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FINAL

SM-1A REACTOR WASTE PIPELINE CORRIDOR VERIFICATION SURVEY REPORT

FORT GREELY, ALASKA

AUGUST 2004

Prepared for:
Environmental Division
Directorate of Military Programs
U.S. Army Corps of Engineers

Prepared by:
Hazardous, Toxic and Radioactive Waste Center of Expertise
U.S. Army Corps of Engineers

EXECUTIVE SUMMARY
SM-1A REACTOR WASTE PIPELINE CORRIDOR
VERIFICATION SURVEY REPORT

FORT GREELY, ALASKA
PERFORMED 12-14 SEPTEMBER 2000

The U.S. Army Corps of Engineers (USACE) has a two-fold responsibility at Fort Greely, Alaska. The Chief, Environmental Division, Directorate of Military Programs (CEMP-R) is responsible for the safety, security and decommissioning of the SM-1A deactivated reactor, while the USACE Alaska District is currently executing cleanup activities for U.S. Army-Alaska. Those cleanup activities have included removal of approximately 1700 cubic yards of radioactively contaminated soil from a reactor waste pipeline on property that was potentially to be released under base realignment. The Army Reactor Office required that the CEMP-R, as the reactor permit holder, perform a Verification Survey to ensure that the soil criteria for release for unrestricted use along the SM-1A radioactive waste pipeline corridor have been achieved.

The objective of the Verification Survey was to confirm the conclusions drawn in the draft Closure Report distributed for review by the Alaska District's contractor, namely, that the residual radioactive contamination in the SM-1A pipeline corridor and outfall area soils is below the soil criteria for release for unrestricted use for cesium-137 and strontium-90. The survey Work Plan identified additional sampling to address stakeholder concerns regarding assumptions made in previous survey plans. Specific data objectives were developed and discussed in detail in the survey Work Plan. Both random and biased soil sampling were employed to meet these objectives.

The Verification Survey sampling results support the conclusion that the soil criteria for release for unrestricted use have been achieved by the removal activities. Additionally, the survey results indicate that potential differential migration of contaminants did not lead to higher levels of strontium-90 below or adjacent to the excavated soils. The levels of strontium-90 in windrow material used to backfill excavations were also found to be below its soil criterion for release for unrestricted use. This survey report will be included as an Appendix to the Closure Report and, together, these documents should be adequate to support a request for removal of the pipeline corridor and outfall areas from the reactor permit.

At the request of the Base Realignment and Closure (BRAC) Cleanup Team, USACE performed a Residual Risk Assessment of the SM-1A Reactor Waste Pipeline Corridor soils. The assessment, included as an Attachment to this report, determines that the total carcinogenic risk to a future residential receptor from exposure to residual soil contamination should not exceed the State of Alaska value of $1x10^{-5}$ and supports the release of the pipeline corridor for unrestricted use.

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1.0 Survey Objectives.

1.1 SM-1A Waste Pipeline Removal Project Overview.

From 1997 to 1999, the United States Army Corps of Engineers (USACE) Alaska District through its contractor, Jacobs Engineering Group, Inc. (Jacobs), removed remaining pipe, a dilution station, and approximately 1700 cubic yards of radionuclide contaminated soil from the SM-1A Reactor pipeline corridor. The removal activities were performed in support of the realignment of Fort Greely under the direction of the U.S. Army-Alaska (USARAK). The procedures used for excavation and the radiological sampling were outlined in work plans developed by Jacobs and reviewed by the U.S. Army (USACE, USARAK, and the Army Reactor Office (ARO)), the State of Alaska Department of Environmental Conservation (ADEC), and the U.S. Environmental Protection Agency (EPA), Region 10, prior to implementation. In 1998, The Army Reactor Office (ARO) issued a memorandum to USACE that outlined a process to be used for release of the radionuclide contaminated areas of pipeline corridor from the SM-1A reactor permit prior to transfer of the property for unrestricted use. Nuclear Reactor Possession Permit Number SM1A-2-99 is currently issued to the Chief of the U.S. Army Corps of Engineers Environmental Division (CEMP-R).

After completion of soil excavation and the associated final closure surveys, Jacobs distributed a draft *Closure Report, Removal of the SM-1A Radioactive Pipeline* (Jacobs, 2000). The draft Closure Report asserts that the soil criteria for release for unrestricted use, 10 picocuries per gram (pCi/g) of cesium-137 (Cs-137) and 4 pCi/g of strontium-90 (Sr-90) have been achieved by the removal action. The ARO requires that the permit holder perform a verification survey to ensure that the soil criteria for release for unrestricted use have been achieved as indicated. Review of the draft Closure Report by USACE, USARAK and EPA has raised concerns regarding the location, quantity and/or quality of some types of survey data gathered during and after the removal process (EPA, 2000). A review conference between the USARAK, USACE, ADEC and EPA took place on 8 November 2000 to discuss finalization of the Closure Report. The preliminary results of this Verification Survey were also presented at the review conference.

1.2 Verification Survey Objectives.

The extent of the Verification Survey and the use of Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (NRC, 1997) were clarified in discussions between the USACE Hazardous, Toxic, and Radioactive Waste Center of Expertise (HTRW CX) and the ARO prior to development of the *Work Plan for the Verification Survey of the SM-1A Reactor Waste Pipeline Corridor* (USACE, 2000c). The ARO did not intend for the Verification Survey to repeat the final closure surveys performed by the Alaska District contractor. Only those additional samples deemed necessary to confirm or reject the conclusions of the final closure survey are needed. The objectives of this survey are detailed in the Work Plan and summarized below:

- Collect and analyze soil samples for radiological analysis that are representative of the residual radionuclide concentrations in the pipeline corridor for comparison to the soil criteria for release for unrestricted use. A random sampling approach was employed to meet this objective. At each randomly selected location, a minimum of three soil samples at varying depth intervals were collected. The data from the biased sampling locations may also be used to support this objective since it was collected in the same manner and with the same quality as the random samples.

- Collect and analyze soil samples for radiological analysis that will address the potential for differential migration of Sr-90 with respect to Cs-137 in pipeline corridor soils. Biased sample locations were specifically selected to address this objective, however, some randomly selected sample locations may also be used to support this objective. At each sampling location where excavation had occurred, a sample was taken at varying depths below the bottom of the excavation as determined by the Site Geologist.

- Collect and analyze soil samples for radiological analysis that will address the inadequacy of beta field screening data for pipeline corridor windrow material used as backfill. Biased sample locations were specifically selected to address this objective, however, some randomly selected sample locations may also be used to support this objective. At each sampling location where excavation had occurred and windrow soil was used for backfill as determined by the Site Geologist, the surface and/or mid-depth samples collected contained windrow material.

- Collect and analyze soil samples for radiological analysis that will address the lateral extent of contamination. A few biased sample locations were specifically selected to address this objective, additionally; some randomly selected sample locations may also be used to support this objective. At those sampling locations adjacent to excavated areas, the surface, mid-depth, and bottom samples collected would contain only native soils potentially contaminated by the lateral transport of radionuclides.

- Collect and analyze soil samples for radiological analysis that will address the reporting of minimum detectable concentrations above the soil criteria for release for unrestricted use. A biased sample location was selected at the same location as the contractor sample whose reported minimum detectable concentration was above the Sr-90 soil criterion for release for unrestricted use. Additionally, the minimal detectable concentration (MDC) of analysis methods for this project was requested to be less than 1 picocurie per gram (pCi/g) for total Sr and Cs-137.

1.3 Comments and Responses to the Verification Survey Work Plan.

The Verification Survey Work Plan was provided to EPA and ADEC at the request of USARAK. EPA provided three comments on the Work Plan to the Alaska District Project Manager (Attachment A). The comments were answered by USACE Alaska District with information supplied by the HTRW CX (Attachment B). The EPA letter indicated agreement with the sampling rationale described in the Work Plan.

2.0 Project Support.

2.1 USACE Survey Support.

The USACE Survey Team consisted of Brian Hearty, Health Physicist, HTRW CX, David Hays, Health Physicist, USACE Tulsa District, and Terry Tomasek, Industrial Hygienist, HTRW CX. Mr. Hearty directed the technical sampling approach, including work plan development, field activities, data management, and report preparation. He served as the point of contact with the USACE Alaska District Project Manager, William Abadie. Mr. Hays and Mr. Hearty performed the gamma walkover surveys during the Verification Survey. As the USACE Health Physicist, Mr. Hays ensured that radiological health and safety procedures designed to protect personnel were maintained throughout the field activities and that appropriate screening of field personnel for contamination was performed. Mr. Hays was also responsible for soil sample scanning and collection, and preparation of Chain-of-Custody Report Forms (Attachment D). Mr. Hays maintains the survey field logbook. Mr. Tomasek assisted with sample collection and packaging, performed sampling equipment decontamination, and documented sample locations as the photographer for the Verification Survey (Attachment F). Sam Mills, Alaska District Quality Assurance Representative, participated in a briefing on the Work Plan prior to the initiation of survey activities. Mr. Mills provided assistance to the survey team to gain access to a random sampling location situated in a locked area of the site.

2.2 Jacobs Survey Support.

The Jacobs Site Manager, Dave Kennedy, provided onsite coordination between the USACE survey team, Site Geologist and the drilling subcontractor. Mr. Kennedy arranged for the sample locations to be surveyed and staked out prior to mobilization and obtained all required drilling permits. Mr. Kennedy participated in sampling equipment decontamination and relocation activities and provided historical knowledge of the depth and extent of soil removal actions. As Site Safety and Health Officer, he provided oversight of drilling equipment decontamination, performed drilling equipment final release wipe surveys, and the coordinated the collection, storage and disposal of the investigation derived waste. Mr. Kennedy also provided the survey team with tailgate safety meetings prior to mobilizing for survey activities each day.

The Jacobs Site Geologist, Steven Hammond, logged each soil boring (Attachment C) and identified the soil types present in each split spoon sample collected. As previous Site Manger for the SM-1A soil removal project, Mr. Hammond also provided historical knowledge of the depth and extent of soil removal actions.

Bill Wilson, Jacobs Quality Control Systems Manager, provided QC oversight of the drilling subcontractor and Site Geologist activities.

2.3 Drilling Subcontractor.

Discovery Drilling of Anchorage, Alaska, was contracted by Jacobs to perform the drilling activities. The driller, Ralph Newland, and field technician, David Roes, were very experienced with hollow auger split spoon sampling methods and were able to obtain sufficient sample recovery routinely.

2.4 Analytical Laboratory Support.

Analytical laboratory support was obtained through coordination between the HTRW CX and Laura Percifield, U.S. Army Engineer Research & Development Center, Environmental Chemistry Branch. Ms. Percifield arranged for Severn Trent Laboratories, Inc. (STL St. Louis) to determine the total strontium and cesium-137 activities in the soil samples with the required minimum detectable concentrations. The laboratory used the Health and Safety Laboratory (HASL) AM-02 MOD gamma spectroscopy method, and the Standard Methods for Waste Water (SMWW) 75000SR MOD analytical method for the total strontium analysis. The STL St. Louis Analytical Report and Quality Control Reports were provided to USACE on 25 October 2000 (Attachment E).

