmental Risk Analysis Workshop. Brookhaven National Laboratory, Upton, New York.

Meyer, H.R., C.W. Miller, A.E. DesRosiers, G. Stoetzel, D. Strenge, and R.E. Swaja. 1983. "Assessment of Accidental Releases of Radionuclides." In Radiological Assessment: A Textbook on Environmental Dose Analysis. Chapter 14. Edited by J.E. Till and **H.R. Meyer**. NUREG/CR-3332, ORNL-5968. U.S. Nuclear Regulatory Commission.

Till, J.E. and **H.R. Meyer**, eds. 1983. Radiological Assessment: A Textbook on Environmental Dose Analysis. NUREG/CR-3332, ORNL-5968. U.S. Nuclear Regulatory Commission.

Coffman, J., **H.R. Meyer**, and D. Skinner. 1984. "Radiological Measurements to Support Remedial Action on Uranium Mill Tailings." Proceedings of the American Nuclear Society Annual Meeting.

Meyer, H.R., D. Skinner, J. Coffman, and J. Arthur. 1984. "Environmental Protection in the UMTRA Project." Proceedings of the Fifth U.S. Department of Energy Environmental Protection Information Meeting. CONF-841187, Volume 2. November.

Meyer, H.R. et al. 1984. Health and Environmental Effects Document for the Liquid Metal Fast Breeder Reactor Fuel Cycle-1982. ORNL/TM-8802. Oak Ridge National Laboratory. March.

Meyer, H.R and J. Purvis. 1985. "Development of an Interference-Corrected Soil Radium Measurement System." Proceedings of the American Nuclear Society Annual Meeting. San Francisco, California. November. 184–186.

Meyer, H.R, D. Skinner, and J. Coffman. 1985. "Environmental Monitoring in the UMTRA Project." Proceedings of the Health Physics Society Midyear Symposium on Environmental Radioactivity. Colorado Springs, Colorado. January.

Skinner, D. and **H.R. Meyer**. 1985. "Demonstration of 10CFR20 Air Particulate Compliance Requirements on the UMTRA Project." Proceedings of the Health Physics Society Midyear Symposium on Environmental Radioactivity. Colorado Springs, Colorado. January.

Travis, C.C., E.L. Etnier, and **H.R. Meyer**. 1985. "Health Risks of Residential Wood Heat." Environmental Management 9 (3).

Meyer, H.R and D. Skinner. 1986. "Public Information Experience in the UMTRA Project." Proceedings of the Health Physics Society Midyear Symposium. Knoxville, Tennessee. February.

Miller, C.W. and **H.R. Meyer**. 1986. "Estimated Doses and Risks Resulting from Routine Radionuclide Releases from Fast Breeder Reactor Fuel Cycle Facilities: A Summary." Nuclear Safety 27 (1): 28–35. January–March.

Skinner, D., **H.R. Meyer**, and L.G. Hoffman. 1986. "Environmental Monitoring Requirements During Remedial Action and Stabilization of the Uranium Mill Tailings Project." Proceedings of the Health Physics Society Midyear Symposium. Knoxville, Tennessee. February.

Holton, G.A., K.R. Meyer, and **H.R. Meyer**. 1987. "Siting a Radioactive Waste Facility: A Pathways Analysis Case Study." Proceedings of the Air Pollution Control Association Annual Meeting. New York, New York, June 21–26, 1987.

Meyer, H.R. 1987. "Hazardous and Radioactive Wastes: Public Health Issues and Concerns." Proceedings of the American Institute of Chemical Engineers Meeting. Houston, Texas. March.

Meyer, H.R. and C. Daily. 1987. "QA Verification Procedures in Uranium Mill Tailings Processing Site Remedial Action." Proceedings of the American Society for Quality Control, Second Topical Conference on Nuclear Waste Management Quality Assurance. Las Vegas, Nevada, February 9-11, 1987.

Meyer, H.R., C. Begley, and C. Daily. 1987. "Field Instruments Developed for Use on the UMTRA Project." Proceedings of the Waste Management 1987 Annual Meeting. University of Arizona, Tucson. March.

Reith, C.H., R. Richey, M. Matthews, **H.R. Meyer**, C. Daily, F. Petelka, W. Glover, D. Lechel, and J.E. Till. 1988. "Characterization and Remedial Planning for Non-Radiological Toxicants at UMTRA Project Sites." In Waste Management 88. Edited by R.G. Post and M.E. Wacks. Tucson, Arizona: University of Arizona Press.

Reith, C.H., J.E. Till, and **H.R. Meyer**. 1989. "DECHEM: A Program for Characterization and Mitigation." In Proceedings of the American Institute of Chemical Engineers. 1989 Summer Meeting, Philadelphia, Pennsylvania, August 20–23, 1989.

Reith, C.H., **H.R. Meyer**, J.E. Till, and M.L. Matthews. 1989. "DECHEM: A Program for Characterizing and Mitigating Chemical Contaminants at UMTRA Project Sites." In Waste Management 89, Proceedings. DOE Waste Management Meeting, Denver, Colorado, April.

Faraday, M.A., B. Legrand, and **H.R. Meyer**. 1991. Planning for Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident. IAEA STI/DOC/10/327. Vienna.

Grogan, H., K. Meyer, P. Voillequé, S. Rope, M. Case, H. Meyer, R. Moore, T. Winsor, and J. Till. 1993. The Rocky Flats Nuclear Weapons Plant Dose Reconstruction Project - Task 2: Verify Phase I Source Term and Uncertainty Estimates. RAC Report No. CDH-1. Radiological Assessments Corporation, Neeses, South Carolina. December.

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Grogan, H.A, M.O. Langan, **H.R. Meyer**, E.A. Stetar, and J.E. Till. 1995. Savannah River Site Dose Reconstruction Project Phase I: Tasks 1 and 2, Identification and Cataloging of Information Sources. RAC Report No. 3-CDC-SRS-95-Final. Radiological Assessments Corporation, Neeses, South Carolina. June.

Stetar, E.A., M.J. Case, L.W. Bell, H.A. Grogan, K.R. **Meyer, H.R** Meyer, S.K. Rope, D.W. Schmidt, T.F. Winsor, and J.E. Till. 1995. Savannah River Site Dose Reconstruction Project Phase I: Task 4, Identifying Sources of Environmental Monitoring and Research Data. RAC Report No. 2 CDC-SRS-95-Final. Radiological Assessments Corporation, Neeses, South Carolina. June.

Meyer, H.R., S.K. Rope, T.F. Winsor, P.G. Voillequé, K.R. Meyer, L.A. Stetar, J.E. Till, and J.M. Weber. 1996. The Rocky Flats Plant 903 Area Characterization. RAC Report

No. 2-CDPHE-RFP-1996-Final. Radiological Assessments Corporation, Neeses, South Carolina. December.

Wiltshire, S., R. Ahrens, G. Anderson, C. Baskerville, R. Bassett, L. Brothers, H. Brown, G. Cederberg, J. Croes, W. Dornsife, J. Ebel, W. Freudenburg, R. Hatcher, C. Hornibrook, J. Johnson, L. Lehman, **H.R. Meyer**, D. Roy, M. Salamon, L. Slosky, and A. Socolow. 1996. Review of New York State Low-Level Radioactive Waste Siting Process. National Research Council, National Academy of Sciences. Washington, D.C.: National Academy Press.

Meyer, H.R. 1997. Savannah River Site Reactor Power and Canyon/Tritium Production Levels. Technical report. Radiological Assessments Corporation, Neeses, South Carolina. July 21.

Meyer, H.R. 1997. Book review of Radiation Risk, Risk Perception and Social Constructions. Health Physics 73 (3). September.

Weber J.M., A.S. Rood, J. Binder, and **H.R. Meyer**. 1998. Task 3: Development of the Rocky Flats Plant 903 Area Source Term. RAC Report No. 3-CDPHE-RFP-1999. Phase II, Rocky Flats Historical Public Exposure Studies. Radiological Assessments Corporation, Neeses, South Carolina. October.

Till, J. E., **H.R. Meyer**, Mohler, J., et al. 1999. Savannah River Site Dose Reconstruction Project Phase II Report. RAC Report No. 1-CDC-SRS-1999-Draft Final, Radiological Assessments Corporation, Neeses, SC. April 30. Published on paper and CD-ROM.

Meyer, H. R. 1998 – 2001. Book reviews published in Health Physics Journal.

Meyer, H.R. 2000-2001. Project research reports released as SMI documents, various topics and dates.

Till, JE, AS Rood, PG. Voillequé, PD McGavran, K.R. Meyer, H.A. Grogan, W.K. Sinclair, J.W. Aanenson, **H.R. Meyer**, S.K. Rope, and M.J. Case. 2002. Risks to the public from historical releases of radionuclides and chemicals at the Rocky Flats Nuclear Weapons Plant. *J of Exp. Analysis and Epidemiology* 12(5): 355-372.

Chen, Shih-Yew, D.J. Strom, J.G. Yusko, A. LaMastra, **H.R. Meyer**, D.W. Moeller. 2002. Managing potentially radioactive scrap metal. National Council on Radiation Protection and Measurements Report No. 141. November.

Meyer, H.R., J. Johnson, C. Little, R. Whicker. 2005. Use of a GPS-based gamma scanning system during field characterization activities. Proceedings, American Nuclear Society topical session, Denver, CO. July.

Meyer, H.R., M. Shields, S. Green. 2005. Scanning for radioactive contamination at remedial action facilities in the U.S. and Eurasia. 2005. Uranium mining remedial action conference, Friesing, Germany. September.

Selected Presentations

Meyer, H.R. et al. 1978. "Thorium Mining and Milling—An Analysis of Radiological Impacts." Health Physics Society Annual Meeting, Minneapolis, Minnesota, June.

Meyer, H.R. 1979. "An Overview of the Radiological Risks Associated with Thorium Mining in the Lemhi Pass Region." Department of Radiology and Radiation Biology Seminar Series, Colorado State University, Fort Collins, May.

Meyer, H.R., C.A. Little, J.P. Witherspoon, and J.E. Till. 1979. "A Comparison of Potential Radiological Impacts of 233U and 239Pu Fuel Cycles." American Nuclear Society Winter Meeting, San Francisco, California, November.

Meyer, H.R. et al. 1979. "Recycle of Thorium-Uranium Fuels—A Radiological Assessment." Health Physics Society Annual Meeting, July.

Meyer, H.R. 1980. "Radiological Assessment of an Alternate Breeder Reactor Fuel Cycle." Presented at the Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, Tennessee, October 1–3.

Meyer, H.R., J.E. Till, and E.L. Etnier. 1980. "Tritium—Potential Impacts of Nuclear Fuel Cycle Releases." Health Physics Society Annual Meeting, Seattle, Washington, July.

Meyer, H.R. 1981. "The Contribution of Residential Wood Combustion Emissions to Local Airshed Concentrations." Presented at the Conference on Residential Solid Fuels, Portland, Oregon, June 1–5.

Meyer, H.R. 1981. "The Human Health Risk Associated with Coal Liquefaction, Residential Wood Combustion and Nuclear Fuel Reprocessing." Department of Radiology and Radiation Biology Seminar Series, Colorado State University, Fort Collins, Colorado, July 30.

Meyer, H.R. 1981. "Coal Liquefaction." Presented at U.S. Department of Energy Health and Environmental Risk Analysis Program (HERAP) Annual Technical Review Session, Germantown, Maryland, December 7.

Meyer, H.R. 1982. "Coal Conversion Risk Assessment Research Requirements." Presented at the U.S. Department of Energy Retreat/Workshop, Warrenton, Virginia, January 26–28.

Meyer, H.R. 1982. "Breeder Reactor Risk Assessment." Presented at U.S. Department of Energy Annual Contractors Meeting for the Health and Environmental Risk Assessment Program, Alexandria, Virginia, February 16–18.

Meyer, H.R. 1982. "Reactor Emergency Planning—Analysis of Key Uncertainties." Presented at the Annual Health Physics Society Meeting, Las Vegas, Nevada, June 30.

Meyer, H.R. 1982. "Long Range Transport and Effects Modeling." Invited presentations at the U.S. Department of Energy Workshop on Risk Assessment Modeling, Airlie House, Virginia, August 2–4.

Meyer, H.R. 1982. "Assessment of Dose from Tritium Releases—Application of Environmental Transport Models" and "Tritium Source Terms." Invited presentations at the European Seminar on the Risks from Tritium Exposure. Sponsored jointly by CEC, CEN/SCK, Mol, Belgium, November 22.

Meyer, H.R. 1983. "The LMFBR Health and Environmental Effects Document Risk Assessment." Project Review for U.S. Department of Energy Health and Environmental Risk Assessment Program (HERAP), Washington, D.C., February 7.

Meyer, H.R. 1983. "Assessing the Environmental Impact of the LMFBR Fuel Cycle—A Multiple-Site Approach." Department of Radiology and Radiation Biology Seminar Series, Colorado State University, Fort Collins, Colorado, February 17.

Meyer, H.R. 1984. "Environmental Assessment in the UMTRA Project." Health Physics Society Annual Meeting, New Orleans, Louisiana, June.

Meyer, H.R. 1984. "Relative Risks Associated with the Uranium Mill Tailings Remedial Action (UMTRA) Program." Series of public meetings held in Canonsburg, Pennsylvania, before cleanup of the uranium mill tailings site. Separate presentations were made to the school board, teachers and administrators, nurses, realtors, and several mid school and high school classes, August 21–24.

Meyer, H.R. 1984. "Environmental Protection in the UMTRA Project." Fifth U.S. Department of Energy Environmental Protection Information Meeting, Albuquerque, New Mexico, November.

