DOE/OR/01-1214&D2
Y/ER-149&D2

Energy Systems Environmental Restoration Program
Y-12 Environmental Restoration Program

Remedial Investigation Report on the Abandoned Nitric Acid Pipeline at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

Date Issued—February 1994

Prepared by
Science Applications International Corporation
Oak Ridge, Tennessee
under subcontract 18B-99069C, Y-05

Prepared for
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
under budget and reporting codes CD 1072 and EW 20

OAK RIDGE Y-12 PLANT
Oak Ridge, Tennessee 37831-8169
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

CONTENTS

APPENDIXES

FIGURES

TABLES

ACRONYMS

ANAP	Abandoned Nitric Acid Pipeline
bgs	below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDI	chronic daily intake
CFR	*Code of Federal Regulations*
COPC	contaminant of potential concern
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
GFAA	graphite furnace atomic absorption
HI	hazard index
LET	linear energy transfer
LOAEL	lowest-observed-adverse-effect-level
NOAEL	no-observed-adverse-effect-level
NRC	Nuclear Regulatory Commission
ORR	Oak Ridge Reservation
OU	operable unit
PRG	preliminary remediation goal
QAPjP	Quality Assurance Project Plan
QA	quality assurance
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SCS	Site Characterization Summary
SF	slope factor
SI	screening indices
SOW	Statement of Work
TIC	tentatively identified compound
UEFPC	Upper East Fork Poplar Creek
VOC	volatile organic compound

EXECUTIVE SUMMARY

Upper East Fork Poplar Creek Operable Unit 2 consists of the Abandoned Nitric Acid Pipeline (ANAP). This pipeline was installed in 1951 to transport liquid wastes ~4800 ft from Buildings 9212, 9215, and 9206 to the S-3 Ponds. Materials known to have been discharged through the pipeline include nitric acid, depleted and enriched uranium, various metal nitrates, salts, and lead skimmings. When operational, the pipeline was buried from 1 to 14 ft below land surface and consisted of stainless steel from 1 to 3 in. in diameter. In 1983, the pipeline was plugged with cement grout and abandoned. During the mid-1980s, sections of the pipeline were removed during various construction projects.

A total of 19 locations were chosen to be investigated along the pipeline for the first phase of this Remedial Investigation. Each location was chosen because it was either a low point in the pipeline, a boundary area between two different soil types, or a known or suspected leak location. Original drawings and surveyors' logbooks were used to identify each of these locations, several of which had to be moved slightly due to the presence of buildings or other obstructions. Sampling consisted of drilling down to obtain a soil sample at a depth immediately below the pipeline. Additional samples were obtained deeper in the subsurface depending upon the depth of the pipeline, the depth of the water table, and the point of auger refusal. The 19 samples collected below the pipeline were analyzed by the Oak Ridge Y-12 Plant's laboratory for metals, nitrate/nitrite, and isotopic uranium. Samples collected from three boreholes were also analyzed for volatile organic compounds because these samples produced a response with organic vapor monitoring equipment.

Uranium activities in the soil samples ranged from 0.53 to 13.0 pCi/g for ^{234}U, from 0.075 to 0.75 pCi/g for ^{235}U, and from 0.71 to 5.0 pCi/g for ^{238}U. Maximum total values for lead, chromium, and nickel were 75.1 mg/kg, 56.3 mg/kg, and 53.0 mg/kg, respectively. The maximum nitrate/nitrite value detected was 32.0 mg-N/kg. One sample obtained adjacent to a sewer line contained various organic compounds, at least some of which were tentatively identified as fragrance chemicals commonly associated with soaps and cleaning solutions.

The results of the baseline human health risk assessment for the ANAP contaminants of potential concern show no unacceptable risks to human health via incidental ingestion of soil, inhalation of dust, dermal contact with the soil, or external exposure to radionuclides in the ANAP soils, under the construction worker and/or the residential land-use scenarios. In summary, the total cumulative pathway risk estimates (i.e., the sum of the risks from all analytes across all pathways) for the carcinogenic contaminants of potential concern were 1.9E-06 and 1.5E-05 for the construction worker and residential scenarios, respectively. These carcinogenic risks are less than the U.S. Environmental Protection Agency (EPA) action level of 1.0E-04. The total cumulative pathway hazard index estimates for the noncarcinogenic contaminants of potential concern were 4.7E-03 and 5.2E-02 for the construction worker and residential scenarios, respectively. These noncarcinogenic risks are less than the EPA action level of 1.0.