2.5 Survey Observers.

Bill Macon, Army Reactor Program Manager, Ken Spiers, BRAC Environmental Coordinator, Mike Murphy, Fort Greely Department of Public Works, and Bill Abadie, Alaska District Project Manger were on-site to observe survey activities at various times throughout the two days of sampling.

3.0 Survey Overview

3.1 Chronology.

12 SEPTEMBER 2000

0710 Survey Team meets at USACE Trailer.
0715 Tailgate safety meeting provided by Jacobs SSHO.
0745 USACE Survey Team performs instrument source and operability checks.
0910 Brief Survey Work Plan to Alaska District QAR.
0910 Sample number convention changed to meet Jacobs's computer system requirements. Sample numbers now correspond to location number and not station designator as originally planned. See Section 3.3 for further details.
0935 Survey Team mobilizes at the first sampling point. The survey began at the outfall area and the team collected both random and biased samples while working back up the pipeline corridor towards the SM-1A reactor.
1009 Drilling safety briefing and sampling spoon decontamination performed.
1027 First sample boring made at location GV24. Several stationary dose rate measurements are made during each drilling operation for health and safety purposes. Samples are collected subsequently at GV12 and GV25. A walkover survey of the outfall sampling locations and the surrounding areas is performed. Readings on backfill range from 6 to 8 μR/hr, off backfill readings are 12 to 14 μR/hr.
1300 Survey Team frisks out and breaks for lunch.
1400 Problems with pressure washer system had the potential to reduce the number of borings possible per day. There was no impact to completion of the survey.
1500 Survey Team mobilizes at sampling location GV11.
1540 A one-pass walkover survey between locations GV11 (61+30) and GV23 (56+00) is performed. Readings range from 8 to 15 then back to 12μR/hr in gradual changes.
1600 A walkover survey of the areas surrounding the former dilution station is performed specifically concentrating on the ravine to the right (as if walking from reactor to outfall) of the pipeline corridor. Readings range from 9 to 12 μR/hr. Locations GV23 and GV10 are sampled.
1630 Location GV10 is moved from R15 to R35 to ensure that it is outside of the excavated area as plotted in the program used to generate random sampling locations.
1700 GV22 and GV21 are sampled.
1818 A tailgate safety briefing is called to remind team members working around the drill rig to make sure that their hearing protection is in place during operations.
1855 GV09, GV20 and GV08 are sampled.
2030 Survey team frisks out.
2040 Samples secured in USACE vehicle.

13 SEPTEMBER 2000

0700 Survey Team meets at USACE Trailer.
0715 USACE Survey Team performs instrument source and operability checks. All instruments are operable.
0720 Tailgate safety meeting including overhead line safety.

0800 Mobilization at location GV07.
0830 Location GV19 moved to avoid overhead communication line.
0945 A walkover survey of the pipeline corridor from location GV19 past GV06 to Station 37+00 is performed. Readings range from 7.5 to 9.5 μR/hr
1006 Survey Team frisks out for a break.
1045 Locations GV18, GV05, and GV17 sampled.
1215 A walkover survey between GV05 (31+50) and GV16 (26+40) is performed. Readings generally range from 8 to 13 μR/hr. An elevated (13-15 μR/h) of approximately 840 square feet is encountered and a biased surface sample GV26 is collected at the centerline of Station 27+51 using a hand scoop.
1315 Location GV16 is sampled.
1410 Break for lunch and drilling equipment decontamination.
1540 Sample location GV04 is sampled.
1610 Location GV15 is sampled.
1615 A walkover survey of the roadbed and surrounding soil is performed. Readings on roadbed range from 6 to 8 μR/hr while soil on either side ranges from 9 to 11 μR/hr.
1645 Location GV14 is sampled.
1700 A one-pass walkover survey between locations GV14 (17+00) and GV13 (10+00) is performed. Specifically to resurvey areas that exhibited much higher readings during a 1997 USACE survey conducted by Mr. Hays. Readings range from 9 to 11 μR/hr with a small depression that measured around 12.5 μR/hr.
1730 Location GV13 is sampled.
1815 Location GV03 is moved for safety concerns from an overhead power line and sampled.
1900 Location GV02 is inside of a locked hazardous materials storage area. It is skipped until access can be gained.
1930 Location GV01 is sampled.
2015 Alaska District QAR obtains key for access to GV02 and it is sampled.
2040 Sampling completed, team frisks out, and samples are stored in USACE vehicle.

14 SEPTEMBER 2000

0800 Survey Team meets at USACE Trailer for safety briefing concerning handling of samples in the trailer.
0830 Samples are sorted, coolers are obtained, and Chain-of-Custody Reports are prepared.
1400 An on-site conference call regarding dilution well abandonment is held.
1540 USACE Survey Team drives samples to Fairbanks.
1800 Samples shipped Federal Express to STS St. Louis.

3.2 Site Conditions at Time of Survey.

Site conditions during the survey were cool to cold, partly cloudy to sunny with light winds. Light rain fell intermittently during the afternoon of 12 September. There were no impacts to sampling or to health and safety caused by the site conditions.

3.3 Sampling Locations and Changes.

The approximate locations of the 12 randomly selected sample points and the 14 biased sample points are depicted on Figures 3-1 and 3-2 respectively. The random sample points were selected as described in the survey work plan (USACE, 2000c) and additional details on the sample number calculations are provided in Section 4.1 of this report. The handwritten numbers correspond to the sample number listed in Table 3-1 that lists the final locations and primary purpose of each sample. As indicated in the chronology above, the USACE Survey Project Manager moved four sample locations. Three were due to overhead obstructions, and one location was moved to better sample the lateral extent of contamination from the large dilution station excavation. Also, indicated above, a new biased sample was collected based on walkover survey readings. That sample is listed as number 26 on Figure 3-2. Regarding the quality control samples collected for this survey, the collocated samples provide an indication of the short-term variability at the site and are the same as the Collocated Samples described in Section 7.2.2.1 of MARSSIM. The field replicate samples give an overall indication of the precision of the entire sampling and analysis process. The sample numbering system developed in the Work Plan to identify sample location and depth was revised to accommodate Jacobs's computerized Chain-of-Custody Report program. Samples are numbered as follows:

1. A two-digit site Identifier of "GV" is used for Greely, Verification.
2. A two-digit sample number will correspond to a given location as listed in Table 3-1.
3. A single letter depth identifier will be used
   a. S = Surface
   b. M = Mid
   c. B = Bottom
4. An additional identifier for Quality Control samples will be used.
   a. D = Duplicate
   b. R = Replicate

For example, a sample number of "GV01SD" is read as Greely Verification, Sample Location 01, Surface, Duplicate. A Station Designator consistent with historical pipeline activities, such as 37+50, describes each sample location along with a sample location, such as L7, which is keyed to the surveyed centerline of the waste pipeline. Off-center samples are designated by the number of feet right or left of centerline as if the surveyor were walking down the pipeline from the reactor to the outfall area. Centerline samples are marked with a C.

Table 3-1
Final Sample Locations and Primary Sampling Purpose

Sample Number	Station Designator	Sample Location	Sample Purpose	Sample Number	Station Designator	Sample Location	Sample Purpose
GV01B	1+40	R2	Random	GV14B	17+00	C	Biased
GV01M	1+40	R2	Random	GV14M	17+00	C	Biased
GV01S	1+40	R2	Random	GV14MD	17+00	C	Field QC
GV02B	5+90	R10	Random	GV14S	17+00	C	Biased
GV02M	5+90	R10	Random	GV15B	17+35	C	Biased
GV02S	5+90	R10	Random	GV15M	17+35	C	Biased
GV03B	8+30	L18 (M)	Random	GV15S	17+35	C	Biased
GV03M	8+30	L18 (M)	Random	GV16B	26+40	C	Biased
GV03S	8+30	L18 (M)	Random	GV16M	26+40	C	Biased
GV04B	25+00	R5	Random	GV16S	26+40	C	Biased
GV04M	25+00	R5	Random	GV17B	30+00	C	Biased
GV04S	25+00	R5	Random	GV17M	30+00	C	Biased
GV05B	31+50	L4	Random	GV17MD	30+00	C	Field QC
GV05M	31+50	L4	Random	GV17S	30+00	C	Biased
GV05S	31+50	L4	Random	GV18B	34+20	C	Biased
GV06B	37+60	L2 (M)	Random	GV18M	34+20	C	Biased
GV06M	37+60	L2 (M)	Random	GV18S	34+20	C	Biased
GV06MD	37+60	L2 (M)	Field QC	GV19B	39+86 (M)	L2	Biased
GV06S	37+60	L2 (M)	Random	GV19M	39+86 (M)	L2	Biased
GV07B	43+00	L10	Random	GV19S	39+86 (M)	L2	Biased
GV07M	43+00	L10	Random	GV20B	45+00	L5	Biased
GV07S	43+00	L10	Random	GV20BD	45+00	L5	Field QC
GV08B	44+80	R8	Random	GV20M	45+00	L5	Biased
GV08M	44+80	R8	Random	GV20S	45+00	L5	Biased
GV08S	44+80	R8	Random	GV21B	54+00	L5	Biased
GV09B	47+00	R7	Random	GV21M	54+00	L5	Biased
GV09M	47+00	R7	Random	GV21S	54+00	L5	Biased
GV09S	47+00	R7	Random	GV22B	55+00	C	Biased
GV10B	56+00	R35 (M)	Random	GV22M	55+00	C	Biased
GV10M	56+00	R35 (M)	Random	GV22S	55+00	C	Biased
GV10S	56+00	R35 (M)	Random	GV23B	56+00	C	Biased
GV10SD	56+00	R35 (M)	Field QC	GV23M	56+00	C	Biased
GV11B	61+30	R10	Random	GV23S	56+00	C	Biased
GV11M	61+30	R10	Random	GV23SD	56+00	C	Field QC
GV11S	61+30	R10	Random	GV24B	62+50	R20	Biased
GV12B	62+30	R10	Random	GV24M	62+50	R20	Biased
GV12M	62+30	R10	Random	GV24S	62+50	R20	Biased
GV12S	62+30	R10	Random	GV25B	62+50	L25	Biased
GV13B	10+00	C	Biased	GV25M	62+50	L25	Biased
GV13BR	10+00	C	Field/Lab QC	GV25MR	62+50	L25	Field/Lab QC
GV13M	10+00	C	Biased	GV25S	62+50	L25	Biased
GV13S	10+00	C	Biased	GV26S	27+51 (N)	C	Biased