Meyer, H.R. 1984. "How to Communicate Health Effects Facts to Laymen." 1985 U.S. Department of Energy Remedial Action Annual Meeting, Albuquerque, New Mexico, November.

Meyer, H.R. 1985. "Analysis of Radon and Air Particulate Data in the UMTRA Project." Health Physics Society Midyear Symposium on Environmental Radioactivity, Colorado Springs, Colorado, January.

Meyer, H.R. 1985. "The UMTRA Project Health Physics Program." Presented to the U.S. Department of Energy Policy, Safety and Environment Appraisal Team, Carl Welty, Chairman, Albuquerque, New Mexico, April.

Meyer, H.R. 1985. "Relative Risks Associated with the Uranium Mill Tailings Remedial Action (UMTRA) Program." Presented in a series of public meetings held in Tuba City, Window Rock, and Moenkopi, Arizona, before the cleanup of mill tailings sites, October 8–9.

Meyer, H.R. and J. Purvis. 1985. "Development of an Interference-Corrected Soil Radium Measurement System." American Nuclear Society Annual Meeting (invited paper), San Francisco, November.

Meyer, H.R. 1986. "Review of Uranium Mill Tailings Remedial Action Project." Presented at the U.S. Department of Energy Remedial Action Contractors Annual Meeting, Oak Ridge, Tennessee, May 5–6.

Meyer, H.R. 1986. "Relative Risks Associated with the Uranium Mill Tailings Remedial Action (UMTRA) Program." Presented at a public meeting to explain the UMTRAP radiation protection program before cleanup work began. Lakeview, Oregon, May 20.

Meyer, H.R. 1986. "Health Risk Experience on the UMTRA Project." Presented at a U.S. Department of Energy Seminar on Concerns of Insurance Companies Regarding Remedial Action Risk, Denver, Colorado, November.

Meyer, H.R. 1987. "Instrumentation and Quality Control Techniques for Mill Tailings Remedial Action." Invited presentation at a U.S. Nuclear Regulatory Commission Workshop for mill owners, Denver, Colorado, June 3.

Meyer, H.R. 1987. "Relative Risks Associated with the Uranium Mill Tailings Remedial Action (UMTRA) Program." A series of public meetings held to discuss the UMTRAP radiation protection program before cleanup began. Held in Durango, Colorado, January 20; Rifle, Colorado, May 21; Gunnison, Colorado, July 7; and Mexican Hat, Utah, July 14.

Meyer, H.R. 1989. "Risk Assessment—Disposal in Arid Lands." American Association for the Advancement of Science, Southwest Chapter, topical meeting, Las Cruces, New Mexico, April 6.

Meyer, H.R. 1989. "Proposed LLRW Facility Contract Status and Schedule, Site Screening and Characterization, Design and Operation." Invited presentation, Penn State University, State College, Pennsylvania, November 4.

Meyer, H.R. 1989. "Site Screening and Characterization, Facility Design, Contract Status." Invited presentation, Sierra Club, Pennsylvania PA Chapter, and Environmental Coalition on Nuclear Power joint meeting, State College, Pennsylvania, November 18.

Meyer, H.R., V.J. Barnhart, and M.T. Ryan. 1989. "Developing a Low Level Radioactive Waste Site for the Commonwealth." A series of seven public meeting presentations throughout Pennsylvania, January–February.

Meyer, H.R. 1990. "Political, Administrative and Public Information Aspects." Invited lecture, Management and Disposal of Radioactive Wastes, Harvard School of Public Health, Boston, Massachusetts, July 18.

Meyer, H.R. 1990. "Status of Pennsylvania's Contract with Chem-Nuclear Systems." Invited presentation, Appalachian States Low-Level Radioactive Waste Compact Commission meeting, Harrisburg, Pennsylvania, September 24.

Meyer, H.R. 1990. "Status Report, Low-Level RadWaste Siting Project." Invited presentation to Pennsylvania's Citizens Low-Level Waste Advisory Committee, Harrisburg, Pennsylvania, October 5.

Meyer, H.R. 1990. "Progress Report, LLRW Siting." Presentation to CNSI's Citizens Task Force on Siting, Harrisburg, Pennsylvania, November 7.

Meyer, H.R. 1990. "Status of the Siting Plan." Presentation to CNSI's Citizens Low-Level Waste Advisory Committee, Harrisburg, Pennsylvania, December 13.

Meyer, H.R. 1991. "The LLRW Siting Plan Review Process" and "Site Design." Presentations to CNSI's Citizens Low-Level RadWaste Advisory Committee, Harrisburg, Pennsylvania, February 15.

Meyer, H.R. 1991. "Siting a Low-Level Radioactive Waste Facility for the Commonwealth." Invited presentation, Three Mile Island Alert Annual Meeting, Harrisburg, Pennsylvania, March 28.

Meyer, H.R. and T. Noel. 1991. "Progress in Siting Pennsylvania's LLRW Facility." Invited presentation, Appalachian Compact Users of Radioactive Isotopes Board of Directors Meeting, Allentown, Pennsylvania, April 10.

Meyer, H.R. 1991. "Siting a Low-Level Radioactive Waste Facility for the Commonwealth." Invited presentation, Headwaters Resource Conservation and Development Council, Clearfield, Pennsylvania, April 25.

Meyer, H.R. 1991. "Siting a Low-Level Radioactive Waste Facility for the Commonwealth." Invited presentation, East York Rotary Club, York, Pennsylvania, April 30.

Meyer, H.R. 1991. "The Pennsylvania Low-Level Radioactive Waste Facility Siting Process; Host Community Benefits." Invited presentation, NorthWest Planning Commission, Franklin, Pennsylvania, May 3.

Meyer, H.R. 1991. "The Low Level Radioactive Waste Site." Invited presentation, Limerick Community Advisory Council, Linfield, Pennsylvania, May 8.

Meyer, H.R. 1991. "Low Level Radioactive Waste." Invited presentation, Pennsylvania League of Women Voters Annual Meeting, Ligonier, Pennsylvania, May 11.

Meyer, H.R. 1991. "Siting a Low-Level Radioactive Waste Facility in Pennsylvania." Invited presentation, Peach Bottom Community Advisory Council, Peach Bottom, Pennsylvania, May 16.

Meyer, H.R. 1991. "A Program Overview for Siting the Appalachian States' LLRW Disposal Facility." Invited presentation, PELLRAD Annual Meeting, Penn State University, State College, Pennsylvania, May 23.

Meyer, H.R. 1991. "Status Report from Chem-Nuclear Systems, Inc." Invited presentation at Appalachian States Low-Level Radioactive Waste Compact Commission Meeting, Harrisburg, Pennsylvania, June 12.

Meyer, H.R., T. Loughead, K. Kingsley, and J. Barron. 1991. "The Revised Siting Plan." Invited presentation, Pennsylvania's Citizens Low-Level Waste Advisory Committee Meeting, Harrisburg, Pennsylvania, June 21.

Meyer, H.R. 1991. "Political, Administrative and Public Information Aspects." invited lecture in "Management and Disposal of Radioactive Wastes." Harvard School of Public Health, Boston, Massachusetts, July 17.

Meyer, H.R. 1991. "The Low Level Radioactive Waste Siting Process." Invited presentation at Penn State University Nuclear Concepts Program, State College, Pennsylvania, July 18.

Meyer, H.R. 1991. "Siting a Low Level Radioactive Waste Facility in Pennsylvania—Risk Communication in the Correct Direction." Opening invited paper, Plenary Session, Risk Communication for the 90's, Annual Health Physics Society National Meeting, Washington, D.C., July 22.

Meyer, H.R. 1991. "Risk Communication in the Right Direction." Invited presentation, joint meeting, American Nuclear Society Northern Ohio Section and Health Physics Society Northern Ohio Section, Independence, Ohio, September 11.

Meyer, H.R. 1991. "Low Level Radwaste Siting in Pennsylvania." Invited presentation at Appalachian Compact Users of Radioactive Isotopes breakfast for State Legislators, Harrisburg, Pennsylvania, September 24.

Meyer, H.R. 1991. "Low Level RadWaste." Invited presentation, American Nuclear Society Chapter Meeting, Allentown, Pennsylvania, September 25.

Meyer, H.R. 1991. "Status of the Low Level Radioactive Waste Project." Invited presentation at Appalachian Compact Users of Radioactive Isotopes breakfast for State Legislators, Harrisburg, Pennsylvania, October 23.

Meyer, H.R. and J. Barron. 1991. "Release of Stage One Disqualification Information." Press Conference, Pennsylvania State Capital Media Center, Harrisburg, Pennsylvania, November 13.

Meyer, H.R. and J. Barron. 1991. "Results of Stage One Disqualification." Invited presentation, meeting of Pennsylvania's Low Level Radioactive Waste Citizens' Advisory Committee, Harrisburg, Pennsylvania, November 13.

Meyer, H.R. and W. Dornsife. 1991. "Disposal of Low-Level Radioactive Waste in Pennsylvania." Invited presentation, PP&L media day, Berwick, Pennsylvania, September 26.

Meyer, H.R., K. Kingsley, and T. Loughead. 1991. "LLRW Project Overview." Presentation at bimonthly meeting of CNSI's Low Level Waste Citizens Advisory Committee, Harrisburg, Pennsylvania, June 5.

Meyer, H.R. 1992. "Siting Process Update." Invited presentation, Appalachian Compact Users of Radioactive Isotopes Board of Directors Meeting, King of Prussia, January 8.

Meyer, H.R. 1992. Series of public information presentations—status of the low level radioactive waste site selection process in Pennsylvania.

Meyer, H.R. and G. Longwell. 1992. "The Radioactive Waste Site Selection Process." Invited presentation at Leadership Lackawanna, City and County Government session, Scranton, Pennsylvania, January 9.

Meyer, H.R. 1993. Series of public information presentations—status of dose reconstruction research at the Savannah River Site.

Meyer, H.R. 1994. Series of public information workshops and presentations—status of dose reconstruction research at the Savannah River Site

Meyer, H.R. 1994. "Windblown Suspension of Plutonium from the Rocky Flats Plant." Public workshop, Boulder, Colorado, June.

Meyer, H.R. 1995. Instructor, personal computer laboratory and problem sessions, Radiological Assessments Corporation course in Chemical Risk Assessment, Kiawah Island, South Carolina, February 27–March 3.

Meyer, H.R. 1995. Series of public information workshops and presentations—status of dose reconstruction research at the Savannah River Site

Meyer, H.R. 1996. Series of presentations to the Savannah River Site Centers for Disease Control Citizens' Health Effects Subcommittee on the status of the dose reconstruction project.

Meyer, H.R. 1996. Series of public information workshops and presentations on the status of dose reconstruction research at the Savannah River Site.

Meyer, H.R. 1996. Series of presentations to the Rocky Flats Dose Reconstruction Project Citizens Health Advisory Panel on 903 area risk assessment research.

Meyer, H.R. 1997. Series of presentations to the Centers for Disease Control SRS Citizens' Health Effects Subcommittee.

Meyer, H.R. 1997. Series of public information workshops and presentations on the status of dose reconstruction research at the Savannah River Site.

Meyer, H.R. 1997. Series of presentations to the Rocky Flats Dose Reconstruction Project Citizens Health Advisory Panel on the 903 Area Risk Assessment.

Meyer, H.R. 1998. "The Savannah River Site Dose Reconstruction, a Summary." Presentations at public meetings held in Columbia and Aiken, South Carolina, and Savannah, Georgia, February 18–20.

Meyer, H.R. 1998. Instructor, Risk Assessment Modeling, RAC-sponsored public course in Radiological Risk Assessment, Seattle, Washington.

Meyer, H.R. 1999. "The Savannah River Site Dose Reconstruction Project." Presentations at public meetings held in Columbia SC, Aiken SC and Savannah GA, February 1999.

Meyer, H.R. 1999. Series of presentations to the Rocky Flats Dose Reconstruction Project Citizens Health Advisory Panel, and to members of the public, January - August, 1999.

JANET A. JOHNSON, Ph.D., CHP, CIH
SENIOR RADIATION SCIENTIST
Tetra Tech Inc. (formerly MFG, Inc.)

SUMMARY

Dr. Johnson has extensive experience in radiation health physics, specifically in the following areas:

- Radiological Site Surveys, including MARSSIM
- RSO 40-Hour Course Instructor
- Radon Measurements and Risk Assessment
- NRC License Applications for Consumer Products
- Radiation Risk Assessment
- Radiation Worker Training

Dr. Johnson has evaluated radiation exposure rate, dose and risk from facilities with residual radioactive materials from both licensed activities and from naturally occurring radioactive materials. Dr. Johnson was a member of the U.S. Environmental Protection Agency Science Advisory Board Radiation Advisory Committee (RAC) from 1995 to 2003. She chaired the EPA RAC from 1999 through 2003. During her tenure on the committee the RAC reviewed the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) and the Multi-Agency Radiation Laboratory Analytical Protocols Manual (MARLAP). Dr. Johnson is a member of Scientific Committee 64-22 of the National Council on Radiation Protection and Measurements (NCRP). She has experience in planning and conducting MARSSIM-based site surveys. She has also developed and implemented radiation safety training programs for workers and radiation safety officers. Dr. Johnson taught in the Department of Radiological Health Sciences at Colorado State University for fourteen years. She is currently working on radiological aspects of the reclamation plans for several uranium mills and has performed risk assessments for a variety of uranium recovery facilities. In addition, Dr. Johnson assessed the adequacy of the monitoring methods used at a former nuclear weapons production facility, the Rocky Flats plant, as a member of the Scientific Panel on Monitoring at Rocky Flats, an independent panel commissioned and appointed by the Governor of Colorado. Dr. Johnson is a member of the Colorado Radiation Advisory Committee and served on the Colorado Hazardous Waste Commission from 1993 to 1997. Dr. Johnson, with her colleagues at MFG, Inc. developed training manuals and visuals for radiation safety officers involved in NORM and uranium facilities. The MFG, Inc. team taught 40-hour 40-hour RSO refresher training classes in May 2003 and in May 2005.