1. INTRODUCTION

1.1 REGULATORY BACKGROUND

The U.S. Department of Energy's (DOE's) Abandoned Nitric Acid Pipeline (ANAP) is a 1- to 3-in.-diam stainless-steel pipe located underground at the Oak Ridge Y-12 Plant, formerly used to pump waste effluent from the H-1 Foundry to the S-3 Ponds for disposal. The waste effluent consisted of nitric acid containing depleted uranium in solution that was produced during the uranium recovery process. ANAP was taken out of service in 1983. Section 2.2 of this report gives a more detailed description of the pipeline.

ANAP was originally part of the Group 4 Resource Conservation and Recovery Act (RCRA) Facility Investigation Plan under development in 1988 to investigate four areas of the Y-12 Plant. The project report, *RCRA Facility Investigation Plan for Group 4 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, was issued in December 1990 (Energy Systems 1990). The four sites were subsequently separated at U.S. Environmental Protection Agency (EPA) request, to be dealt with on an individual basis.

The ANAP site was discussed by DOE, EPA, and Martin Marietta Energy Systems, Inc. (Energy Systems) at a meeting held in Chattanooga, Tennessee, on June 4 and 5, 1991. The study proposed for ANAP and under consideration at that time was labeled a remedial investigation (RI). The scope and design of the field investigation were agreed upon by EPA, and an addendum to the Sampling Plan was proposed. The addendum was issued on November 30, 1991, by the Y-12 Environmental Restoration (ER) Division (Energy Systems 1991a).

Energy Systems had intended to conduct the investigation in phases. The first phase was to include soil sampling, generation of a Site Characterization Summary (SCS), and generation of a groundwater sampling plan. This report was originally produced as an SCS, a document typically used to report results of an initial phase of a long-term field sampling effort. However, since no significant levels of contamination were detected in subsurface soil samples obtained along the pipeline, a second phase field sampling effort was not required.

The results of the sampling effort were presented to the Tennessee Department of Environment and Conservation and EPA Region IV in Chattanooga on August 18, 1993. Both the Tennessee Department of Environment and Conservation and EPA received draft copies of the SCS for internal review. All parties discussed the idea of adding a Baseline Human Health Risk Assessment, changing the title of the document to an RI, and submitting it as such in order to streamline/shorten the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process and reduce the overall project cost. In a subsequent meeting on October 20, 1993, it was agreed to submit this document as an RI for formal review.

Because ANAP is buried underground and is within the operational Y-12 Plant facility, there are no completed exposure pathways for an ecological receptor. Therefore, ecological risk assessment is not addressed in this source-control operable unit (OU). Any cumulative ecological risks from exposure to contaminated groundwater associated with this OU will be addressed in the integrated OUs for Bear Creek Valley (OU 4) and Upper East Fork Poplar Creek (UEFPC) (OU 1).

1.2 OBJECTIVE

The objective of the sampling program was to determine whether ANAP had leaked, allowing contaminants to migrate to surrounding environmental media at levels of concern. Nineteen points were selected along the pipeline for subsurface soil sampling. These sampling points were selected based on an identification of those portions of the pipeline judged most susceptible to failure or where leaking fluids may have preferentially migrated. These areas included low points in the pipeline, sections of the pipeline in contact with varying soil types, and sections of the pipeline that crossed the Y-12 Plant storm sewer system. All sampling locations are shown in Fig. 1.1, and sampling point coordinates and elevations are given in Table 1.1.

The Statement of Work (SOW) provided by Science Applications International Corporation (SAIC) determined that two contaminants—uranium and nitrate—would be used to determine whether a leak had occurred. An EPA review comment regarding the SOW recommended the development of action levels for uranium and nitrate that would trigger additional sampling or sample analyses. These action levels were developed, and a copy of the response to the EPA comment is included in Appendix A. The action level for uranium was established by using background values for the Y-12 Plant and determining that results three times background levels would trigger additional sample analysis. The highest average background value used as a trigger was 1.37 pCi/g. At EPA request, three background locations were selected at the west end of the Y-12 Plant in an area undisturbed by plant activities. One sample was collected at each location for nitrate analysis; the results were to be averaged, and the action level was established as twice this average value. No nitrates were detected at any of the background locations (where naturally occurring nitrates were assumed to be present) and nitrates were detected along ANAP only in the low parts per million (ppm) range. The detection of nitrates and other analytes in low concentrations below human health concerns was cause to reexamine the decision behind action levels established for this project. It was determined to be inappropriate to use public funds to pursue further investigation of a site that poses no threat to human health or the environment as indicated by the results of a risk assessment.