M=moved sample location, N=new sample location

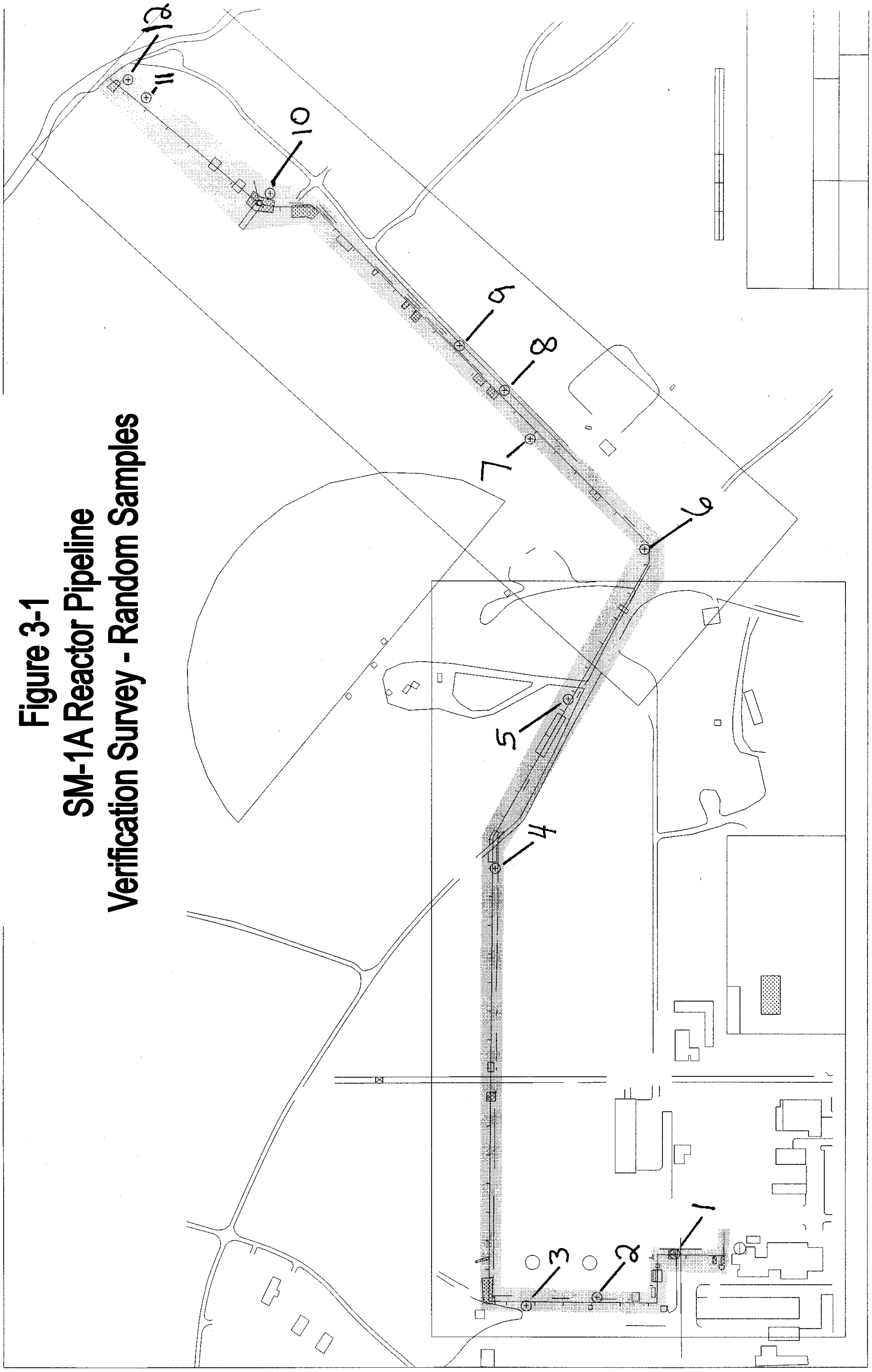


Figure 3-1
SM-1A Reactor Pipeline
Verification Survey - Random Samples

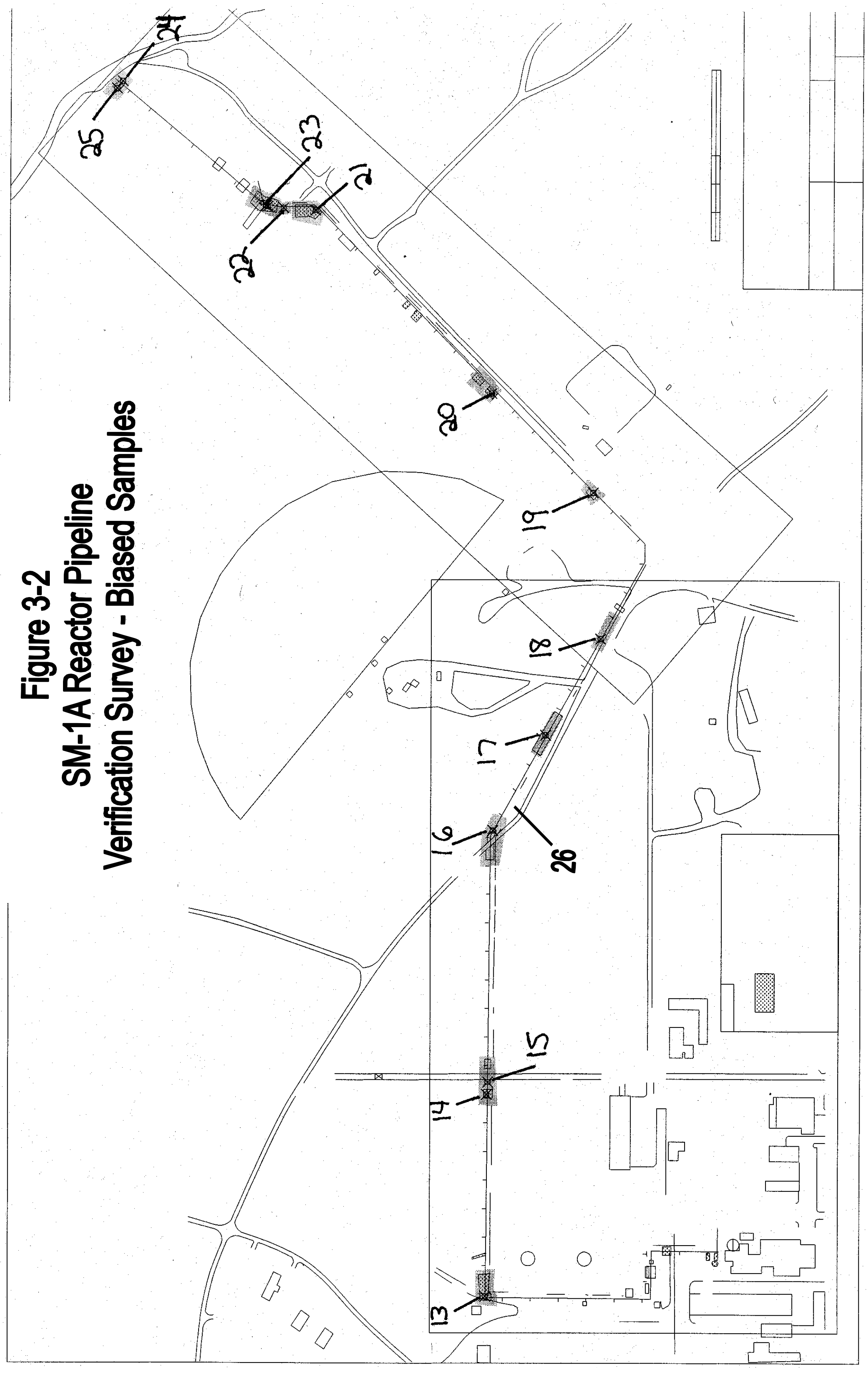


Figure 3-2
SM-1A Reactor Pipeline
Verification Survey - Biased Samples

4.0 Survey Results

4.1 Soil Sample Analytical Results

Table 4-1 contains a summary of the Analytical Report provided by STL St. Louis (Attachment E). The table includes the sampling depth interval (in feet) and the soil type identified by the Site Geologist at the time of sampling. Data is qualified in accordance with the Analytical Report and explained in footnote 1 of the table below. The sample result uncertainty and minimum detectable concentration (MDC) based on instrument performance are provided.

Table 4-1
SM-1A Reactor Pipeline Corridor Verification Survey
Soil Sample Analytical Results

Sample Number	Station Designator	Sample Location	Sample Interval (ft)	Soil Type	Total Strontium (pCi/g)				Cesium-137 (pCi/g)			
					Result	Q[1]	±2σ	MDC	Result	Q	±2σ	MDC
GV01B	1+40	R2	7.5-8	Native	0.14	U	0.28	0.48	0.006	U	0.045	0.087
GV01M	1+40	R2	3.5-4	Windrow	0.75	J	0.31	0.41	0.22		0.11	0.13
GV01S	1+40	R2	0-0.5	Fill	1.06	J	0.42	0.55	0.51		0.14	0.09
GV02B	5+90	R10	6-6.5	Native	0.79	J	0.33	0.44	0.053	U	0.096	0.19
GV02M	5+90	R10	2.5-3	Windrow	0.04	U	0.27	0.47	-0.009	U	0.053	0.11
GV02S	5+90	R10	0-0.5	Windrow	0.13	U	0.29	0.49	0.097	U	0.070	0.15
GV03B	8+30	L18	6.5-7	Native	0.007	U	0.28	0.50	-0.016	U	0.049	0.097
GV03M	8+30	L18	5-5.5	Native	0.16	U	0.27	0.45	0.048	U	0.050	0.11
GV03S	8+30	L18	0-0.5	Native	0.33	U	0.28	0.46	0.005	U	0.041	0.087
GV04B	25+00	R5	4-4.5	Native	0.54	J	0.23	0.31	0.085	U	0.085	0.17
GV04M	25+00	R5	3.5-4	Windrow	0.46	U	0.31	0.49	0.082	U	0.088	0.16
GV04S	25+00	R5	0-0.5	Windrow	0.35	U	0.29	0.46	0.16	U	0.12	0.24
GV05B	31+50	L4	11.5-12	Native	0.13	U	0.28	0.47	-0.002	U	0.057	0.12
GV05M	31+50	L4	5.5-6	Native	0.64	J	0.39	0.59	0.021	U	0.071	0.14
GV05S	31+50	L4	0-0.5	Native	0.30	U	0.30	0.48	0.04	U	0.01	0.19
GV06B	37+60	L2	5.5-6	Native	0.36	U	0.23	0.36	-0.063	U	0.055	0.085
GV06M	37+60	L2	2.5-3	Windrow	0.47	U	0.34	0.54	0.003	U	0.061	0.12
GV06MD	37+60	L2	4-4.5	Windrow	0.31	U	0.29	0.47	0.063	U	0.071	0.15
GV06S	37+60	L2	0-1[2]	Windrow	0.30	U	0.30	0.49	0.057	U	0.067	0.14
GV07B	43+00	L10	5.5-6	Native	-0.27	U	0.29	0.52	-0.0008	U	0.040	0.079
GV07M	43+00	L10	2-2.5	Windrow	0.61	J	0.31	0.44	0.047	U	0.061	0.12
GV07S	43+00	L10	0-0.5	Fill	0.64	J	0.27	0.36	-0.05	U	0.044	0.077
GV08B	44+80	R8	9-9.5	Native	0.42	J	0.27	0.42	0.016	U	0.051	0.097
GV08M	44+80	R8	5-5.5	Native	0.42	J	0.27	0.42	0.012	U	0.055	0.12
GV08S	44+80	R8	0-0.5	Native	1.34	J	0.42	0.48	0.033	U	0.062	0.13
GV09B	47+00	R7	8.5-9	Native	0.27	U	0.26	0.42	-0.038	U	0.051	0.084
GV09M	47+00	R7	4-4.5	Native	0.49	J	0.26	0.38	0.027	U	0.092	0.19
GV09S	47+00	R7	0-0.5	Native	0.22	U	0.27	0.45	-0.013	U	0.052	0.093
GV10B	56+00	R35	11.5-12	Native	0.08	U	0.29	0.51	-0.046	U	0.037	0.062
GV10M	56+00	R35	6-6.5	Native	0.39	U	0.26	0.41	-0.04	U	0.11	0.19
GV10S	56+00	R35	0-0.5	Native	0.42	J	0.24	0.36	0.29		0.10	0.09