Dr. Johnson managed the environmental health and safety program at Colorado State University from 1993 to 1995. The program included industrial hygiene, radiation protection, hazardous waste management, and biosafety.

Dr. Johnson assisted legal counsel for Rockwell International in regard to a class action suit against the corporation. Dr. Johnson served on the Westinghouse Government Operations Nuclear Safety and Environmental Oversight Committee. In that capacity she visited six of the major facilities for which Westinghouse was a contractor during the late 1980s and early 1990s.

Dr. Johnson is a Fellow of the Health Physics Society.

EDUCATION

Ph.D. Microbiology/Environmental Health, Colorado State University (1986)
M.S. Health Physics, AEC Health Physics Fellow, University of Rochester (1959)
B.S. Chemistry, University of Massachusetts (1958)

CERTIFICATIONS

- Certified in the Comprehensive Practice of Health Physics, American Board of Health Physics, 1976; Recertified 1985, 1989, 1993, 1997, 2002
- Certified Industrial Hygienist (Radiological Aspects), 1986; Recertified 1992, 1998

PROFESSIONAL SERVICE

- Colorado Radiation Advisory Committee, 1988-present
- Colorado Hazardous Waste Commission, 1993-1997
- National Academy of Sciences Committee on Low-Level Radioactive Waste Siting, New York State, 1993-1996
- EPA Science Advisory Board, Radiation Advisory Committee, 1994-2004, Chair 1999-2003
- EPA Science Advisory Board, Executive Committee, 1999 - 2003
- Governor's Rocky Flats Scientific Panel on Monitoring, 1989-1992. Chair, Radiation Committee
- NCRP Scientific Committee 64-22 (Environmental Measurements)

PROFESSIONAL SOCIETIES AND HONORS

- Health Physics Society
  Chair, Public Education Committee, 1992-1995
  Radon Section President 2000 – 2001; President-elect, 1998; Secretary Treasurer, 1996-1998
  Board of Directors – 2000 – 2002
  Fellow - 2002
- American Industrial Hygiene Association
- American Academy of Health Physics
- American Academy of Industrial Hygiene

PROFESSIONAL HISTORY

1995 - Present — MFG Inc. (formerly Shepherd Miller, Inc.) Fort Collins, Colorado

- 1998-present — Senior Technical Advisor
- 1997-1998 — Vice-president for Radiation and Risk Assessment Services
- 1995-1997 — Senior Radiation Scientist

1964 - 1995 — Colorado State University, Fort Collins, Colorado

- 1995 — Research Associate, Environmental Health Services
- 1993-1995 — Interim Director, Environmental Health Services
- 1992-1993 — Associate Director, Environmental Health Services
- 1988-1992 — Hazardous Waste Coordinator, Environmental Health Services
- 1984 — Instructor, Environmental Health and Microbiology (part time)
- 1964-1979 — Research Associate, Radiological Health Sciences (1/2 time)

1970-1995 — Western Radiation Consultants, Inc., Fort Collins, Colorado
President and Consultant

1959 — Student Intern, Brookhaven National Laboratory (3 months)

PROJECT EXPERIENCE

- Radiological Site Assessment. Background radiation measurement and assessment of impacts of uranium mill operation in regard to the reclamation plan.
- Preparation and oversight of site characterization based on MARSSIM
- Preparation of NRC license applications for consumer products. Dose assessment, development of radiological safety and regulatory compliance programs.
- Risk assessment for uranium mill reclamation plans. Preparation of dose/risk assessment under routine operating conditions and potential accident scenarios for a reclamation plan which includes accepting off-site waste byproduct material.
- Risk assessment for uranium in water. Preparation of comments in regard to EPA and Colorado Water Quality Control Commission proposed regulations for uranium in drinking water and ground water.
- Uranium Mill Tailings Remedial Action Program Health and Safety Audit. Industrial hygiene and radiation protection.
- Radon measurements. Gamma and Ambient Radon Dosimeter (GARD).
- Westinghouse Government Operations Nuclear Safety and Environmental Oversight Committee. Review of safety and environmental programs at DOE sites managed and operated by Westinghouse, including evaluation of Total Quality Management programs as they pertained to environmental protection and safety.
- Radiological Health Consultant to legal counsel for Rockwell (Rocky Flats Plant).
- Health Risk Assessment Panel Subcommittee. Preparation of toxicity profiles and radiation risk assessment (Cotter Corporation Canon City Uranium Mill)

- Development and presentation of Radiation Safety Training and Hazardous Waste Operations Training, including training and regulatory compliance for radioactive materials licensees.
- Risk assessment for Naturally Occurring Radioactive Materials (NORM).
- Managed the environmental health and safety program for Colorado State University including routine operations, strategic planning, budgeting and personnel.
- Managed environmental restoration program.
- Managed hazardous waste program for Colorado State University including routine disposal, environmental restoration and emergency response.
- Taught basic industrial hygiene course.
- Taught radiation physics and radiochemistry laboratories and radiation chemistry course.
- Occupational health and safety review for a gold mine in Peru
- Baseline radiological survey for an *in situ* uranium recovery operation in Kazakhstan.
- Taught and developed the training manual for a 40-hour radiation safety officer (RSO) training class for NORM and Uranium facilities (May 2003 and December 2003)

REPRESENTATIVE JOURNAL PUBLICATIONS AND PROCEEDINGS

Johnson, J.A. Riding the RCRA Roller Coaster - Adventures in closing a micro-mixed waste site. Managing Radioactive and Mixed Waste, *Proceedings of the Twenty-seventh Midyear Topical Meeting of the Health Physics Society.* February 1994.

Johnson, J.A., R.M. Buchan and J.S. Reif. Effect of waste anesthetic gas and vapor exposure on reproductive outcome in veterinary personnel. *American Industrial Hygiene Association Journal* 48(1): 62-66, 1987.

Johnson, J.E. and J.A. Johnson: Radioactivity and detection limit problems of environmental surveillance at a gas-cooled reactor. *ACS symposium Series 361, detection in Analytical Chemistry, Importance, Theory, and Practice.* American Chemical Society, Washington, DC, 1988.

Borak, T.B., J.A. Johnson and K.J. Schiager. A comparison of radioactivity and silica standards for limiting dust exposures in uranium mines. In *Radiation Hazards in Mining: Control, Measurement and Medical Aspects*, M. Gomez, ed. Society of Mining Engineers. New York, NY, 1981.

Borak, T.B., E. Franko, K.J. Schiager, J.A. Johnson and R.F. Holub. Evaluation of recent developments in radon progeny measurements. In *Radiation Hazards in Mining: Control, Measurement and Medial Aspects,* M. Gomez, ed. Society of Mining Engineers, New York, NY, 1981.

Johnson, J.A., K.J. Schiager, T.B. Borak. Contribution of human errors to uncertainties in radiation measurements and implications for training. In Radiation *Hazards in Mining:*

Control, Measurement and Medical Aspects, M. Gomez, ed. Society of Mining Engineers, New York, NY, 1981.

Schiager, J.J., J.A. Johnson and T.B. Borak. Radiation monitoring priorities for uranium miners. In *Radiation Hazards in Mining: Control, Measurement and Medical Aspects*, M. Gomez, ed. Society of Mining Engineers, New York, NY, 1981.

Johnson, J.A. "Basic Radiation Protection for Use of Radionuclides in Laboratories," 1991. Teaching manual for forty-hour course.

Johnson, J.A. "Radiation Protection for Uranium Mills," 1997 (Revised 2000). Teaching manual for forty-hour course.

REPORTS

Hersloff, J., J.A. Johnson and S. Ibrahim. *Radiological Risk Assessment of Abandoned Mine Lands, Radium Land Clean-up Standard.* Wyoming Department of Environmental Quality, 1988.

Borak, T.B. and J.A. Johnson. *Estimating the Risk of Lung cancer from Inhalation of Radon Daughters Indoors: Review and Evaluation.* Colorado State University for USEPA, 1988.

Schiager, K.J., T.B. Borak and J.A. Johnson. *Radiation Monitoring for Uranium Miners: Evaluation and Optimization.* U.S. Department of the Interior, Bureau of Mines. Final Report on contract.

TECHNICAL PRESENTATIONS:

Dr. Johnson has presented numerous technical papers at Health Physics Society Annual Meetings, Mid-year Symposia, Mill Tailings Conferences, American Industrial Hygiene Association Conferences, European Conferences and a meeting of the American Veterinary Medicine Association. She presented a paper and a poster summary at a conference on uranium in groundwater in Freiburg Germany (1998) and presented an invited paper at a SCOPE Radsite meeting in Munich in September 2000. Dr. Johnson presented an invited paper on the effects of radon and smoking at the American Radiation Safety Conference and Exposition in San Diego in June 2003.

CRAIG A. LITTLE

896 Overview Rd.
Grand Junction, Colorado 81506
970-260-2810 (cell) 309-214-2569 (efax)
craig.little@mfgenv.com

PROFESSIONAL EXPERIENCE

2002 – pres	Sr. Scientist, Tetra Tech Inc. (formerly MFG, Inc.). Conduct radiation risk assessments, dose calculations and field assessments of radioactivity for a variety of clients nationwide. Projects include field surveys of contaminated sites to design cleanup plans and to assure remedial action effectiveness, calculation of potential radiation dose and risk to members of the public and workers at radiation sites, and development of presentations to summarize results to public meetings. Write project proposals, develop work plans and cost estimates, produce site investigation reports, and write monthly reports. Manage projects.
2000 – 2001	Manager, Western Operations, Advanced Infrastructure Management Technologies, a division of the Department of Energy's Y-12 National Security Complex, Oak Ridge, Tennessee. Responsible for twenty-five project managers in offices in Grand Junction, Colorado; Sacramento, California; and Lancaster, California. Projects included a variety of site assessment, risk analysis, and infrastructure improvements at numerous federal facilities nationwide. Projects were funded by Dept. of Energy, Dept. of Defense, Environmental Protection Agency, and others.
1983 – 2000	Leader, Environmental Technology Section (ETS), Life Sciences Division, Oak Ridge National Laboratory located in Grand Junction. Originally established the group to support USDOE Uranium Mill Tailings Remedial Action Project (UMTRAP). Staff developed and applied technologies and methodologies to remedy chemical and radiological pollution at numerous locations nationwide. Section staff conducted over 12,000 field surveys of contaminated properties nationwide. Projects were funded by Dept. of Defense, Dept. of Energy, and other agencies.
1987 – 1998	Adjunct Professor, Department of Radiological Health Sciences, Colorado State University. Served on graduate research committees.
Fall 1979	Guest scientist, Federal Health Office, Munich, Federal Republic of Germany. Assisted in planning and implementing monitoring system for actinides released from nuclear power plants in the Federal Republic.
1976 – 1982	Research Staff, Health and Safety Research Division, ORNL. Developed and applied computer codes to predict transport of nuclear and non-nuclear pollutants through the environment and subsequent impacts on ecosystems and human systems. Conducted research to assess the accuracy of environmental transport models.
Fall 1976	Environmental Research Assistant, Department of Radiology and Radiation Biology, Colorado State University. Collected environmental samples of plutonium for analysis; analyzed, reduced and summarized subsequent data for publication.

EDUCATION AND TRAINING

1976	Ph.D., Radioecology. Department of Radiology and Radiation Biology, Colorado State University, Ft. Collins, CO. Dissertation title: *Plutonium in a Grassland Ecosystem.*
1971	M.S., Radiation Biology/Health Physics. Department of Radiology and Radiation

	Biology, Colorado State University, Ft. Collins, CO.
1970	B. A., Biology. McPherson College, McPherson, KS.
1996	Leading Out Loud. TPG/Learning Systems. Knoxville, Tennessee.
1993	The Effective Executive. American Management Association, New York, NY
1990	Strategic Planning. American Management Association, New York, NY.
1989	Senior Project Management. American Management Association, New Your, NY.
1987	Cost and Schedule Control Systems Criteria (C/SCSC). Humphreys and Associates, Santa Clara, CA. Included project planning, work breakdown structures, and control systems.
1986	The Management Course. American Management Association, New York, NY. Four week course covering all aspects of management including financial analysis of businesses, human resource management, and business simulation.
1980	Modeling of Groundwater Flow. Holcomb Research Institute, Butler University, Indianapolis, IN. Two week course on computer models of groundwater flow.

PUBLICATIONS AND PRESENTATIONS

Author or co-author of more than seventy reports, journal articles, and book chapters on topics such as risk analysis, environmental transport processes, pollutants in the environment, radiological assessments, and computer programming. Presented numerous papers at professional meetings, as both contributing and invited speaker. Served on Oak Ridge Associated Universities speakers bureau for several different terms.