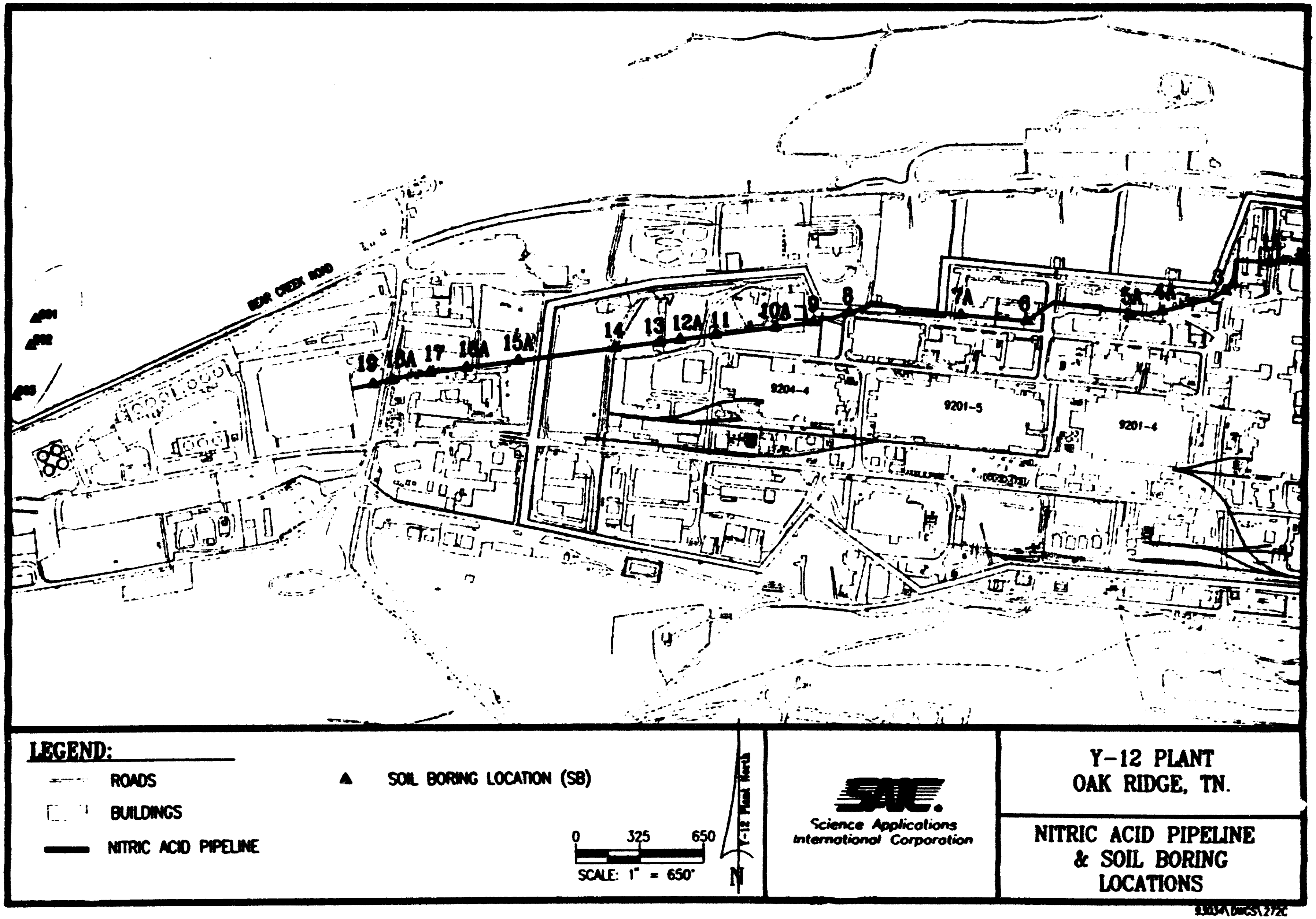


Fig. 1.1. Nitric acid pipeline and soil boring locations.