Sample Number	Station Designator	Sample Location	Sample Interval (ft)	Soil Type	Total Strontium (pCi/g)				Cesium-137 (pCi/g)			
					Result	Q[1]	±2σ	MDC	Result	Q	±2σ	MDC
GV10SD	56+00	R35	0.5-1	Native	0.45	J	0.26	0.40	0.028	U	0.069	0.14
GV11B	61+30	R10	8.5-9	Native	0.08	U	0.26	0.45	0.0007	U	0.034	0.073
GV11M	61+30	R10	5.5-6	Native	0.32	U	0.24	0.38	-0.008	U	0.034	0.064
GV11S	61+30	R10	0-0.5	Native	0.42	J	0.26	0.40	0.25		0.13	0.09
GV12B	62+30	R10	10-10.5	Native	0.26	U	0.23	0.38	0.009	U	0.040	0.076
GV12M	62+30	R10	6-6.5	Windrow	0.40	J	0.25	0.37	0.08	U	0.059	0.11
GV12S	62+30	R10	0-0.5	Fill	0.42	J	0.26	0.40	0.015	U	0.042	0.089
GV13B	10+00	C	8-9	Native	0.19	U	0.26	0.43	-0.009	U	0.041	0.076
GV13BR	10+00	C	8-9[3]	Native	0.16	U	0.26	0.43	-0.027	U	0.032	0.06
GV13M	10+00	C	7-7.5	Windrow	0.69	J	0.26	0.33	0.003	U	0.038	0.074
GV13S	10+00	C	0-0.5	Fill	0.47	J	0.22	0.30	-0.007	U	0.070	0.14
GV14B	17+00	C	7-7.5	Native	0.13	U	0.19	0.32	0.021	U	0.045	0.091
GV14M	17+00	C	2-2.5	Windrow	0.40	J	0.24	0.38	0.142	J	0.068	0.084
GV14MD	17+00	C	3-3.5	Windrow	0.52	J	0.22	0.29	0.052	U	0.059	0.13
GV14S	17+00	C	0-0.5	Windrow	0.47	J	0.22	0.32	0.097	U	0.084	0.18
GV15B	17+35	C	7-7.5	Native	0.24	U	0.26	0.42	-0.049	U	0.055	0.088
GV15M	17+35	C	5-6[4]	Fill	0.17	U	0.20	0.33	0.043	U	0.048	0.11
GV15S	17+35	C	0-0.5	Fill	0.14	U	0.18	0.31	0.013	U	0.048	0.099
GV16B	26+40	C	14.5-15	Native	-0.05	U	0.20	0.34	0.005	U	0.046	0.091
GV16M	26+40	C	8-8.5	Windrow	0.18	U	0.21	0.35	0.02	U	0.057	0.12
GV16S	26+40	C	0-0.5	Windrow	1.30	J	0.39	0.43	-0.003	U	0.11	0.20
GV17B	30+00	C	13.5-14	Native	0.06	U	0.18	0.31	-0.042	U	0.049	0.088
GV17M	30+00	C	3.5-4	Windrow	0.74	J	0.26	0.32	0.44		0.14	0.12
GV17MD	30+00	C	5.5-6	Windrow	0.68	J	0.25	0.32	0.61		0.20	0.13
GV17S	30+00	C	0-0.5	Fill	0.19	U	0.23	0.38	0.044	U	0.061	0.13
GV18B	34+20	C	3.5-4	Native	0.21	U	0.19	0.31	0.07	U	0.053	0.099
GV18M	34+20	C	0.5-1	Windrow	1.37	J	0.35	0.29	0.32		0.17	0.08
GV18S	34+20	C	0-0.5	Fill	0.32	U	0.22	0.34	0.008	U	0.089	0.17
GV19B	39+86	L2	5.5-6	Native	0.14	U	0.23	0.38	-0.0009	U	0.060	0.11
GV19M	39+86	L2	3.5-4	Native	0.18	U	0.20	0.33	-0.02	U	0.053	0.093
GV19S	39+86	L2	0-0.5	Native	0.03	U	0.20	0.34	0.036	U	0.070	0.14
GV20B	45+00	L5	8.5-9	Native	0.36	J	0.22	0.33	-0.0009	U	0.052	0.1
GV20BD	45+00	L5	9.5-10	Native	0.17	U	0.20	0.33	0.006	U	0.047	0.09
GV20M	45+00	L5	5.75-6.25	Windrow	0.26	U	0.23	0.36	0.148	J	0.090	0.11
GV20S	45+00	L5	0-0.5	Fill	0.12	U	0.21	0.36	0.001	U	0.041	0.077
GV21B	54+00	L5	10-10.5	Native	0.01	U	0.20	0.34	-0.005	U	0.040	0.08
GV21M	54+00	L5	3.5-4	Native	0.21	U	0.24	0.39	0.09	U	0.12	0.22
GV21S	54+00	L5	0-0.5	Windrow	0.25	U	0.22	0.35	0.115	U	0.090	0.12
GV22B	55+00	C	8.5-9	Native	0.15	U	0.22	0.37	-0.016	U	0.036	0.072
GV22M	55+00	C	5-5.5	Native	0.01	U	0.20	0.34	-0.001	U	0.041	0.078
GV22S	55+00	C	0-0.5	Native	0.29	U	0.19	0.29	0.27		0.12	0.10
GV23B	56+00	C	7-7.5	Native	-0.06	U	0.22	0.39	-0.004	U	0.044	0.082
GV23M	56+00	C	5-5.5	Windrow	-0.03	U	0.19	0.33	0.087	U	0.081	0.17
GV23S	56+00	C	0-0.5	Windrow	-0.10	U	0.18	0.32	0.068	U	0.068	0.11
GV23SD	56+00	C	0.5-1	Windrow	0.56	J	0.22	0.29	0.02	U	0.077	0.15
GV24B	62+50	R20	11.5-12	Native	0.14	U	0.17	0.28	-0.02	U	0.037	0.071

Sample Number	Station Designator	Sample Location	Sample Interval (ft)	Soil Type	Total Strontium (pCi/g)				Cesium-137 (pCi/g)			
					Result	Q[1]	±2σ	MDC	Result	Q	±2σ	MDC
GV24M	62+50	R20	6-6.5	Windrow	-0.06	U	0.19	0.33	-0.02	U	0.046	0.082
GV24S	62+50	R20	0-0.5	Fill	0.49	J	0.27	0.41	0.055	U	0.043	0.096
GV25B	62+50	L25	10.5-11	Native	0.26	U	0.24	0.39	0.006	U	0.035	0.074
GV25M	62+50	L25	6-7[3]	Windrow	0.23	U	0.23	0.37	0.34		0.10	0.09
GV25MR	62+50	L25	6-7	Windrow	0.79	J	0.30	0.39	0.10	U	0.12	0.14
GV25S	62+50	L25	0-0.5	Fill	0.22	U	0.22	0.36	0.065	U	0.042	0.098
GV26S	27+51	C	0-0.5	Windrow	1.50	J	0.39	0.33	0.04	U	0.10	0.21

[1] Q = Data Qualifier from Analytical Report (See Attachment E)
U Result is less than the sample minimum detectable concentration (MDC)
J Result is greater than the sample MDC but less than the STL St Louis laboratory reporting limit
(The laboratory reporting limits of 3 pCi/g for total strontium and 0.2 pCi/g for Cs-137 were established through the routine analysis of samples at the laboratory and represent results that can be achieved on most samples with these analyses)
[2] Sample interval greater than 6 inches due to recovery volume.
[3] Sample interval is 1 foot for field replicates where the larger sample volume is mixed and split between the two samples.
[4] Sample interval greater than 6 inches due to larger pebbles not included in the sample.

MARSSIM guidance recommends that four basic statistical quantities, mean, median, standard deviation, and range be calculated for a data set during preliminary data review. All reported values, including negative values, were used in the calculation of the statistical quantities. Table 4-2 presents these statistical values for nine different data sets that will be used to satisfy the survey objectives. All 84 samples collected will be used as an indication of the status of the pipeline corridor and outfall soils. The 19 samples from the bottom of excavations and the 25 samples from undisturbed locations will be used to determine if Sr-90 migrated vertically or laterally outside of the known contaminated areas. The 28 samples containing windrow material will be used to assess the adequacy of the field methods used to screen this material prior to its use as backfill in the excavated areas. The other data sets are included for completeness. The statistical quantities were calculated using a spreadsheet program and copies of the individual worksheets are provided in Attachment G.

Section 8.2.2.1 of MARSSIM provides recommendations on how the statistical values should be used. Because MARSSIM guidance uses the term "derived concentration guideline level" ($DCGL_W$), it is used in the following discussion and is set equal to the soil criterion for release for unrestricted use of 10 pCi/g and 4 pCi/g for Cs-137 and Sr-90 respectively.

The mean concentration can be compared to the $DCGL_W$ for an indication of the status of the survey unit. For this survey, the average Sr-90 and Cs-137 concentrations were much less than their respective $DCGL_W$ for all the sample groups. As can be seen, each of the 168 sample results is less than the appropriate $DCGL_W$, and in accordance with MARSSIM Section 8.2.5, performance of the Sign Test is not required. Figures 4-1 and 4-2 are provided to give a visual indication of the data. The data labels for Figure 4-1 correspond to samples with measured Sr-90 concentrations greater than 0.50 pCi/g. The data labels in Figure 4-2 are for each sample with a measured Cs-137 concentration greater than its respective MDC. Frequency plots of the data are included in Attachment G.

A large difference between the median and mean is an early indication of skewness in the data. Since the difference between the median and mean is only a small fraction of the standard deviation, the data does not appear to be skewed.

The range of the data is not unusually large when compared to the standard deviation, MARSSIM indicates that 4 or 5 standard deviations for data sets less than 30 samples in not unusual and that a wider range would be expected for a greater number of samples.