OTHER ACTIVITIES

2003 - pres	Member, Board of Directors, Marillac Clinic. Provides low-cost medical, dental and vision care to uninsured, low-income patients. Previously served as board president in earlier term.
1999 - pres	Member, Board of Trustees, McPherson College, McPherson, Kansas
2000 - 2003	Member, Board of Directors, Health Physics Society
1998 - 2001	Member, Board of Directors, Joint Utilization Commission and Riverview Technology Corp.; groups founded to negotiate and receive the DOE/Grand Junction property into private, non-for-profit ownership.
1991 - pres	Associate Editor, *Health Physics* journal.
2005 - pres	Editor-in-Chief, *Operational Radiation Safety* journal.
1996 - 2001	Member, Victim-Witness/Law Enforcement Board, Mesa County District Court. Provide court-raised funds to victim advocacy/services organizations.
1997 - 1999	Member, Environmental Pathways Modeling Working Group of Health Physics Standards Committee
1996 - 1999	Member, Program Committee, Health Physics Society.
1995 - 1999	Member, Program Advisory Board of Foster Grandparents, Inc. Served as Chair.
1994 - 1996	Member, Board of Directors, Environmental Radiation Section, Health Physics Society.
1991 - 1996	Member, Board of Directors, Public Radio of Colorado, Inc., operator of Colorado Public Radio network.
1990 - 1996	Member, Nominating Committee, Health Physics Society. Chair, 1994-1996.

1989 - 1995	Member, Board of Directors, Mesa County United Way. President, 1993-1994.
1987 - 1990	Chair, Public Information Committee, Environmental Radiation Section, Health Physics Society.
1988 - 1991	Member, Board of Directors, Chemrad Tennessee, Inc., manufacturer of ultrasonic-based system for transmitting environmental data to computers in the field.
1987 - 1991	Chairman, Board of Directors, Western Colorado Public Radio, Inc., operator of public radio station KPRN. Development and Planning chairman.
1986 - 1987	Member, Mesa County (CO) Task Force to Evaluate the Aid to Families with Dependent Children (AFDC) Program. Edited final report of task force.

Designer and Manufacturer of Scientific and Industrial Instruments

7 1

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257407/303341

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 98616

Cal. Date 21-Jun-06 Cal Due Date 21-Jun-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 48 % Alt 697.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☑ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity

☑ F/S Resp. check ☑ Reset check ☑ Window Operation

☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC

☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check

☑ Data Log check ☑ Overload check ☑ Scaler Readout check Threshold Dial Ratio 100 = 10 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 497 V Ref./Inst. 2000 / 1996 V

COMMENTS: Firmware: 37122N26
ID Firmware: 37123N05
Resolution for Cs-137 ≈ 10%
Calibrated w/39" cable.
No as-founds (Loss of memory)

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR-102508	1000	100	7 / 1	1.629357E-05	1.000000E+00	
Detector # 2	LMI44-10	PR-102508	1000	100	4 / 2	1.629357E-05	5.568443E+10	✓
Detector # 3	PEAK	CS-137	694	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	40012 (0)	40012 (0)	400cpm	40 (0)	40 (0)
	40kcpm	4011 (5)	4011 (5)	40cpm	4 (5)	4 (5)
	4kcpm	401 (2)	401 (2)			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978.
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☑ Alpha S/N ☐ Beta S/N ☑ Other Am 241 ≈ 0.7μCi

☑ m 500 S/N 50800 ☑ Multimeter S/N 83990502

Calibrated By: Charles Disk Date 21 Jun 06

Reviewed By: [signature] Date 22 June 06

FORM C44A 11/26/2003

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

MFG-3

CUSTOMER MFG INC ORDER NO. 263479/306131

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 98631

Cal. Date 25-Sep-06 Cal Due Date 25-Sep-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 33 % Alt 708.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1997 V

COMMENTS: *Firmware: 37122N26*

I/O firmware:37123n05 Instrument calibrated with 39" C cable
resolution for Cs-137 9%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	RN011772	850	100	4 / 2	1.498379E-05	5.549865E+10	
Detector # 2	LMI44-10	RN011772	850	100	7 / 1	1.498379E-05	1.000000E+00	
Detector # 3	CS-137	662KEV	599	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	399243	399243	400cpm	399	399
	40kcpm	39926	39926	40cpm	40	40
	4kcpm	3993	3993			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N ☐ S-394 ☐ 1122 ☐ 781
☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304
☐ Alpha S/N ☐ Beta S/N ☑ Other Am-241 ~0.77uCi
☑ m 500 S/N 121025 ☑ Multimeter S/N 78846185

Calibrated By: [signature] Date 25-Sep-06
Reviewed By: [signature] Date 25 Sep 06

FORM C44A 06/02/2006

Designer and Manufacturer of Scientific and Industrial Instruments

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CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257271 / 303277

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 120625

Cal. Date 19-Jun-06 Cal Due Date 19-Jun-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☑ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity

☑ F/S Resp. check ☑ Reset check ☑ Window Operation

☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC

☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold

☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 2000 / 1998 V

COMMENTS: *Firmware: 37122N28*

I/O Firmware: 37123N05

No "As Found" readings because of M2350-1 memory loss.

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 9.37%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR122614	900	100	4 / 2	1.290054E-05	5.418134E+10	✓
Detector # 2	LMI44-10	PR122614	900	100	7 / 1	1.290053E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	605	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm		39922 (0)	400cpm	N/A	40 (0)
	40kcpm	N/A	3994	40cpm		4
	4kcpm		400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241 ≈ 0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Ceballos Date 19-Jun-06

Reviewed By: [signature] Date [illegible]

FORM C44C 11/26/2003

Designer and Manufacturer of Scientific and Industrial Instruments

#5

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257273 / 303278

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 129426

Cal. Date 16-Jun-06 Cal Due Date 16-Jun-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 70 °F RH 36 % Alt 699.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Threshold Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 1996 V

COMMENTS: *Firmware: 37122N21*

I/O Firmware: 37123N05

Resolution for Cs137 ≈ 9.67%.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135855	1050	100	4 / 2	1.461701E-05	5.414237E+10	✓
Detector # 2	LMI44-10	PR135855	1050	100	7 / 1	1.461701E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	708	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 -- rad, 1 -- Gray, 2 -- rem, 3 -- Sv, 4 -- R, 5 -- C/Kg, 6 -- Disintegrations, 7 -- Counts, 8 -- Ci/cm sq., 9 -- Bq/cm sq.
Time Base: 0 -- Seconds, 1 -- Minutes, 2 -- Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	39978 (0)	39978 (0)	400cpm	40 (0)	40 (0)
	40kcpm	3996	3996	40cpm	4 ↓	4 ↓
	4kcpm	400 ↓	400 ↓			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈ 0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Cebalos Date 16-Jun-06
Reviewed By: [signature] Date 19 Jun 06

FORM C44C 11/26/2003 This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

MFG-6

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 263479/306131

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 152361

Cal. Date 22-Sep-06 Cal Due Date 22-Sep-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 24 % Alt 693.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity

☑ F/S Resp. check ☑ Reset check ☑ Window Operation

☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC

☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check

☑ Data Log check ☑ Overload check ☑ Scaler Readout check Threshold Dial Ratio 100 = 10 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1995 V

COMMENTS: *Firmware: 37122N24*

I/O firmware:37123n05 Instrument calibrated with 39" C cable

resolution for Cs-137 11%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR121036	1100	100	4 / 2	1.594473E-05	5.359899E+10	
Detector # 2	LMI44-10	PR121036	1100	100	7 / 1	1.594473E-05	1.000000E+00	
Detector # 3	CS-137PK	662KEV	799	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout

REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400kcpm	400354	400354	400cpm	400	400
40kcpm	39994	39994	40cpm	40	40
4kcpm	3999	3999			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N ☐ S-394 ☐ 1122 ☐ 781

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am-241 =0.77μCi

☑ m 500 S/N 121025 ☑ Multimeter S/N 78846185

Calibrated By: [signature] Date 22-Sep-06

Reviewed By: [signature] Date 25 Sep 06

FORM C44A 06/02/2006

MFG #8

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 261133 / 304908

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 134759

Cal. Date 24-Aug-06 Cal Due Date 24-Aug-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 40 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☑ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 2000 / 1997 V

COMMENTS: *Firmware: 37122N28*

I/O Firmware: 37123N05

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 10.12%

No "As Found" readings because of M2350-1 memory loss.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR139483	950	100	4 / 2	1.218875E-05	5.244675E+10	✓
Detector # 2	LMI44-10	PR139483	950	100	7 / 1	1.218874E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	672	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	N/A	39966 (0)	400cpm	N/A	40 (0)
	40kcpm		3997	40cpm		4
	4kcpm		400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈ 0.83 μCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Ceballos Date 24-Aug-06

Reviewed By: [signature] Date 25 Aug 06

FORM C44C 11/26/2003

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

MFG-9

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER: MFG INC — ORDER NO. 263479/306131

Mfg. Ludlum Measurements, Inc. — Model 2350-1 — Serial No. 129403

Cal. Date 22-Sep-06 — Cal Due Date 22-Sep-07 — Cal. Interval 1 Year — Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 24 % Alt 693.8 mm Hg

☐ New Instrument — Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check
☑ Data Log check ☑ Overload check ☑ Scaler Readout check — Threshold Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 1997. V

COMMENTS: *Firmware: 37122N21*
I/O Firmware:371230n5 Instrument calibrated with 39"C cable
Resolution for Cs-137 11%
Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135858	1150	100	4 / 2	1.307108E-05	5.294387E+10	
Detector # 2	LMI44-10	PR135858	1150	100	7 / 1	1.307108E-05	1.000000E+00	
Detector # 3	CS-137PK	662KEV	821	662	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours
* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	400222	400222	400cpm	400	400
	40kcpm	39977	39979	40cpm	40	40
	4kcpm	3998	3998			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N ☐ S-394 ☐ 1122 ☐ 781
☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304
☐ Alpha S/N ☐ Beta S/N ☑ Other Am-241 ~0.77uCi
☑ m 500 S/N 121025 ☑ Multimeter S/N 78846185

Calibrated By: [signature] Date 22-Sep-06
Reviewed By: [signature] Date 25 Sep 06

FORM C44A 06/02/2006

MFG-12

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257557 / 303433

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 134764

Cal. Date 13-Jul-06 Cal Due Date 13-Jul-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 49 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☑ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 1997 V

COMMENTS: *Firmware: 37122N21*

I/O Firmware: 37123N05

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 9.52%

No "As Found" readings because of M2350-1 memory loss.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR139484	900	100	4 / 2	1.259847E-05	5.465646E+10	✓
Detector # 2	LMI44-10	PR139484	900	100	7 / 1	1.259846E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	596	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	N/A	39989(0)	400cpm	N/A	40(0)
	40kcpm		3995	40cpm		4
	4kcpm		400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Cepalls Date 13-Jul-06

Reviewed By: [signature] Date 13 Jul 06

FORM C44C 11/26/2003

Designer and Manufacturer of Scientific and Industrial Instruments

MFG #13

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. ~~261133/304908~~ 261654 / 305206

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 129434

Cal. Date 24-Aug-06 Cal Due Date 24-Aug-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 40 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 2000 / 1999 V

COMMENTS: *Firmware: 37122N21*

I/O Firmware: 37123N05

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 9.97%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135854	1050	100	4 / 2	1.450212E-05	5.233001E+10	✓
Detector # 2	LMI44-10	PR135854	1050	100	7 / 1	1.450211E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	721	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	39979(0)	39979(0)	400cpm	40(0)	40(0)
	40kcpm	3993 ↓	3993 ↓	40cpm	4 ↓	4 ↓
	4kcpm	400 ↓	400 ↓			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: *Sebastn Ceballos* Date 24-Aug-06

Reviewed By: *[signature]* Date 25 Aug 06

FORM C44C 11/26/2003

MFG-15

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257557 / 303433

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 134768

Cal. Date 13-Jul-06 Cal Due Date 13-Jul-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 49 % Alt 701.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 1997 V

COMMENTS: *Firmware: 37122N21*

I/O Firmware: 37123N05

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 10.42%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR139491	1100	100	4 / 2	1.379348E-05	5.412704E+10	✓
Detector # 2	LMI44-10	PR139491	1100	100	7 / 1	1.379348E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	751	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	39990 (0)	39990 (0)	400cpm	40 (0)	40 (0)
	40kcpm	3997 ↓	3997 ↓	40cpm	4 ↓	↓
	4kcpm	400 ↓	400 ↓			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastian Ceballos Date 13-Jul-06

Reviewed By: [signature] Date 13 July 06

FORM C44C 11/26/2003

17-16

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257271 / 303277

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 129405

Cal. Date 19-Jun-06 Cal Due Date 19-Jun-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☑ Other-See comments

☑ Mechanical check ☑ Input Sens. Linearity
☑ F/S Resp. check ☑ Reset check ☑ Window Operation
☑ Audio check ☑ Alarm Setting check ☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check ☑ Integrated Dose check ☑ Recycle Mode check Threshold
☑ Data Log check ☑ Overload check ☑ Scaler Readout check Dial Ratio 100 = 10 mV
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 1996 V

COMMENTS:

Firmware: 37122N21

I/O Firmware: 37123N05

No "As Found" readings because of M2350-1 memory loss.

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 9.82%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR137085	900	100	4 / 2	1.444180E-05	5.491888E+10	✓
Detector # 2	LMI44-10	PR137085	900	100	7 / 1	1.444180E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	583	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	N/A	39977(0)	400cpm	N/A	40(0)
	40kcpm		3993	40cpm		4
	4kcpm		400			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈ 0.83 µCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Ceballos Date 19-Jun-06

Reviewed By: [signature] Date 19 Jun 06

FORM C44C 11/26/2003

Designer and Manufacturer of Scientific and Industrial Instruments

17

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER MFG INC ORDER NO. 257271 / 303277

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 120630

Cal. Date 19-Jun-06 Cal Due Date 19-Jun-07 Cal. Interval 1 Year Meterface N/A

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 700.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical check
☑ Input Sens. Linearity
☑ F/S Resp. check
☑ Reset check
☑ Window Operation
☑ Audio check
☑ Alarm Setting check
☑ Battery check (Min. Volt) 4.4 VDC
☑ Ratemeter Linearity check
☑ Integrated Dose check
☑ Recycle Mode check
Threshold Dial Ratio 100 = 10 mV
☑ Data Log check
☑ Overload check
☑ Scaler Readout check
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.
☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

☑ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 2000 / 2001 V

COMMENTS: *Firmware: 37122N21*

I/O Firmware: 37123N04

Calibrated using 39" C-cable.