Table 1.1. Nitric acid pipeline sampling coordinates

Borehole location[a]	Northing	Easting	Y-12 block plan	Ground elevation (ft above msl)[b]
		As-built sampling locations		
SB001A	31004.27	57108.72	D-2	998.89
SB002	30894.27	56923.88	D-2	995.26
SB003	30859.46	56882.36	D-2	1003.83
SB004A	30755.83	56567.06	D-2	1001.25
SB005A	30731.83	56399.94	D-2	1002.17
SB006	30703.63	55889.05	E-2	992.69
SB007A	30735.29	55557.44	E-2	996.73
SB008	30748.00	54991.86	E-2	994.33
SB009	30696.61	54811.05	E-2	1014.52
SB010A	30672.98	54620.04	E-2	1014.41
SB011	30632.07	54315.03	E-2	998.04
SB012A	30608.60	54136.53	E-2	995.90
SB013	30594.60	54035.04	E-2	1004.34
SB014	30566.06	53810.25	F-2	1014.32
SB015A	30501.79	53321.46	F-2	1014.63
SB016A	30468.03	53060.31	F-2	1019.30
SB017	30444.17	52876.10	F-3	1017.42
SB018A	30407.09	52682.43	F-3	1016.33
SB019	30385.91	52589.11	F-3	1013.59
		Background sampling locations		
001	30714.38	50890.82		1051.44
002	30578.95	50864.91		1031.27
003	30323.03	50790.08		1003.32

[a] See Chap. 3, "Field Investigation," for an explanation of borehole location numbers.

[b] msl = mean sea level.

2. SITE HISTORY

2.1 GEOGRAPHICAL INFORMATION

ANAP is ~4800 ft in length and travels from the H-1 Foundry to the S-3 Ponds, mainly through the protected area of the Y-12 Plant. The elevation of the pipeline ranges from a high of 1013.5 ft above mean sea level (MSL) at 254 ft from the discharge point at the center of the S-3 Ponds to a low of ~986 ft MSL at 2017 ft from the discharge point.

The unconsolidated material in which the pipeline runs probably consists of a combination of man-made fill and weathered bedrock. The weathered bedrock is presumably from the Nolichucky formation and would consist mainly of weathered shale. The Nolichucky consists of maroon-brown to green-gray, massive to thinly-bedded, locally calcareous mudstones and shales interstratified with thinly-bedded, medium gray limestones and calcareous siltstones.

2.2 BACKGROUND AND HISTORY

ANAP was completed by October 1951 and was used to pump effluent under pressure from the H-1 Foundry (Building 9215) to the S-3 Ponds for disposal. Before their closure in 1988, the S-3 Ponds consisted of four unlined surface impoundments. Discharge from the pipeline originally was routed to both the northeast and southeast ponds, and overflow was conducted to the northwest and southwest ponds. In 1972, the routing system in the ponds was changed so that all discharge from the pipeline first went to the northeast pond before being passed to the other ponds.

ANAP was constructed of 1- to 3-in.-diam 347-stainless-steel pipe. The stainless steel (trade name Monel) had a high nickel content. ANAP was originally buried from 0 to 14 ft below ground surface (bgs). One drawing indicates that the pipeline was buried at least 1 ft bgs throughout its length and averaged 5 ft bgs. ANAP was encased in concrete where it passed over water and sewer lines. The encasements extended up to 10 ft on either side of the overlain utility line. Available drawings show that no utility lines are buried above the pipeline.

As a result of construction and design changes, ANAP has many turns, bends, and welded joints along its course. The line also crosses ditches and a former swampy area and has several topographical low points in the line where waste may have accumulated. These are locations of suspected leaks along the pipeline.

ANAP was taken out of service in 1983, at which time it reportedly was flushed with water and then plugged with grout or concrete. Although some records indicate that the entire pipeline was not grouted, the portions near the inlet or outlet probably were. Sections of the pipeline were removed and/or renovated when they were in the path of plant construction. Figure 2.1 shows the areas where the pipeline was removed. Sections of removed pipe were checked by Y-12 Plant Health Physics personnel and were determined to be uncontaminated and suitable for disposal in the Y-12 Burial Grounds.