Table 4-2
Basic Statistical Quantities for Various Soil Sample Groups

		Total Strontium (pCi/g)				Cesium-137 (pCi/g)			
Soil Sample Group	**# In Group**	**Arithmetic Mean**	**Median**	**Standard Deviation**	**Range (Difference)**	**Arithmetic Mean**	**Median**	**Standard Deviation**	**Range (Difference)**
All Samples (includes Field QA)	84	0.35	0.28	0.33	-0.27 to 1.5 (1.77)	0.06	0.020	0.12	-0.06 to 0.61 (0.67)
All Surface Samples	28	0.45	0.34	0.39	-0.1 to 1.5 (1.6)	0.08	0.04	0.12	-0.05 to 0.51 (0.56)
All Mid-Depth Samples	29	0.41	0.40	0.31	-0.06 to 1.37 (1.43)	0.10	0.05	0.15	-0.04 to 0.61 (0.65)
All Bottom Samples	27	0.18	0.15	0.20	-0.27 to 0.79 (1.06)	0.00	0.00	0.03	-0.06 to 0.09 (0.15)
All Samples Containing Windrow Material	28	0.48	0.43	0.40	-0.1 to 1.5 (1.6)	0.12	0.08	0.15	-0.02 to 0.61 (0.63)
Bottom Samples from Excavated Areas	19	0.19	0.17	0.23	-0.27 to 0.79 (1.06)	0.00	0.00	0.04	-0.06 to 0.09 (0.15)
Samples from Randomly Selected Locations	38	0.39	0.38	0.29	-0.27 to 1.34 (1.61)	0.05	0.02	0.11	-0.06 to 0.51 (0.57)
Samples from Locations Containing Native Soil Only	25	0.31	0.29	0.27	0.007 to 1.34 (1.33)	0.04	0.01	0.09	-0.05 to 0.29 (0.34)
Samples Identified as Fill	11	0.39	0.32	0.28	0.12 to 1.06 (0.94)	0.06	0.02	0.15	-0.05 to 0.51 (0.56)

Figure 4-1
SM-1A Reactor Pipeline Corridor Verification Survey
Total Strontium Results

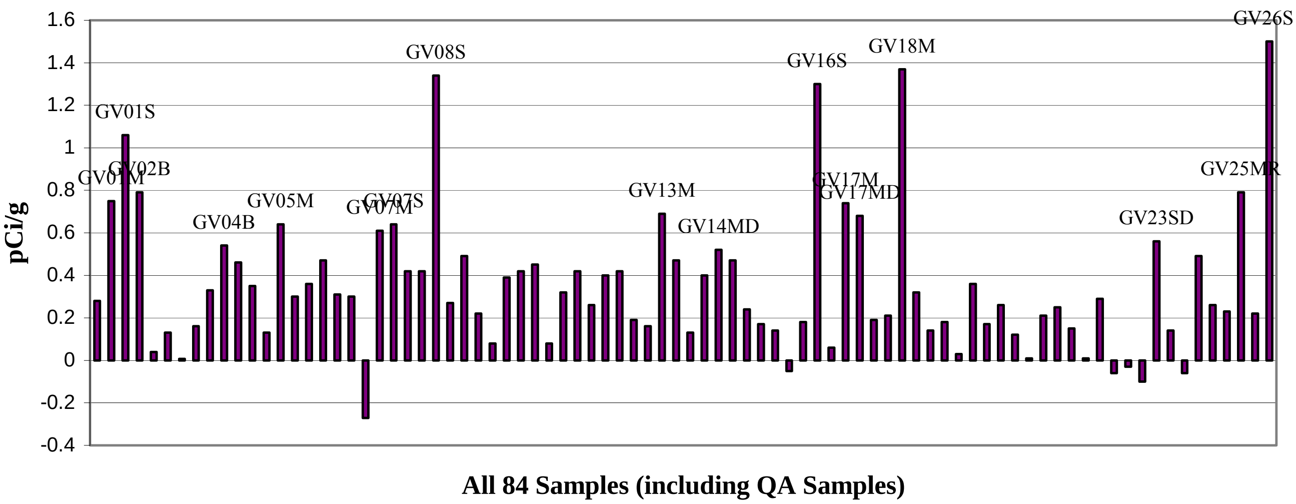
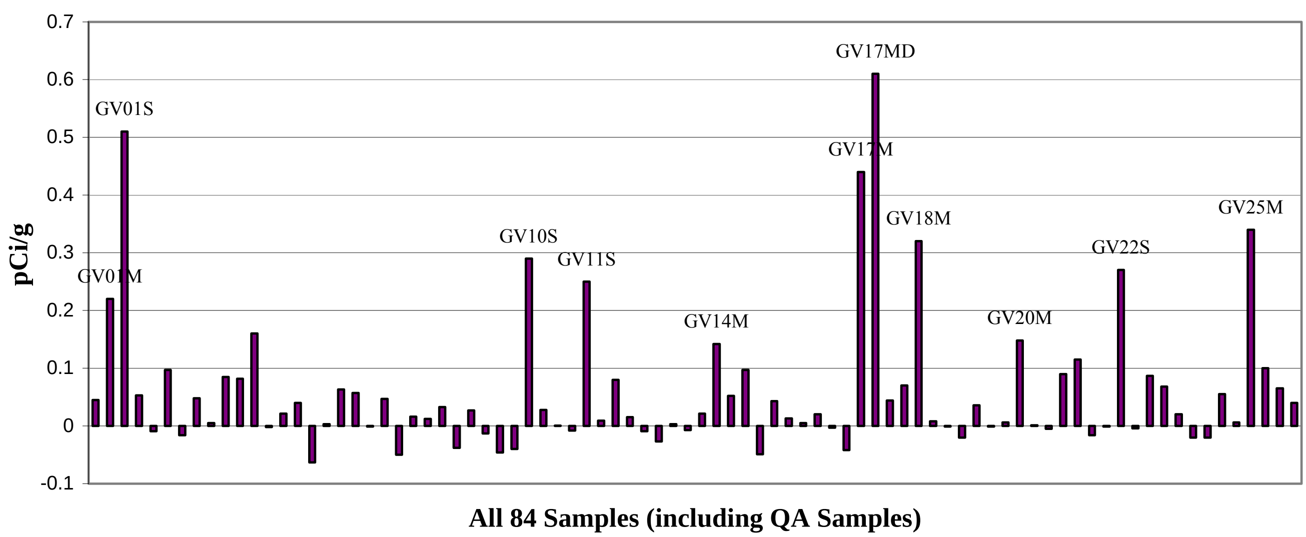


Figure 4-2
SM-1A Reactor Pipeline Corridor Verification Survey
Cesium-137 Results



The number of random samples that were required in the work plan, 12, was determined using the methodology in Section 5.5.2.3 of MARSSIM. The relative shifts, an indication of the measurement resolution, were calculated using the highest standard deviation from the final closure survey data. For Cs-137, the standard deviation of 2.74 pCi/g for the outfall windrow samples, and for Sr-90, the standard deviation of 1.09 pCi/g for the 175 pipeline samples. The number of samples for Cs-137 and Sr-90 are recalculated using the standard deviations from the verification survey data to demonstrate that a sufficient number of samples were collected. For all calculations the lower bound of the gray region (LBGR) is set at one-half of the $DCGL_W$, the Type I error rate is $\alpha = 0.05$, and the Type II error rate is $\beta = 0.10$. Table 5.5 in MARSSIM provides the number of samples required using these values and the calculated relative shift.

Cs-137 (using final closure survey data)
$\Delta/\sigma = (DCGL_W - LBGR) / \sigma = (10\ pCi/g - 5\ pCi/g) / (2.74\ pCi/g) = 1.82$

Sr-90 (using final closure survey data)
$\Delta/\sigma = (DCGL_W - LBGR) / \sigma = (4\ pCi/g - 2\ pCi/g) / (1.09\ pCi/g) = 1.83$

A relative shift of 1.8, and the above error rates, requires 12 random samples for both Cs-137 and Sr-90. Recalculating the relative shift with the standard deviations from all 84 reported results, both negative and positive, from the verification survey gives:

Cs-137 (using verification survey data)
$\Delta/\sigma = (DCGL_W - LBGR) / \sigma = (10\ pCi/g - 5\ pCi/g) / (0.12\ pCi/g) = 41.6$

Sr-90 (using verification survey data)
$\Delta/\sigma = (DCGL_W - LBGR) / \sigma = (4\ pCi/g - 2\ pCi/g) / (0.33\ pCi/g) = 6.1$

The significantly increased relative shifts calculated using the verification survey standard deviations confirms that a sufficient number of random samples were collected for the observed variability in the data.

4.2 Walkover Survey Results

The walkover surveys performed during the Verification Survey were used to identify areas where additional verification sampling may be warranted. Though a 100% scan of the pipeline corridor was not an objective of this survey, the areas that were scanned, as identified in Section 3.1 above, appear to be free from large areas of Cs-137 surface contamination. The gradual, and in one instance (GV26), short-range variations in the surface dose rates have historically been linked to elevated levels of naturally occurring radionuclides such as potassium-40.

The sensitivity of the scanning performed can be demonstrated by estimating the Scanning Minimum Detectable Concentration (MDC_{scan}) for the Ludlum model 2350 and 44-10 NaI detector as it was used during this survey. This calculation uses the methodology and approach provided in MARSSIM (Section 6.7.2.1) for a 2-inch by 2-inch NaI scintillation detector. Factors included in this analysis are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, size of the contaminated surface, and the energy and yield of gamma emissions. The mean background response for the gamma instrument in the pipeline area during the survey can be estimated from the 40 dose rate measurements taken at the sampling locations. The average dose rate was 8.35 µR/hr with a standard deviation of 1.44 µR/hr. Using the average plus two standard deviations, 11.2 µR/hr, as a conservative estimate of the natural background corresponds to 10,117 counts per minute (cpm). Using this value, information from MARSSIM, and surveyor factors that reasonably describe the willingness to stop and take a longer reading on encountering elevated readings the MDC_{scan} is calculated as follows:

b_i	=	(10,117 cpm) x (1 sec) x (1 min/60 sec)	=	169 counts
MDCR	=	$(1.9^{a}) \times (169^{1/2}) \times (60\ sec/1min)$	=	1482 cpm
$MDCR_{surveyor}$	=	$1482/0.5^{b1/2}$	=	2096 cpm
MDER	=	2096 cpm/900[c]cpm/µR/hr	=	2.33 µR/hr
MDC_{scan}	=	(5pCi/g)(2.33 µR/h/1.307[d]µR/hr)	=	8.91 pCi/g

[a] Level of performance factor, MARSSIM Table 6-5
[b] Efficiency of surveyor
[c] From manufacturer's technical data sheets.
[d] Exposure rate from 5pCi/g Cs-137 calculated by Microshield (provided in MARSSIM).
b_i = counts in observation interval (1 second)
MDCR = Minimum Detectable Count Rate
MDER = Minimum Detectable Exposure Rate

The estimated MDC_{scan} (9 pCi/g) for the gamma instrument is less than the Cs-137 $DCGL_{W;}$ therefore, any areas of Cs-137 contamination located in the surface of the surveyed areas that exceeded the $DCGL_W$ should have been identified.