Resolution for Cs137 ≈ 9.21%

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

	Probe Model	Serial #	High Voltage	Threshold	Units/ Time Base	Dead Time Correction Factor	Calibration Constant	Linearity ±10%*
Detector # 1	LMI44-10	PR135847	900	100	4 / 2	1.313019E-05	5.377700E+10	✓
Detector # 2	LMI44-10	PR135847	900	100	7 / 1	1.313018E-05	1.000000E+00	
Detector # 3	CS137PK	662KEV	566	642	7 / 1	0.000000E+00	1.000000E+00	
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								
Detector #								

Units: 0 – rad, 1 – Gray, 2 – rem, 3 – Sv, 4 – R, 5 – C/Kg, 6 – Disintegrations, 7 – Counts, 8 – Ci/cm sq., 9 – Bq/cm sq.
Time Base: 0 – Seconds, 1 – Minutes, 2 – Hours

* See attached detector documentation, if applicable.

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400kcpm	39958 (o)	39959 (o)	400cpm	40 (o)	40 (o)
	40kcpm	3996	3996	40cpm	4 ↓	4 ↓
	4kcpm	400 ↓	400 ↓			

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 Gamma S/N

☐ 1162 ☐ G112 ☑ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241≈ 0.83 μCi

☑ m 500 S/N 81084 ☑ Multimeter S/N 78401030

Calibrated By: Sebastn Ceballos Date 19-Jun-06

Reviewed By: [signature] Date 19 Jun 06

FORM C44C 11/26/2003

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type:	100 mR/Hr
Serial Number:	98100046
Calibration Date:	9/8/06
Sensitivity:	12.24 mV/μR/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type: 100 mR/Hr

Serial Number: 98100046

Calibration Date: 9/8/06

Customer Name: MFG

Sensitivity (Ra-226): 12.24 mV/μR/h

Source (CS-137): BB-400

Date of Certification: 12/1/94

Exposure Rate at 1 meter: 4.226 mR/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	μR/h	V	V	V	mV/μR/h
11.8	359	244.936	3.840	0.807	3.033	12.38
13.8	420	178.300	2.913	0.708	2.205	12.37
15.8	481	135.430	2.307	0.631	1.676	12.38
17.8	542	106.250	1.887	0.571	1.316	12.39

k(CS-137) = 12.38 mv/μR/h

k(Ra-226) = .9892 k(CS-137)

k(Ra-226) = 12.24 mv/μR/h

$\bar{k}$ = 12.38 mv/μR/h

σ = .009 mv/μR/h

$V = \frac{\hat{\sigma}}{\bar{k}} =$ 0.075%

By: Wm Radwanski

Date: 9/15/06

Reuter-Stokes

RSS-131 FIRMWARE PARAMETERS

S/N 98I00046

RAC	2.497E-08
ZLN	0.000E-00
ZMN	5.513E-02
ZHN	2.431E-04
ZLD	0.000E-00
ZMD	3.720E-05
ZHD	-5.600E-06
RLN	4.901E+11
RMN	2.016E+09
RHN	1.998E+07
RLV	-1.150E+08
RMV	2.520E+05
RHV	3.030E+03

Only change in constants is the RAC.
As found RAC 2.536E-08.

By: Wm Radwanski
Level 2 Nuclear / Electrical Inspector

Date: 9/15/06

Reviewed By: Ken Lambach
Senior Engineer

Page 1 of 2

CHAIN OF CUSTODY RECORD
REQUEST FOR ANALYSIS

MFG, Inc.
3801 Automation Way #100
Fort Collins, CO 80525
(970) 223-9600 Fax (970) 223-7171

MFG consulting scientists and engineers

Client/Project Name: Red Desert

MFG, Inc. Contact / Phone Number: Randy Whicker / 970-556-1174

Project Number: 181445 P.O. Number: 181445-10-5-06

Delivery Method / Shipping Document Number:

Send Results / Report To: Randy Whicker, MFG Inc., 3801 Automation Way, Suite 100, Ft. Collins, CO 80525

Sampler (Print Name / Affiliation): Randy Whicker

Signature: [signature]

Analysis Requested: Ra-226 by HPGe Gamma spec; U-nat by wet Radiochemistry methods

Preservative

Container Type and Size

Field Sample No./ Identification	Date	Time	Sample Matrix	Total No. of Cont.	Ra-226	U-nat	Filt. Y N	Filt. Y N	Filt. Y N	Filt. Y N	Remarks
LC-1	9-29-06		Soil		X	X					These are composite samples -
LC-2	↓		↓		X	X					please dry, crush and grind
LC-3					X	X					all rocks, and thoroughly
LC-4					X	X					homogenize each sample.
LC-5					X	X					
LC-6					X	X					For Ra-226, allow 21 days
LC-7					X	X					after sealing containers
LC-8					X	X					to insure Rn-222 equilibrium
LC-9					X	X					
LC-10					X	X					

Relinquished by: (Print Name/Affiliation)	Date/Time	Received by: (Print Name/Affiliation)	Date/Time
Randy Whicker / MFG; Signature: [signature]	Date: 10-5-06; Time:	Received by: ; Signature:	Date: ; Time:
Relinquished by: ; Signature:	Date: ; Time:	Received by: ; Signature:	Date: ; Time:
Relinquished by: ; Signature:	Date: ; Time:	Received by: ; Signature:	Date: ; Time:

Analytical Laboratory (Destination): Energy Laboratories Incorporated, 2393 Salt Creek Highway, Casper, WY 82602

Condition/Temperature of Samples when Received:

Serial No.: № 005662

White: Return to MFG, Inc. Yellow: Laboratory Pink: Field Team

Matrix Codes: SW=Surface Water GW=Ground Water S=Soil Sediment ___ = ______

CHAIN OF CUSTODY RECORD
REQUEST FOR ANALYSIS

MFG, Inc.
3801 Automation Way #100
Fort Collins, CO 80526
(970) 223-9600 Fax (970) 223-7171

consulting scientists and engineers

Client/Project Name: Red Desert

MFG, Inc. Contact / Phone Number: Randy Whicker 1970-556-1174

Project Number: 181445

P.O. Number: 181445-10-5-06

Delivery Method / Shipping Document Number:

Send Results / Report To:
Randy Whicker
MFG Inc.
3801 Automation Way, suite 100
Ft. Collins, CO 80525

Sampler (Print Name / Affiliation): Randy Whicker

Signature: [signature]

Analysis Requested: Ra-226 by HPGe Gamma-Spec; U-Nat by wet Radiochemistry methods

Preservative

Container Type and Size

Field Sample No./ Identification	Date	Time	Sample Matrix	Total No. of Cont.	Ra-226 by HPGe Gamma-Spec	U-Nat by wet Radiochemistry methods	Filt. Y N	Filt. Y N	Filt. Y N	Filt. Y N	Remarks
LS-1	9-27-06		Soil		X	X					- Please follow special
LS-2	↓		↓		X	X					instructions on
LS-3	↓		↓		X	X					page 1 of 2
LS-4	↓		↓		X	X					
LS-5	9-28-06		↓		X	X					
LS-6	↓		↓		X	X					
LS-7	↓		↓		X	X					
LS-8	↓		↓		X	X					
LS-9	↓		↓		X	X					
LS-10	↓		↓		X	X					

Relinquished by: (Print Name/Affiliation)	Date / Time	Received by: (Print Name/Affiliation)	Date / Time
Randy Whicker / MFG; Signature: [signature]	Date: 10-5-06; Time:	Signature:	Date: ; Time:
Signature:	Date: ; Time:	Signature:	Date: ; Time:
Signature:	Date: ; Time:	Signature:	Date: ; Time:

Analytical Laboratory (Destination):
Energy Laboratories, Inc
2393 Salt Creek Highway
Casper, WY 82602

Condition/Temperature of Samples when Received:

Serial No.: № 005663

White: Return to MFG, Inc. Yellow: Laboratory Pink: Field Team

Matrix Codes: SW=Surface Water GW=Ground Water S=Soil Sediment ___ = ___

2

8-28-06

Rhino-1 (main with winch)

	L	C	R
meter:	MFG-12	MFG-15	MFG-3

Rhino-2 (2nd ATV)

L	C	R
MFG-9	MFG-5	MFG-6

8-29-06 sunny, mild ≈75°F

- Mobilized to Red Desert: arrived @ Lost Creek Site ≈ 10:30 am
- set up Rhinos & system checks
- ironing out problems most of day
- 3 ft & 6 ft grid meas.

8-30-06 RW

- switched detector MFG-9 on Rhino-2 (MFG-9 reading low)
- QC

		mean	σ	Battery	
(L)	MFG-12	24.61	1.12		Rhino-1 after scans
(R)	MFG-3	23.8	0.93	5.6	
(C)	MFG-15	23.64	0.91	5.9	

3

QC (BKG)

		mean	σ	Battery	
(L)	MFG-17	23.4	5.5	5.7	Rhino-2 after scans
(C)	MFG-5	21.7	7.3	5.4	
(R)	MFG-6	19.9	4.6	5.7	

loose switch needs repair

8-31-06 RW sunny mild, windy

QC	BKG x̄	σ	Source x̄	σ	Battery
(L) MFG-12	24.5	1.04	126.0	2.0	5.9
(R) MFG-3	22.5	5.3	112.4	26	6.0
(C) MFG-15	24.5	0.8	111.1	37	5.7
(L) MFG-17	21.5	9.1	118	2.3	5.8
(C) MFG-5	25.2	1.1	109	2.5	6.2
(R) MFG-6	20.4	4.7	92	21	5.8

9-1-06 RW sunny, mild, windy

QC	BKG x̄	σ	Source x̄	σ	Battery
Rhino-1 MFG-12	24.9	1.1	122	2.5	5.7
MFG-3	21.5	9.1	110	25.3	5.8
MFG-16	22.0	7.4	115	2.7	5.9
MFG-17	26.0	0.9	113	26	6.2
MFG-5	22.0	7.4	110	25	6.0
MFG-6	21.6	5.1	123	2.4	6.2

switched detector 15 for detector 16 → bad switch

→ switched detector 6 for detector 15 - detector 6 is broken

4

9-6-06 RW Cloudy mild

- returned ATV's to site after repairs & revision of design & systems

Left - QC for Rhino-2

MFG-17	BKG x̄	Source x̄	ore rock x̄	σ
1	24	83	1887.5	143
2	24.7	82.4		
3	24.9	81.9		
4	24.3	82.6		
5	25.0	80.5		
6	24.8	81.7		
7	24.6	82.6		
8	24.8	80.7		
9	24.6	80.9		
10	24.1	81.9		

Right

MFG-4	BKG x̄	Source x̄	ore rock x̄	σ
1	23.4	70.3	2312	28
2	24.1	69.2		
3	24.1	69.8		
4	24.0	69.0		
5	24.3	69.9		
6	23.7	69.9		
7	23.8	69.2		
8	23.8	69.5		
9	23.8	69.5		
10	23.9	69.6		

5

center

MFG-5	BKG (x̄)	Source (x̄)	ore rock x̄	σ
1	24.6	73.7	2500	13
2	24.0	74.0		
3	23.4	75.6		
4	23.7	73.4		
5	24.1	73.8		
6	24.2	72.9		
7	23.9	74.6		
8	24.5	73.4		
9	23.7	71.7		
10	24.2	74.0		

9-7-06 RW P. sunny, mild, breezy

QC Rhino-2

		x̄ (Bkg)	x̄ (Source)	Battery
Left	MFG-17	25.9	82.4	6.2
Right	MFG-4	25.0	71.2	6.0
Center	MFG-5	23.8	73.5	6.0

9-7-06 Cont...

Rhino-1 Control Limit measurements:

Left MFG-12

	BKG	Source	$\bar{x}$	ore 6	Battery
					5.8
1	24.9	89.6	2255	304	
2	25.0	89.9			
3	25.1	88.7			
4	25.1	90.4			
5	24.8	88.3			
6	24.4	88.0			
7	24.6	88.8			
8	24.4	87.7			
9	23.9	88.8			
10	24.1	88.2			

Right MFG-15 — 6.0

1	24.8	84.3	2335	32
2	24.8	84.8		
3	24.5	84.1		
4	25.0	84.6		
5	24.9	84.7		
6	24.2	82.6		
7	24.4	83.1		
8	25.1	84.9		
9	24.4	83.8		
10	25.1	83.7		

Software says Right, but active meter is Center.

Center MFG-3

	BKG	Source	$\bar{x}$	ore 6	Battery
1	25.5	76.0	2114	8.6	5.9
2	24.9	75.3			
3	25.4	76.5			
4	25.1	75.9			
5	25.1	76.7			
6	25.4	76.1			
7	25.0	77.0			
8	25.2	76.5			
9	24.9	76.5			
10	24.9	76.0			

9-8-06 RW Cloudy/Hazy mild ≈ 70°F

QC Rhino-2		$\bar{x}$ (bkg)	$\bar{x}$ (source)	Battery
Left	MFG-1	23.4	60.1	6.0
Right	MFG-4	24.7	74.23	
Center	MFG-5	software not reading MFG-5		

Rhino-1			
Left	MFG-12	23.8	89.4
Right	MFG-15	24.4	85.6
Center	MFG-3	25.3	78.5

Replaced meter 17 w/ meter 1

9-9-06 RW cloudy cool, rain

QC Rhino-1		Bkg	Source
Left	MFG-12	24.0	115.1
Right	MFG-15	23.9	119.1
Center	MFG-16	24.7	116.0

(Replaced MFG-3 w/ MFG-16)

* made all detector geometries same for Cs-137 source.