5.0 Quality Assurance

5.1 Field Instrument Quality Control.

Field instruments were in calibration when brought to Ft. Greely. The instruments were checked for daily operability using a Cs-137 check source. The daily readings of the source did not differ from the expected value by more than 20%. Figures 5-1 to 5-4 and Tables 5-1 and 5-2 are included to document the daily QC data. The instruments operated as expected throughout the survey.

5.2 Calculation Of Data Quality Indicators

Completeness

Sample collection data completeness is calculated using Equation (1) and the results are presented in Table 5-3.

$$\text{Collection Completeness} = \frac{\text{Number of Sample Points Sampled}}{\text{Number of Sample Points Planned}} \times 100\% \qquad \textbf{(1)}$$

Data completeness of laboratory analyses is assessed for compliance with the amount of data required for decision-making. The completeness is calculated using Equation (2) and the results are presented in Table 5-3.

$$\text{Data Completeness} = \frac{\text{Number of Accepted Laboratory Measurements}}{\text{Number of Laboratory Measurements Generated}} \times 100\% \qquad \textbf{(2)}$$

Collocated and Field Replicate Samples

The six collocated samples that were collected during the Verification Survey provide an indication of the short-range variability of the radionuclide concentrations. The samples were collected from adjacent intervals within the same split spoon, or from continuous split spoon sampling not greater than 2.5 feet from the beginning of one sampling interval to the end of the duplicate sampling interval. For those duplicate samples where potassium-40 was identified, it is included in the duplicate analysis.

Two field replicates samples were collected during the Verification Survey to provide an indication of the precision in the entire sampling and analysis process. The samples were collected from a 1-foot interval within the same split spoon, mixed in a sample container, and divided into two separate samples. For those replicate samples where potassium-40 was identified, it is included in the replicate analysis.

The Relative Percent Difference (RPD), Normalized Absolute Difference (NAD) and Duplicate Error Ratio (DER) are calculated for each pair of duplicate analysis using Equations (3), (4) and (5). The error ratio calculation results for the collocated and field replicate sample pairs are presented in Table 5-4. No specific goal was set for these error ratio values in the survey plan, however, the State of Alaska has indicated that an RPD ≤ 40%, an NAD ≤ 1.96, and a DER < 1 are generally considered acceptable in various radioanalytical data validation publications.

$$RPD = \frac{|S - D|}{\frac{(S + D)}{2}} x100 \tag{3}$$

where:

RPD	=	Relative Percent Difference
S	=	first sample value (original or MS value),
D	=	second sample value (duplicate or MSD value),

$$NAD = \frac{|S - D|}{\sqrt{\sigma_S{}^2 + \sigma_D{}^2}} \tag{4}$$

where:

NAD	=	Normalized Absolute Difference
S	=	first sample value (original or MS value),
D	=	second sample value (duplicate or MSD value)
σ_S	=	first sample standard deviation
σ_D	=	second sample standard deviation,

$$DER = \frac{|S - D|}{2\sigma_S + 2\sigma_D} \tag{5}$$

where:

DER	=	Duplicate Error Ratio
S	=	first sample value (original or MS value),
D	=	second sample value (duplicate or MSD value)
σ_S	=	first sample standard deviation
σ_D	=	second sample standard deviation,

Figure 5-1
SM-1A REACTOR PIPELINE VERIFICATION SURVEY
GAMMA QC CHART
Ludlum 2350 with 44-10 NaI Detector

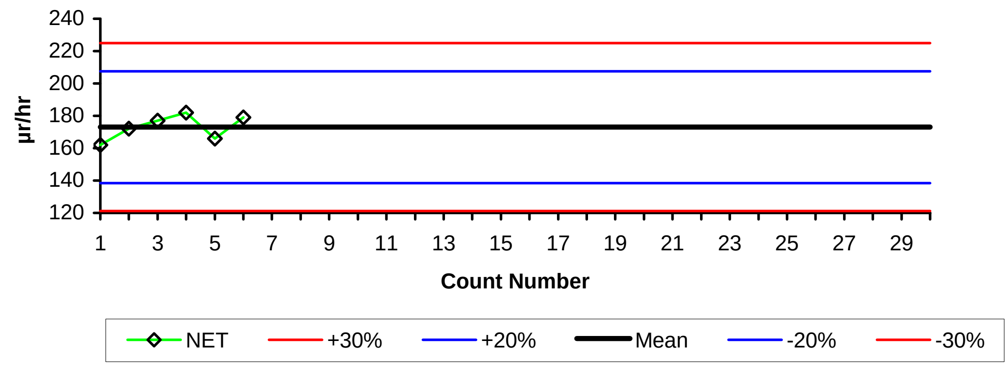


Table 5-1									
Gamma Quality Control Data									
Model:	2350-1	**SN#**	126187	**Probe:**	44-10	**SN#**	PR135866	**Cal Due:**	3Apr01
Source:	Cs-137	**SN#**	686	**Activity:**	0.96 µCi			**Date:**	1Feb98
Mean	+20%		-20%		+30%:		-30%		
173	208	to	138		225	to	121	Efficiency:	NA
Chk.#	Gross	Net	Chk.#	Gross	Net	Chk.#	Gross	Net	COMMENTS
1	168	162	2	178	172	3	183	177	
4	188	182	5	172	166	6	185	179	
Bkgd:	6 µR/hr		Mean:		173 µR/hr	20%:	34 µR/hr	30%:	51 µR/hr

Figure 5-2
SM-1A REACTOR PIPELINE VERIFICATION SURVEY
DAILY GAMMA QC CHECK for 12-13 SEP 00
Ludlum 2350 with 44-10 NaI Detector

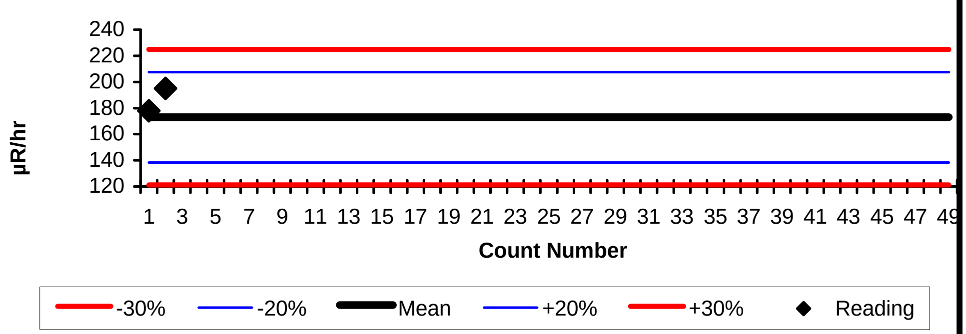


Figure 5-3
SM-1A REACTOR PIPELINE VERIFICATION SURVEY
BETA / GAMMA QC CHART
Ludlum Model 3 with 44-9 GM Detector

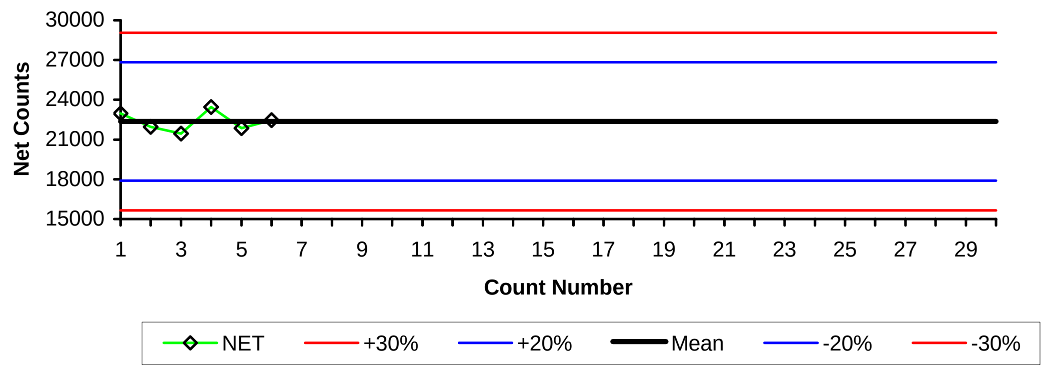


Table 5-2
Beta/Gamma Quality Control Data

Model:	3	**SN#**	96686	**Probe:**	44-9	**SN#**	PR094260	**Cal Due:**	4Apr01
Source:	Cs-137	**SN#**	686	**Activity:**	2,130,000	dpm		**Date:**	1Feb98
Mean	+20%		-20%		+30:		-30%		
22360	26832	to	17888		29068	to	15652	**Efficiency:**	0.0105
Chk.#	Gross	Net	Chk.#	Gross	Net	Chk.#	Gross	Net	COMMENTS
1	23000	22960	2	22000	21960	3	21500	21460	
4	23500	23460	5	21900	21860	6	22500	22460	
Bkgd:	40	cpm	Mean:	22360	cpm	20%:	4472 cpm	30%:	6708 cpm

Figure 5-4
SM-1A REACTOR PIPELINE VERIFICATION SURVEY
DAILY BETA/GAMMA QC CHECK for 12-13 SEP 00
Ludlum Model 3 with 44-9 GM Detector

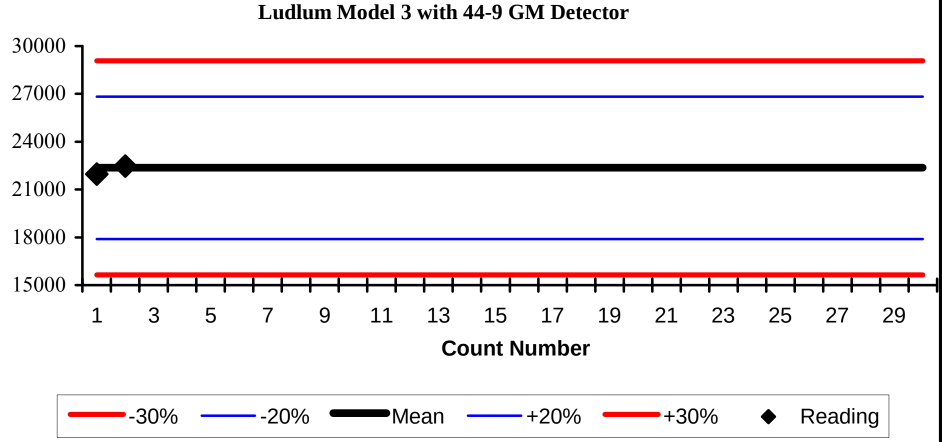


Table 5-3
Collection and Data Completeness

Number of Field Samples Required	Number of Field Samples Acquired	Percent	Goal	Pass/Fail
84	84	100	>98%	Pass
Number of Accepted Laboratory Measurements	**Number of Laboratory Measurements Generated**	**Percent**	**Goal**	**Pass/Fail**
168	168	100	>98%	Pass