QC Rhino-2			
Left	MFG-1	22.8	100.6
Right	MFG-4	24.3	108.6
Center	MFG-5	24.7	115.0

→ wiring switched Right is center & visa versa in software

9-10-06 RW sunny, mild

QC Rhino-1		BKG	Source	Battery
Left	MFG-12	24.8	116	>6
Center	MFG-15	25.1	120	>6
Right	MFG-16	25.5	118	>6

QC Rhino-2		Bkg	source
Left	MFG-1	23.9	105
Center*	MFG-4	N/A	N/A
Right (center)	MFG-5	25.6	114

*note: "center" is the right side detector which is not working

"Right is the center detector which is working

9-11-06 RW sunny, mild

QC Rhino-1		BKG	Source
Left	MFG-12	27.2	117
Center	15	27.1	124
Right	16	26.8	119

QC Rhino-2		BKG	Source
L	MFG-1	24.9	106
C	MFG-4	N/A	N/A
R	MFG-5	27.8	114

(center detector is actual detector)

Lost Soldier – new staging location

9-19-06 RW Sunny mild ≈ 70°F

QC Rhino-1		BK	Source
Left	MFG-12	18.1	113
Center	MFG-16	19.4	112
Right	MFG-15	19.3	116

QC Rhino-2		BKG	Source
Left	MFG-1	19.4	101
Center	MFG-5	20.0	110
Right	MFG-4	21.3	106

9-20-06 RW P. Cloudy mild

same detectors as day before

Rhino-1 / Rhino-2

Left		BKG	Source		BKG	Source
9-20	1	21.4	115	9-20	18.0	99
9-25	2	19.5	115	9-25	18.8	100
9-26	3	19.7	118	9-26	17.7	99
	4	19.6	116		17.7	99
	5	19.5	118		18.3	99
	6	18.3	116		19.8	101
	7	18.3	114		19.6	98
	8	18.1	117		19.7	99
	9	19.6	116		19.6	99
	10	19.7	116		19.3	100

Center		BKG	Source		BKG	Source
9-20	1	18.0	109	9-20	18.3	111
9-25	2	18.0	113	9-25	20.2	111
9-26	3	17.7	106	9-26	20.4	108
	4	18.7	113		20.3	110
	5	18.3	112		21.4	111
	6	19.6	113		21.4	108
	7	19.4	112		21.9	111
	8	19.5	109		21.8	108
	9	18.1	110		20.6	112
	10	19.0	110		20.4	111

Rhino-1 / Rhino-2

Right		BKG	Source		Rhino-2 BKG	Source
9-20	1	19.4	118			
9-25	2	19.7	118	9-25	not working	
9-26	3	19.5	117	9-26		
	4	19.7	119			
	5	19.7	116			
	6	20.9	116			
	7	20.0	115			
	8	20.2	118			
	9	20.0	116			
	10	19.8	115			

9-27-06 RW P. Sunny Windy ≈ 60F

PIC X-calibrations

Location 1 N42.23550 W107.64167

PIC	mR/hr
1	.0605
2	.0601
3	.0599
4	.0601
5	.0593
6	.0575
7	.0593
8	.0599
9	.0605
10	.0617

x-cal ↔ NaI mean (MFG-13) uR/hr = 103.9

Rhino Tie-in:

Rhino-1	MFG	uR/hr	MFG-13
Left	12	78.4	81.9
Center	16	57.0	59.4
Right	15	80.2	86.0

Location 2 N42.23539 W107.64165

1	.0281
2	.0279
3	.0273
4	.0267
5	.0283
6	.0297
7	.0301
8	.0287
9	.0297
10	.0305

MFG-13 uR/hr = 46.7 uR/hr

Rhino-1 tie in:

		uR/hr	MFG13
Left	12	49.4	50.5
Center	16	47.9	49.7
Right	15	46.5	47.9

Location 3 N42. W107.

(use these counts)

1	.0328	.0354
2	.0318	.0336
3	.0326	.0340
4	.0340	.0363
5	.0342	.0377
6	.0373	.0375
7	.0342	.0363
8	.0348	.0350
9	.0350	.0346
10	.0324	.0344

MFG-13 uR/hr = 56.3

Rhino-1 tie in

	uR/hr	MFG13
Left	46.6	48.5
Center	49.2	51.2
Right	54.4	56.2

Location 4 N42.23531 W107.64160

1	.0259
2	.0252
3	.0230
4	.0224
5	.0234
6	.0228
7	.0244
8	.0246
9	.0240
10	.0246

MFG 13 uR/hr = 34.5

Sputnik-1 tie in

	uR/hr	MFG13
Left	34.7	35.6
Center	35.7	36.9
Right	35.4	37.0

Location 5 N42.23392 W.107.64408

1	.0216
2	.0228
3	.0234
4	.0206
5	.0210
6	.0212
7	.0216
8	.0228
9	.0246
10	.0228

MFG13
uR/hr= 29.9
Sputnik-1 tie in

	uR/hr	MFG13
Left	29.7	32.7
Center	29.4	31.1
Right	29.1	29.9

Location 6 N42.23128 W107.64904

1	.0177
2	.0165
3	.0157
4	.0163
5	.0169
6	.0173
7	.0175
8	.0159
9	.0148
10	.0150

MFG 13
uR/hr 21.1
Sputnik-1 tie in

	uR/hr	MFG13
Left	23.3	24.7
Center	21.1	22.1
Right	24.3	25.7

collected soil samples
LS-1 through LS-4
with correlation grid scans
(ATV + backpack)

QC: Rhino-1		Bkg	source
Left	MFG-12	19.1	119
Center	"-16	18.4	111
Right	"-15	19.2	117

9-28-06 RW sunny ≈65°F

QC: Rhino-1		Bkg	source
Left	MFG-12	20.8	118
center	"-16	19.5	113
Right	"-15	20.3	119

11-2-06 RW P. Sunny ≈ 45°F
- PIC x-calibrations (Lost soldier)
QC: new control limits inside Hotel. mean of 20 + std. dev.

	R1-L	R1-C	R1-R	R2-L	R2-C	R2-R
B	6.5	6.4	6.7	6.6	6.4	6.8
σ	0.35	0.47	0.62	0.51	0.38	0.72
S	112	105	113	97	107	114
σ	1.8	2.7	1.9	2.5	2.7	2.0
Baroil Steinberg	MFG-12	MFG-16	MFG-15	MFG-1	MFG-5	MFG-8
	20.84	21.19	20.59	19.09	19.59	19.75

11-2 cont...

Location 1 [42.23560 107.67158] (switched R2-R to MFG-17)

PIC	mR/hr
1	.0305
2	.0286
3	.0268
4	.0266
5	.0293
6	.0280
7	.0305
8	.0295
9	.0289
10	.0278

	4.5ft uR/hr	3ft uR/hr
R1-L	40.6	40.22
R1-C	39.41	39.40
R1-R	39.82	40.13
R2-L	37.47	36.95
R2-C	39.10	38.28
R2-R	42.59	42.49

Location 2 [42.23552 107.64164]

PIC	
1	.0561
2	.0545
3	.0539
4	.0528
5	.0530
6	.0541
7	.0530
8	.0516
9	.0530
10	.0522

	4.5ft uR/hr	3ft uR/hr
R1-L	69.51	76.69
R1-C	71.62	80.64
R1-R	69.75	76.64
R2-L	66.00	74.01
R2-C	68.87	77.02
R2-R	74.37	81.83

11-3-06

Location 3 [42.25346 107.62907]

PIC	mR/hr
1	.0217
2	.0211
3	.0189
4	.0195
5	.0199
6	.0191
7	.0191
8	.0209
9	.0193
10	.0205

	4.5ft uR/hr	3ft uR/hr
R1-L	22.09	22.11
R1-C	21.40	21.32
R1-R	21.22	21.69
R2-L	20.49	20.26
R2-C	23.22	23.11
R2-R	21.27	20.44

Location 4 [~~42.24594~~ 107.63345]

PIC	mR/hr
1	.0325
2	.0313
3	.0315
4	.0341
5	.0331
6	.0323
7	.0337
8	.0317
9	.0319
10	.0307

	4.5ft uR/hr	3ft uR/hr
R1-L	42.20	43.23
R1-C	41.9	43.99
R1-R	41.56	43.80
R2-L	39.41	41.58
R2-C	40.12	42.13
R2-R	43.61	46.38

11-3-06 Cont.

Location 5

42.24326
107.62296

PIC	mR/hr
1	.0248
2	.0248
3	.0234
4	.0223
5	.0254
6	.0264
7	.0252
8	.0248
9	.0262
10	.0256

	4.5ft µR/hr	3-ft µR/hr
R1-L	36.37	36.70
R1-C	36.08	35.73
R1-R	35.78	36.13
R2-L	33.48	34.76
R2-C	35.32	35.71
R2-R	38.81	37.94

Location 6

42.23880
107.62864

PIC	mR/hr
1	.0238
2	.0240
3	.0229
4	.0221
5	.0238
6	.0244
7	.0240
8	.0234
9	.0240
10	.0225

	4.5ft µR/hr	3-ft µR/hr
R1-L	28.71	29.64
R1-C	28.27	28.37
R1-R	28.30	28.36
R2-L	26.58	27.38
R2-C	28.36	28.28
R2-R	30.46	30.65

Location 7

42.23643
107.63219

PIC	mR/hr	
1	.0228	.0219
2	.0274	.0246
3	.0256	.0242
4	.0272	.0252
5	.0295	.0244
6	.0211	.0236
7	.0221	.0211
8	.0211	.0266
9	.0223	.0284
10	.0205	.0252

	4.5ft µR/hr	3ft µR/hr
R1-L	34.74	36.08
R1-C	35.32	35.96
R1-R	34.21	35.56
R2-L	32.63	33.95
R2-C	34.79	35.03
R2-R	36.97	37.79

Location 8

42.23540
107.62983

potential hot spot location

PIC	mR/hr
1	.0333
2	.0331
3	.0325
4	.0329
5	.0327
6	.0329
7	.0329
8	.0335
9	.0339
10	.0348

	4.5ft µR/hr	3-ft µR/hr
R1-L	44.16	47.16
R1-C	44.12	47.09
R1-R	42.76	46.12
R2-L	41.65	44.35
R2-C	42.35	45.92
R2-R	45.46	48.73

11-3-06 Cont.

Location 9

42.22[illegible]
107.63505

PIC	?	mR/hr
1	.0128	.0185
2	.0126	.0172
3	.0138	.0187
4	.0140	.0175
5	.0144	.0183
6	.0115	.0183
7	.0174	.0197
8	.0175	.0199
9	.0187	.0201
10	.0183	.0177

	4.5ft µR/hr	3-ft µR/hr
R1-L	24.65	24.83
R1-C	23.41	24.18
R1-R	24.06	23.69
R2-L	22.58	23.02
R2-C	23.80	23.49
R2-R	25.94	25.59

Location 10

42.23467
107.62006

PIC	mR/hr
1	.0425
2	.0408
3	0.392
4	.0386
5	.0402
6	.0400
7	.0390
8	.0376
9	.0380
10	.0406

	4.5ft µR/hr	3ft µR/hr
R1-L	62.80	66.26
R1-C	63.03	65.43
R1-R	62.91	64.68
R2-L	60.07	63.70
R2-C	62.43	64.05
R2-R	66.99	68.79

11-3-06 QC — RW lost soldier — Cloudy ≈ 45°F

	R1-L	R1-C	R1-R	R2-L	R2-C	R2-R
B	6.7	6.6	6.7	6.8	6.7	7.0±0.6
S	112	105	114	97	107	106±20
						MFG-17 (new detector)
Field	20.22	18.75	20.17	18.75	18.72	20.46

– PIC vs. 3' vs. 4.5' correlation measurements

11-4-06 — RW Lost Soldier — Sunny ≈ 45°F

QC

	R1-L	R1-C	R1-R	R2-L	R2-C	R2R
B	7.2	6.8	6.5	6.3	6.5	7.2
S	112	107	115	98	105	106
Field	20.07	19.74	20.92	20.01	20.64	19.32

– Re-scans of central & east border areas

11-5-06 RW Lost Creek PIC vs 4.5' vs 3' meas.

QC:

	R1-L	R1-C	R1-R	R2-L	R2-C	R2-R
B	6.5	6.5	6.7	6.3	6.5	6.9
S	111	10.6	114	96	106	106
F	21.81	22.01	22.24	20.[illegible]	21.46	23.12

Lost creek
11-5-06 Cont....

42.11733
107.86353

Location 1

PIC	mR/hr
1	.0219
2	.0227
3	.0225
4	.0235
5	.0259
6	.0248
7	.0245
8	.0253
9	.0223
10	.0233

	4.5ft uR/hr	3 ft uR/hr
R1 - L	30.71	31.76
R1 - C	30.12	31.23
R1 - R	30.34	30.91
R2 - L	29.06	30.34
R2 - C	29.19	30.87
R2 - R	32.03	33.14

Location 2

local outcrop of source material (rotated?) in wash

42.10687
107.87045

PIC	mR/hr
1	.0341
2	.0327
3	.0327
4	.0321
5	.0321
6	.0315
7	.0329
8	.0339
9	.0341
10	.0335

	uR/hr 4.5ft	uR/hr 3 ft
R1 - L	40.98	43.92
R1 - C	42.48	44.75
R1 - R	40.91	43.17
R2 - L	39.88	42.62
R2 - C	40.50	43.34
R2 - R	43.45	46.01

Location 3

42.12827
107.87157

PIC	uR/hr
1	.0207
2	.0211
3	.0209
4	.0205
5	.0207
6	.0221
7	.0225
8	.0209
9	.0193
10	.0185

	4.5ft uR/hr	3 ft uR/hr
R1 - L	22.66	22.62
R1 - C	21.71	21.83
R1 - R	22.53	21.71
R2 - L	21.04	20.56
R2 - C	21.80	22.21
R2 - R	23.49	23.95

Location 4

42.13095
107.85934

PIC	mR/hr
1	.0260
2	.0254
3	.0240
4	.0248
5	.0264
6	.0266
7	.0262
8	.0260
9	.0252
10	.0262

	4.5ft uR/hr	3 ft uR/hr
R1 - L	34.43	36.07
R1 - C	34.43	35.21
R1 - R	33.97	35.06
R2 - L	32.39	33.65
R2 - C	34.09	35.29
R2 - R	36.59	37.67

Location 5

42.13122
107.85960

PIC	mR/hr
1	.0386
2	.0382
3	.0378
4	.0380
5	.0372
6	.0384
7	.0378
8	.0372
9	.0366
10	.0370

	4.5ft uR/hr	3ft uR/hr
R1 - L	51.54	54.98
R1 - C	50.37	53.97
R1 - R	49.88	52.23
R2 - L	49.42	52.14
R2 - C	49.55	51.94
R2 - R	52.23	54.89

Location 6

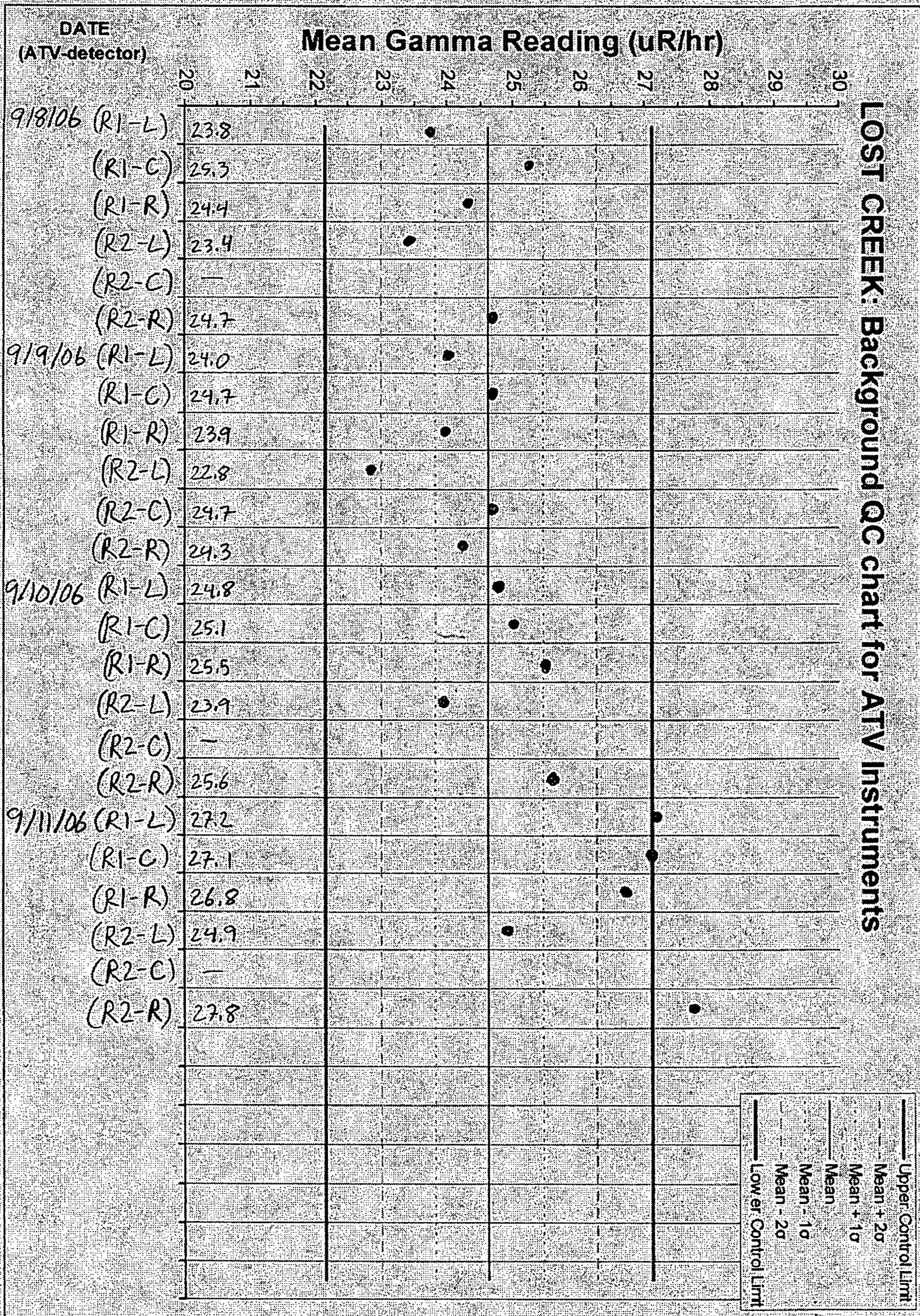
42.13195
109.84903

PIC	mR/hr
1	.0237
2	.0221
3	.0213
4	.0209
5	.0215
6	.0219
7	.0211
8	.0215
9	.0211
10	.0219

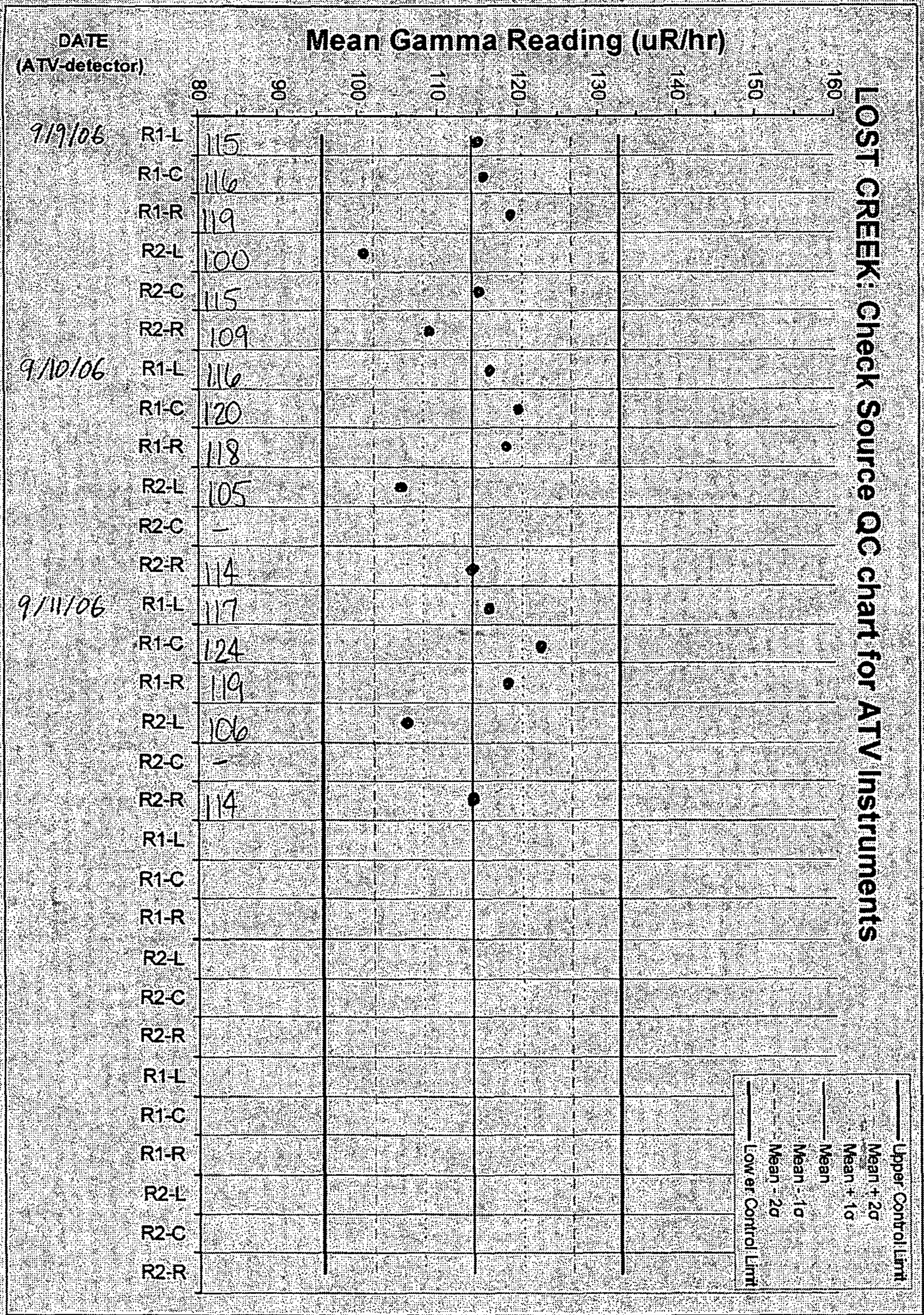
	4.5ft uR/hr	3 ft uR/hr
R1 - L	25.49	25.88
R1 - C	24.99	25.82
R1 - R	24.29	25.10
R2 - L	23.47	24.01
R2 - C	24.37	24.73
R2 - R	26.53	26.53

Attachment 3.12-2 Data Quality Control Documentation

LOST CREEK: Background QC chart for ATV Instruments



DATE (ATV-detector)		Mean Gamma Reading (uR/hr)
9/8/06	(R1-L)	23.8
	(R1-C)	25.3
	(R1-R)	24.4
	(R2-L)	23.4
	(R2-C)	—
	(R2-R)	24.7
9/9/06	(R1-L)	24.0
	(R1-C)	24.7
	(R1-R)	23.9
	(R2-L)	22.8
	(R2-C)	24.7
	(R2-R)	24.3
9/10/06	(R1-L)	24.8
	(R1-C)	25.1
	(R1-R)	25.5
	(R2-L)	23.9
	(R2-C)	—
	(R2-R)	25.6
9/11/06	(R1-L)	27.2
	(R1-C)	27.1
	(R1-R)	26.8
	(R2-L)	24.9
	(R2-C)	—
	(R2-R)	27.8


LOST CREEK: Check Source QC chart for ATV Instruments
Mean Gamma Reading (uR/hr)
DATE (ATV-detector)
80 90 100 110 120 130 140 150 160
9/9/06
R1-L 115
R1-C 116
R1-R 119
R2-L 100
R2-C 115
R2-R 109
9/10/06
R1-L 116
R1-C 120
R1-R 118
R2-L 105
R2-C -
R2-R 114
9/11/06
R1-L 117
R1-C 124
R1-R 119
R2-L 106
R2-C -
R2-R 114
R1-L
R1-C
R1-R
R2-L
R2-C
R2-R
R1-L
R1-C
R1-R
R2-L
R2-C
R2-R
Upper Control Limit
Mean + 2σ
Mean + 1σ
Mean
Mean - 1σ
Mean - 2σ
Lower Control Limit

ERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
ll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