Table 5-4
Collocated and Field Replicate Samples
Error Ratio Calculation Results

Sample Number	Cs-137 Sample (pCi/g)	Cs-137 Duplicate (pCi/g)	%RPD ≤ 40%	NAD ≤ 1.96	DER < 1
GV06M/MD	0.003U	0.063U	182	1.28	0.45
GV10S/SD	0.29	0.028U	165	4.31	1.55
GV14M/MD	0.142J	0.052U	93	2.00	0.71
GV17M/MD	0.44	0.61	32	1.39	0.50
GV20B/BD	-0.0009U	0.006U	271	0.20	0.07
GV23S/SD	0.068U	0.02U	109	0.93	0.33
GV13B/BR	-0.009U	-0.027U	-100	0.69	0.25
GV25M/MR	0.34	0.1U	109	3.07	1.09
	K-40 Sample (pCi/g)	**K-40 Duplicate (pCi/g)**	**%RPD ≤ 40%**	**NAD ≤ 1.96**	**DER < 1**
GV06M/MD	12.6	12.7	1	0.06	0.02
GV10S/SD	15.8	13.8	14	0.97	0.34
GV14M/MD	10.8	13	18	1.24	0.44
GV17M/MD	16.7	15.4	8	0.58	0.21
GV20B/BD	9.3	10.4	11	0.76	0.27
GV23S/SD	14.3	16.1	12	0.91	0.32
GV13B/BR	6.9	5.3	26	1.51	0.53
GV25M/MR	17	18.6	9	0.67	0.24
	Sr Sample (pCi/g)	**Sr Duplicate (pCi/g)**	**%RPD ≤ 40%**	**NAD ≤ 1.96**	**DER < 1**
GV06M/MD	0.47U	0.31U	41	0.72	0.25
GV10S/SD	0.42J	0.45J	7	0.17	0.06

GV14M/MD	0.40J	0.52J	26	0.74	0.26
GV17M/MD	0.74J	0.68J	8	0.33	0.12
GV20B/BD	0.36J	0.17U	72	1.28	0.45
GV23S/SD	-0.1U	0.56	287	4.64	1.65
GV13B/BR	0.19U	0.16U	17	0.16	0.06
GV25M/MR	0.23U	0.79J	110	2.96	1.06

Of the collocated samples, only one Cs-137 sample pair and one Sr sample pair failed to meet at least one of the error ratio goals. In both GV10S/SD and GV23S/SD, one of the sample pair was below the MDC while the other was slightly higher than the MDC. One of the field replicate samples, GV25M/MR, did not meet an error ratio goal for either the Cs-137 or Sr sample pair. For both pairs, however, the DER was only slightly higher than the goal value of 1. The K-40 sample pairs met all three error ratio goals for both the collocated and replicate samples.

Laboratory Precision

The precision of the laboratory analytical methods was determined through evaluation of laboratory duplicate analyses. This precision measurement includes variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity. The Relative Percent Difference (RPD), Normalized Absolute Difference (NAD) and Duplicate Error Ratio (DER) are calculated for each pair of duplicate analysis using Equations (3), (4) and (5). The error ratio calculation results for the collocated and field replicate sample pairs are presented in Table 5-5. A goal for RPD was not set in the survey plan, however. The State of Alaska suggested that an RPD ≤ 20% would be appropriate for laboratory samples and indicated that an NAD ≤ 1.96, and a DER < 1 are also generally considered acceptable in various radioanalytical data validation publications.

Table 5-5
Laboratory Duplicate Results
Other naturally occurring radionuclides detected during gamma spectroscopy were included in the laboratory duplicate evaluation

Laboratory Sample No.	Cs-137 Sample (pCi/g)	Cs-137 Duplicate (pCi/g)	%RPD ≤ 20%	NAD ≤ 1.96	DER < 1
0278330	0.006U	0.004U	40	0.07	0.02
0285519	0.047U	0.00002U	200	1.28	0.46
0290245	0.003U	0.034U	168	1.01	0.36
0290297	-0.020U	-0.015U	-29	0.13	0.05
0290307	0.34	0.26	27	1.02	0.36
	K-40 Sample (pCi/g)	**K-40 Duplicate (pCi/g)**	**%RPD ≤ 20%**	**NAD ≤ 1.96**	**DER < 1**
0278330	8.7	9.4	8	0.51	0.18
0285519	12.2	9.2	28	2.11	0.75
0290245	7.8	8.2	5	0.33	0.12

0290297	12.4	12.1	2	0.18	0.06
0290307	17	13.9	20	1.43	0.51
	Sr Sample (pCi/g)	**Sr Duplicate (pCi/g)**	**%RPD ≤ 20%**	**NAD ≤ 1.96**	**DER < 1**
0279169	0.14U	0.23U	49	0.43	0.15
0283188	0.61J	0.64J	5	0.14	0.05
0285121	0.69J	0.18U	117	3.11	1.11
0291100	0.18U	0.07U	88	0.78	0.28
0293128	0.49J	0.48J	2	0.06	0.02
	Th-232 Sample (pCi/g)	**Th-232 Duplicate (pCi/g)**	**%RPD ≤ 20%**	**NAD ≤ 1.96**	**DER < 1**
0285519	0.62	0.74	18	0.51	0.18
0290245	0.37	0.55	39	1.07	0.38
	Pb-214 Sample (pCi/g)	**Pb-214 Duplicate (pCi/g)**	**%RPD ≤ 20%**	**NAD ≤ 1.96**	**DER < 1**
0290297	0.54	0.65	19%	0.86	0.31
0290307	0.67	0.47	35%	1.31	0.47
	Ac-228 Sample (pCi/g)	**Ac-228 Duplicate (pCi/g)**	**%RPD ≤ 20%**	**NAD ≤ 1.96**	**DER < 1**
0290307	1.07	1.03	4	0.12	0.04

Only one of the laboratory duplicate sample pairs failed to meet at least one of the error ratio goals. The Sr analysis on Sample No. 0285121 included one result that was below the MDC and the DER was only slightly higher than the goal of 1.

Accuracy

The accuracy of the laboratory analytical measurement process was determined by comparing the percent recovery (%R) of a Matrix Spike Sample (MS) to the true value. The percent recovery (%R) of MS samples is calculated using Equation (6) and presented in Table 5-6. This accuracy will include variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity.

$$\%R = \frac{A - B}{C} \times 100 \qquad \textbf{(6)}$$

where:

%R = percent recovery
A = the analyte concentration determined experimentally from the spiked sample,
B = the background level determined by a separate analysis of the unspiked sample,
C = the amount of the spike added.

Table 5-6
Matrix Spike Samples

Cs-137 Spike (pCi/g)	Cs-137 Result (pCi/g)	% R	Goal*	Pass/Fail
8970	10300	114	88 to 117	Pass
8970	10300	115	88 to 117	Pass
8970	10000	112	88 to 117	Pass
8970	10500	117	88 to 117	Pass
8970	10200	114	88 to 117	Pass
Sr-90 Spike (pCi/g)	**Sr-90 Result (pCi/g)**	**%R**	**Goal***	**Pass/Fail**
9.59	5.6	58	49 to 126	Pass
9.59	7.7	80	49 to 126	Pass
9.59	8.4	87	49 to 126	Pass
9.59	8.8	91	49 to 126	Pass
9.59	8.8	92	49 to 126	Pass

* Established by Lab

Method Blank Report

The laboratory analyzed five blank samples for each of the two methods used. All samples were below the MDC.

5.3 Quality Assurance Conclusions

Project Completeness

The data collected is precise, accurate, and complete.

Consideration was given for project changes and alterations during implementation. The review, evaluation, and assessment process did not result in the rejection of any data. Overall, the project completeness was assessed relative to media, analyte, and area of investigation.

In assessing the data, the reviewers applied professional judgement and consideration of the project data quality objectives in qualifying data. Although a few failures of laboratory quality assurance tests occurred, given the inherent error of results reported at less than the minimal detectable concentration and the low MDC obtained by the laboratory this is not unexpected. Ideally, only results greater than 2 to 5 times the MDC would be considered valid for quality assurance comparisons. Additionally, field replicates rely on homogenization of the sample in the field. Given the low activity levels in all samples the uncertainty associated with the field homogenization must be considered in assessing the data.

Field instrument data met all quality control criteria.

Representativeness And Comparability Conclusion

Data is representative and comparable.

Data reviewers considered project data quality objectives and typical assessment criteria. Specifically;

- Data is expressed in the same units as the criteria
- MDC for laboratory sample analysis were less than 25% of the criteria
- Data was collected in accordance with approved plans
- Field instruments passed all QC checks
- Project Data Quality Objectives were met

Quality Assurance Conclusion

Data collected for this project is precise, accurate, representative, complete, and comparable.

6.0 Conclusions and Recommendations.

The Verification Survey sampling results support the conclusion that the radiological criteria have been achieved by the removal activities. All 84 surface and subsurface soil samples collected were below the soil criteria for release for unrestricted use and were of adequate quantity and quality to confirm the final status of the pipeline corridor and outfall soils as indicated in the Draft Closure Report.

The survey design allowed for subsets of the survey data to be used for addressing specific concerns regarding the mobility and detection of strontium-90 in the pipeline corridor. The survey results indicate that potential differential migration of contaminants did not lead to higher levels of strontium-90 below or adjacent to the excavated soils. The levels of strontium-90 in windrow material used to backfill excavations were also found to be below its soil criterion for release for unrestricted use.

In accordance with the 1998 Memorandum from Army Reactor Office, it is recommended that this report, together, with the Final Closure Report, be submitted to the Army Reactor Office with a request from CEMP-R to have the pipeline corridor removed from Reactor Possession Permit Number SM1A-2-99. The land would then be available for unrestricted use.

7.0 REFERENCES

Army 1996. *Army Reactor Program* AR 50-7 Department of the Army, Washington, DC.

NRC 1997. *Multi-Agency Radiation Survey and Site Investigation Manual*, NUREG-1575, December

USACE 1994. *Requirements for the Preparation of Sampling and Analysis Plans*, EM-200-1-3, www.usace.army.mil/inet/usace-docs/eng-manuals/ em200-1-3, September.

USACE 1996. *Soil Sampling* EM 1110-1-1906 Department of the Army, Washington, DC, September.

USACE 1998. *Technical Project Planning Process* EM-200-1-2, www.usace.army.mil/inet/ usace-docs/eng-manuals/em200-1-2, August.

USACE 1999. *Management Plan for the U.S Army Deactivated Reactor Program*, September.

USACE 1999b. USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy.

USACE 2000a. *Draft Closure Report Fort Greely SM-1A Radioactive Pipeline Removal*, March.

USACE 2000b. *Appendix B, Site Safety and Heath Plan Addendum Fort Greely SM-1A Radioactive Pipeline Removal*, July.

USACE 2000c. *Work Plan for the Verification Survey of the SM-1A Reactor Waste Pipeline Corridor*, September.