QA/QC Summary Report

Client: MFG Inc
Project: Red Desert 181445

Report Date: 11/14/06
Work Order: C06100413

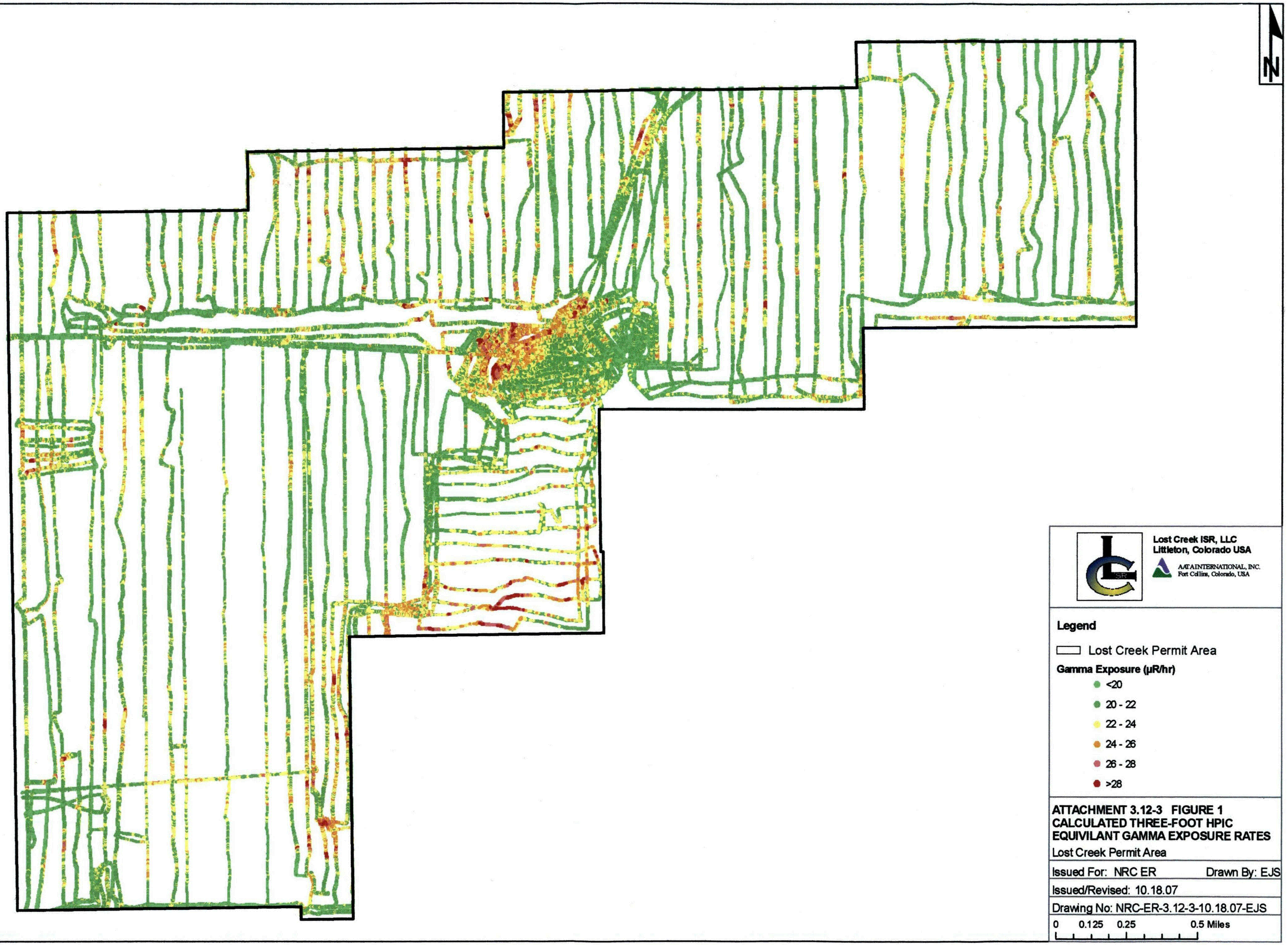
Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: E901.1								Batch: 12393	
Sample ID: LCS-R74833	Laboratory Control Sample				Run: GAMMA EGG-ORTEC_06102			10/25/06 10:40	
Radium 226	7.5	pCi/g-dry	1.0	87	80	120			
Sample ID: MB-R74833	Method Blank				Run: GAMMA EGG-ORTEC_06102			10/25/06 10:40	
Radium 226	ND	pCi/g-dry	1						
Sample ID: C06100332-001ADUP	Sample Duplicate				Run: GAMMA EGG-ORTEC_06102			10/25/06 10:40	
Radium 226	3400	pCi/g-dry	1.0				0.2	30	
Sample ID: C06100413-010ADUP	Sample Duplicate				Run: GAMMA EGG-ORTEC_06102			10/25/06 10:40	
Radium 226	4.8	pCi/g-dry	1.0				2.1	30	
Sample ID: C06100413-020ADUP	Sample Duplicate				Run: GAMMA EGG-ORTEC_06102			10/25/06 10:40	
Radium 226	4.5	pCi/g-dry	1.0				14	30	
Method: SW6020								Batch: 12397	
Sample ID: MB-12397	Method Blank				Run: ICPMS2-C_061011A			10/11/06 18:29	
Uranium	ND	mg/kg-dry	0.003						
Sample ID: LCS1-12397	Laboratory Control Sample				Run: ICPMS2-C_061011A			10/11/06 18:33	
Uranium	1.06	mg/kg-dry	0.015	106	75	125			
Sample ID: C06100413-010A MS	Sample Matrix Spike				Run: ICPMS2-C_061011A			10/11/06 19:56	
Uranium	28.2	mg/kg-dry	0.031	104	75	125			
Sample ID: C06100413-010A MSD	Sample Matrix Spike Duplicate				Run: ICPMS2-C_061011A			10/11/06 20:00	
Uranium	28.5	mg/kg-dry	0.031	105	75	125	1.0	20	
Method: SW6020								Batch: 12398	
Sample ID: MB-12398	Method Blank				Run: ICPMS2-C_061011A			10/11/06 16:29	
Uranium	ND	mg/kg-dry	0.003						
Sample ID: LCS1-12398	Laboratory Control Sample				Run: ICPMS2-C_061011A			10/11/06 16:33	
Uranium	1.12	mg/kg-dry	0.015	112	75	125			
Sample ID: C06100413-020A MS	Sample Matrix Spike				Run: ICPMS2-C_061011A			10/11/06 17:40	
Uranium	32.4	mg/kg-dry	0.031	104	75	125			
Sample ID: C06100413-020A MSD	Sample Matrix Spike Duplicate				Run: ICPMS2-C_061011A			10/11/06 17:44	
Uranium	32.6	mg/kg-dry	0.031	105	75	125	0.5	20	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Attachment 3.12-3 Final Baseline Gamma Survey and Ra-226 Soil Maps

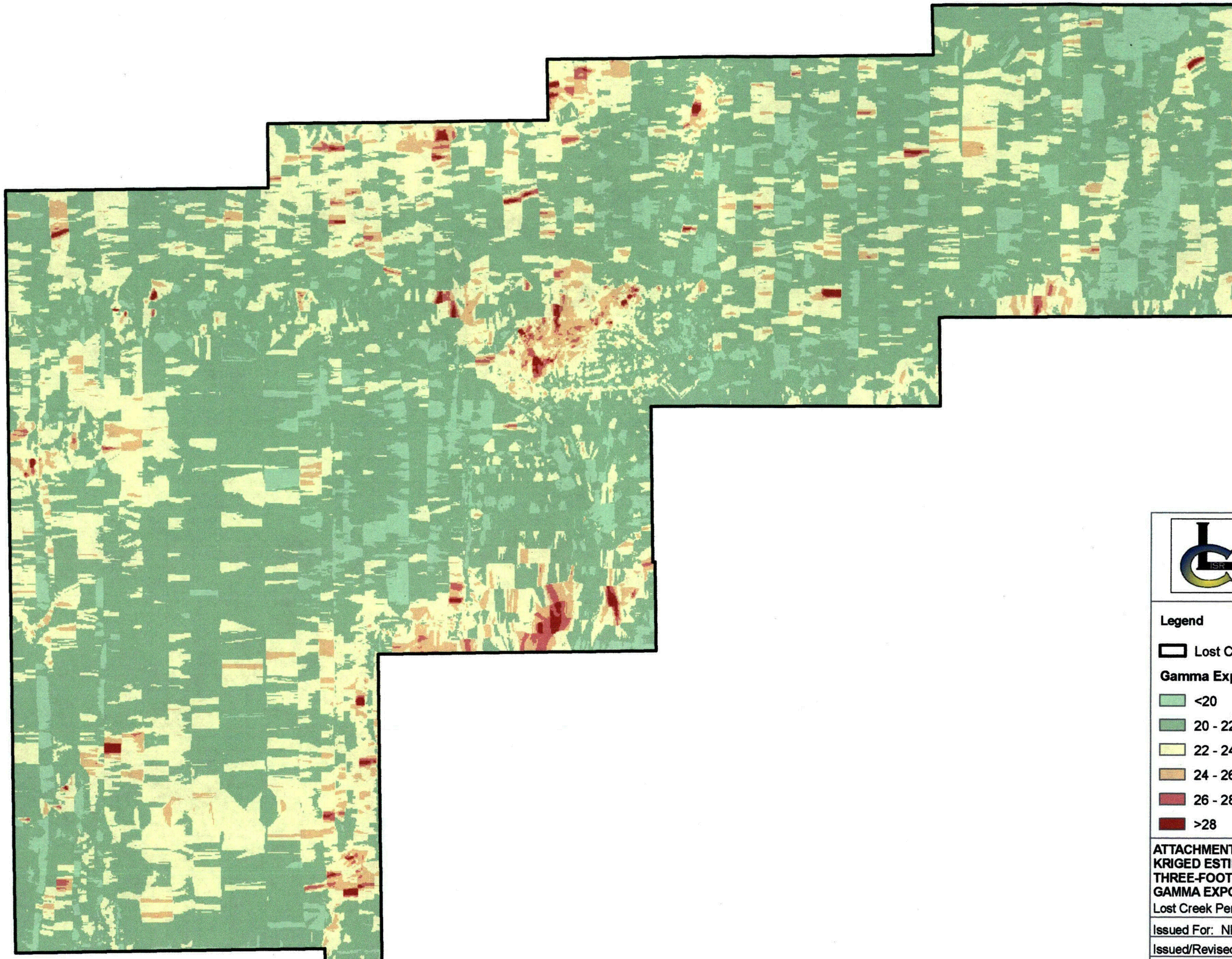


Lost Creek ISR, LLC
Littleton, Colorado USA

AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA

ATTACHMENT 3.12-3 FIGURE 1
CALCULATED THREE-FOOT HPIC EQUIVILANT GAMMA EXPOSURE RATES
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EJS
Issued/Revised: 10.18.07
Drawing No: NRC-ER-3.12-3-10.18.07-EJS



Lost Creek ISR, LLC
Littleton, Colorado USA

AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA

TETRA TECH

Legend

Lost Creek Permit Area

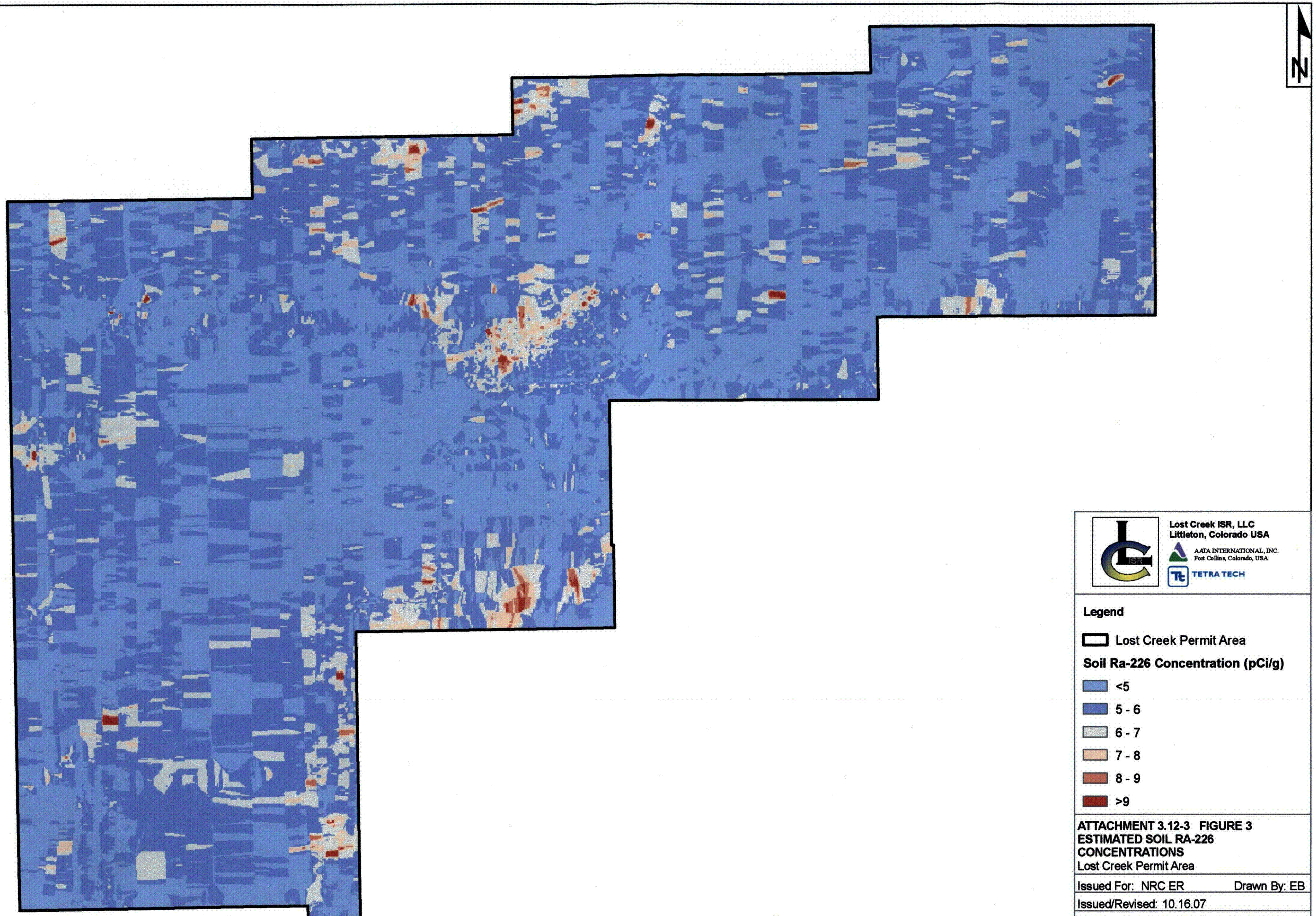
Gamma Exposure Rate (µR/hr)

- <20
- 20 - 22
- 22 - 24
- 24 - 26
- 26 - 28
- >28

ATTACHMENT 3.12-3 FIGURE 2
KRIGED ESTIMATES OF THE THREE-FOOT-HPIC-EQUIVALENT GAMMA EXPOSURE RATES
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EB
Issued/Revised: 10.16.07
Drawing No: NRC-ER-3.12-3-10.16.07-EJS

0 0.125 0.25 0.5 Miles



Lost Creek ISR, LLC
Littleton, Colorado USA

AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA

TETRA TECH

Legend

Lost Creek Permit Area

Soil Ra-226 Concentration (pCi/g)

- <5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- >9

ATTACHMENT 3.12-3 FIGURE 3
ESTIMATED SOIL RA-226 CONCENTRATIONS
Lost Creek Permit Area

Issued For: NRC ER Drawn By: EB

Issued/Revised: 10.16.07

Drawing No: NRC-ER-3.12-3-10.16.07-EJS

0 0.1 0.2 0.4 Miles

Attachment 3.12-4 HPIC-Adjusted Gamma Datasets (electronic dataset only)