Walpole, R.E. and R.H. Meyers, 1978. *Probability and Statistics for Engineers and Scientists*, 2nd ed., MacMillian Publishing Co., Inc. New York, NY.

ATTACHMENT A

EPA COMMENTS ON SURVEY PLAN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, WA 98101

Reply To
Attn Of: ECL-112

Mr. Bill Abadie
Corps of Engineers
CEPOA-PM-M (Abadie)
Anchorage, Alaska 99506-0898

Re: U.S. Army Corps of Engineers Work Plan for the Verification Survey of the SM-1A Reactor Waste Pipeline Corridor - Fort Greely, Alaska - dated September 2000

Dear Mr. Abadie:

We have reviewed the above referenced document and have only the following comments:

1. It is not clear if either random or biased samples are being collected of the “windrow” backfill material. Section 3.3 states an objective to address the inadequacy of beta field screening of this material but the workplan does not clearly outline how this objective will be met and where.

2. Section 4.7 discusses the procedures for checking field instruments and states that “field instruments will be checked for daily operability...”. This check should also include a calibration of the instrument.

3. Attachment B does not include the field technical procedures for soil sample collection with a split spoon and drill rig. Where are these field procedures?

With these comments we are in agreement with the approach for confirming the cleanup of the SM-1A pipeline corridor. Please feel free to contact me at (206) 553-2806 if you have any questions.

Sincerely,

Bill Adams
Project Manager

cc: Greg Light, ADEC - Fairbanks
Ken Spiers, U.S. Army

ATTACHMENT B

USACE RESPONSE TO EPA COMMENTS

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. BOX 898
ANCHORAGE, ALASKA 99506-0898

REPLY TO
ATTENTION OF: Programs and Project Management Division

Mr. Bill Adams
U.S. Environmental Protection Agency, Region X
1200 Sixth Avenue, ECL-112
Seattle, Washington 98101

Dear Mr. Adams:

This is in response to your 20 September 2000 letter providing comments on our September 2000 Work Plan for the Verification Survey of the SM-1A Reactor Waste Pipeline Corridor, Fort Greely, Alaska.

Comment 1. It is not clear if either random or biased samples are being collected of the "windrow" backfill material. Section 3.3 states an objective to address the inadequacy of beta field screening of this material but the workplan does not clearly outline how this objective will be met and where.

Response 1. The assessment of windrow material was the specific objective of the mid-depth sample from the 13 biased sample locations. Additionally, four of the randomly selected sample locations fell into previously remediated areas. Therefore, 17 locations could have contained windrow material in both the surface and/or mid-depth samples. Preliminary soil classification by the site geologist indicates that 29 samples of windrow material were collected. Additionally, 44 samples of native soil and 11 samples of backfill from the borrow area were collected.

Comment 2. Section 4.7 discusses the procedures for checking field instruments and states that "field instruments will be checked for daily operability...". This check should also include a calibration of the instrument.

Response 2. The document should have indicated that the field survey instruments would be calibrated before use with appropriate National Institute of Standards (NIST) traceable radiation sources. Both the Ludlum Model 3 with 44-9 GM pancake probe used to scan split spoon samples and for health and safety, and the Ludlum Model 2350-1 with 44-10 NaI probe used for microR per hour measurements and walkover scanning were within their annual calibration period. Calibration certificates are enclosed.

Comment 3. Attachment B does not include the field technical procedures for soil sample collection with a split spoon and drill rig. Where are these field procedures?

Response 3. The procedures in place for drilling, split spoon sampling, and decontamination are found in the following two Fort Greely site specific documents:

USAED 1999 (October). Final Work Plan Addendum, Remedial Investigation/Removal Action. Fort Greely, Alaska. Prepared by Jacobs Engineering Group Inc.

USAED 1997 (July). Final Work Plan, Site Investigation/Limited Remedial Investigation, Removal of Radioactive Waste Pipeline, Installation of the Cathodic Protection System. Fort Greely, Alaska. Prepared by Jacobs Engineering Group Inc.

If you have any questions, please contact Bill Abadie at the address above, by telephone at (907) 753-2736, or by email at william.d.abadie@usace.army.mil.

Sincerely,

Scott R. Bearden
Deputy District Engineer for
Programs and Project Management

Enclosures

Copies Furnished:

Mr. Greg Light
Alaska Department of Environmental Conservation
610 University Avenue
Fairbanks, Alaska 99709

US Army Alaska
APVR-WPW-EV (Attn: Spiers)
1060 GAFFNEY ROAD, #6500
Fort Wainwright, Alaska 99703-6500

Brian Hearty
U.S. Army Corps of Engineers
HTRW Center of Expertise, CENWO-HX-H
12565 W. Center Rd.
Omaha, NE 68144

Chris Dillon
Jacobs Engineering Group
4300 B Street
Suite 600
Anchorage, AK 99503-5922

FTG Adm File
FTG Rec File

CONCUR:
PM-M
Boyle

Abadie\cb\x2736\04 Oct 00
G:\PM Army Env\dist letters\ftg\FTG SM1A conf sample response to comments

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER US ARMY CORP OF ENGINEERS ORDER NO. 245884/246928

Mfg. Ludlum Measurements, Inc. Model 2350-1 Serial No. 126187

Cal. Date 3-Apr-00 Cal Due Date 3-Apr-01 Cal. Interval 1 Year Meterface n/a

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 30 % Alt 703.8 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 12/19/89.

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

COMMENTS: *Firmware: 37122N20*

I/O firmware version 37123N04
Cs137 5.0µCi check source readings taken using CPM setups, taking a 1 min. scaler count,door open on source holder, and source facing lable side up.
Model 44-10 #PR135866 reads ~ 114684 with source placed against end of probe.
Model 44-3 #PR135326 reads ~ 36143 with source placed against window of probe.

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	PR135866	950	100	4 / 2	2.053598E-05	5.683813E+10	✓
Detector # 2	LMI44-10	PR135866	950	100	7 / 1	2.053598E-05	1.000000E+00	
Detector # 3	44-10 PK	PR135866	670	642	7 / 1	0.000000E+00	1.000000E+00	
Detector # 4	LMI44-3	PR135326	750	100	7 / 1	2.152832E-05	1.000000E+00	
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*
	400 K cpm	40055 (0)	40055 (0)	400 cpm	40 (0)	40 (0)
	40 K cpm	4000	4000	40 cpm	4	4
	4 K cpm	401	401			

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 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241~1.6uCi,I 129#021087

☑ m 500 S/N 70648 ☑ Multimeter S/N 61730074

Calibrated By: [signature] Date 3-Apr-00

Reviewed By: [signature] Date 4 Apr 00

FORM C44C 07/30/99

Designer and Manufacturer
of
Scientific and Industrial
Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Model 2350 Bench Test Data

Customer US ARMY CORP OF ENGINEERS Date 3-Apr-00 Order #. 245884/246928

Model 2350-1 Serial No. 126187 Detector 44-10 Serial No. PR135866

Source Cs137 s/n MS65 (1.9mCi)

High Voltage 950 V As Found 950 V. Input 10.00 mV As Found 10 mV.

Cal. Constant 5.683813E+10 as found 5.420055 e+10

Dead Time 2.053598E-05 as found 18.9 μSec.

Alarm Setting: Ratemeter 1000000000.000000 as found 1.0 e +09

Scaler 1000000.000000 as found 1.0 e +06

Integrated dose 1000000000.0000 as found 1.0 e +09

Overload ☐ On ☑ Off as found ☐ On ☑ Off Window 1000, off as found off

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

Reference Point	"As Found" Readings: Meter Reading	After Adjustment Readings: Meter Reading
2 mR/hr	1.85 mR/hr	2.03 mR/hr
1 "	.98 "	1.00 "
500 μR/hr	500 μR/hr	499 μR/hr
200 "	202 "	200 "
100 "	103 "	101 "

Other

Signature [signature] Date 3-Apr-00

FORM C6-1 09/08/97

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER US ARMY CORP OF ENGINEERS ORDER NO. 245884 / 246928

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 96686

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR 094260

Cal. Date 4-Apr-00 Cal Due Date 4-Apr-01 Cal. Interval 1 Year Meterface 202-608

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 70 °F RH 20 % Alt 709.8 mm Hg

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

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC
☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 12/19/89.

Instrument Volt Set 900 V Input Sens. 33 mV Det. Oper. 900 V at 33 mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:

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

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	150 mR/hr	1.75	1.5
X 100	50 mR/hr	0.6	0.5
X 10	15 mR/hr	1.5	1.5
X 10	5 mR/hr	0.5	0.5
X 1	1.5 mR/hr = 4430 cpm	1.5	1.5
X 1	1.0 mR/hr	1.0	1.0
X 0.1	443 cpm	1.5	1.5
X 0.1	147 cpm	0.5	0.5

*Uncertainty within ± 10% C.F. within ± 20%

X 0.1 Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout				Log Scale			

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 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 134709 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 57390613

Calibrated By: Conrad Galindo Date 4 Apr 00

Reviewed By: Rhonda Harris Date 4 Apr 00

☐ Passed Dielectric (Hi-Pot) and Continuity Test

FORM C22A 12/29/1999

ATTACHMENT C

SOIL BORING LOGS

ATTACHMENT D

CHAIN-OF-CUSTODY REPORT FORMS

ATTACHMENT E

ANALYTICAL REPORT

ATTACHMENT F

SURVEY PHOTOS

(1) Survey Begins at the Outfall Area, 12 SEP 00, 0930

(2) Sample Point GV24

(3) Sample Point GV12

(4) Sample Point GV25

(5) Sample Point GV11

(6) Sample Point GV23

(7) Sample Point GV10, Moved to Ensure Outside of Excavated Area

(8) Sample Point GV22

(9) Sample Point GV21

(10) Sample Point GV09

(11) Sample Point GV20

(12) Sample Point GV08, End of Day One, 2015

(13) Sample Point GV07, Start of Day Two, 13 SEP 00, 0800

(14) Overhead Line Obstruction

(15) Sample Point GV19, Location Moved Due to Overhead Communications Lines

(16) Sample Point GV06, Moved Due to Overhead Communication Lines

(17) Sample Point GV18

(18) Sample Point GV05

(19) Sample Point GV17 [Sample GV26S Taken Between GV17…]

(20) Sample Point GV16 [and GV16 Based on Walkover Gamma Survey]

(21) Sample Point GV04

(22) Sample Point GV15, Showing Distance From Sample to Road Bed

(23) Sample Point GV15

(24) Sample Point GV14

(25) Sample Point GV13

(26) Overhead Power Lines

(27) Sample Point GV03, Moved due to Overhead Power Lines

(28) Sample Point GV01

(29) Awaiting Access to Sample Point GV02 Inside Locked Hazardous Material Storage Area

(30) Last Sample Point GV02, End of Day Two, 2040

ATTACHMENT G

SM-1A REACTOR
WASTE PIPELINE CORRIDOR
RESIDUAL RISK ASSESSMENT