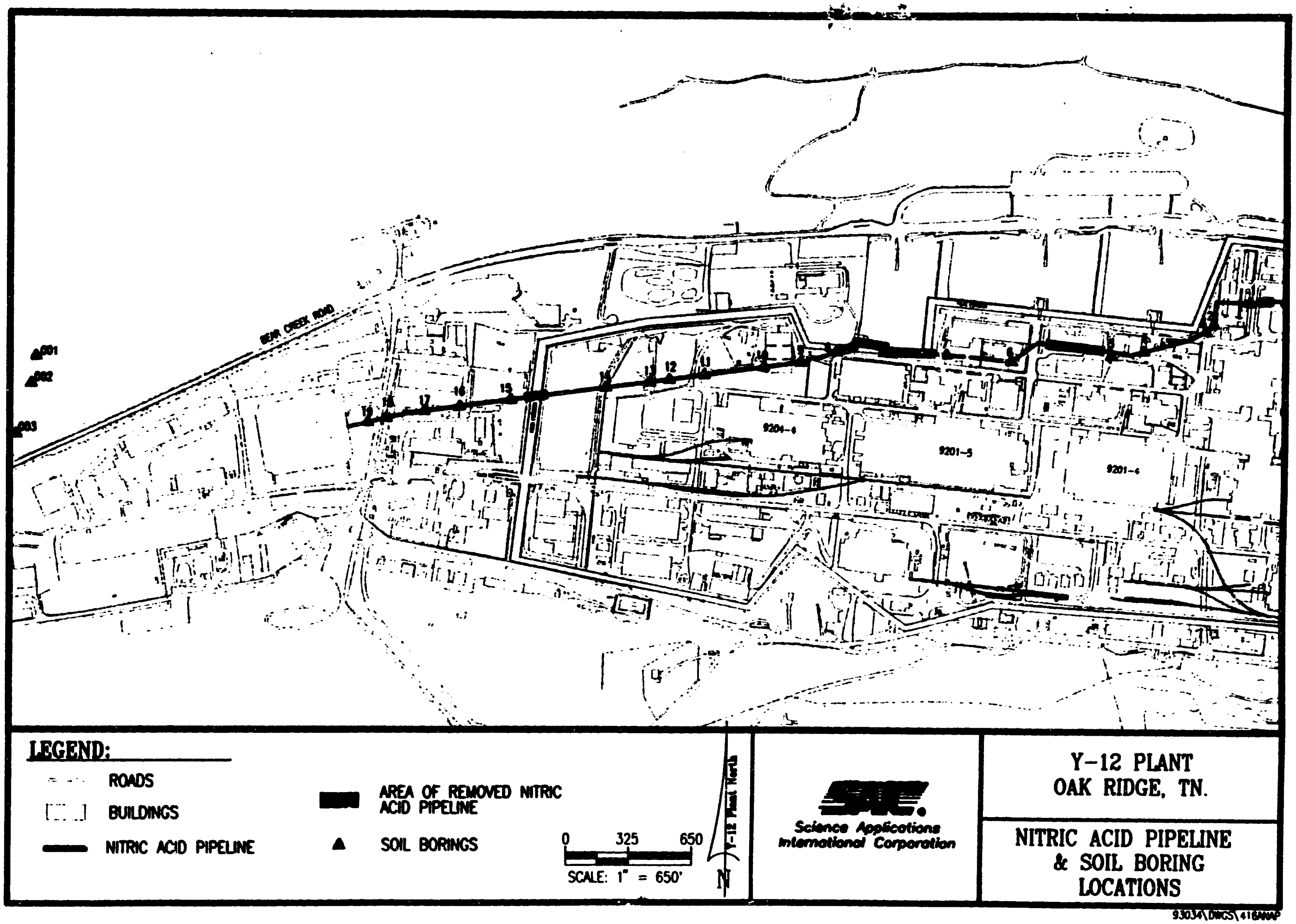


Fig. 2.1. Area of removed nitric acid pipeline.

The waste effluent that traveled through ANAP consisted of nitric acid containing depleted uranium in solution that was produced during the uranium recovery process. The effluent was kept acidic to avoid a buildup of solid sludge in the S-3 Ponds. It is possible that organic and metal wastes were sent through the pipeline, but no evidence exists to document this. The total volume of wastes discharged to the S-3 Ponds averaged about 5500 gal/d.

3. FIELD INVESTIGATION

SAIC conducted the subsurface soil field investigation of ANAP from January 22 to February 10, 1993. The investigation was conducted to locate areas where contaminants attributable to ANAP may have leaked into the surrounding soils. This investigation was conducted in accordance with the ANAP project Field and Laboratory Quality Assurance Project Plan (QAPjP) (SAIC 1992a), the Health and Safety Plan (SAIC 1992b), and the Sampling and Analysis Plan (SAIC 1993), under the guidelines of the Mobilization Plan (SAIC 1992c).

ANAP was surveyed by placing stakes every 50 ft and at bends and turns. As-built drawings provided by Energy Systems ER were used to survey the pipeline. In addition, a copy of the original surveyors' notebook, compiled when the pipeline was installed, was obtained and compared with the as-built drawings. Minor differences were noted, but none appeared that would call into question the location of the pipeline. The surveyor also examined as-built drawings of buildings constructed over ANAP to determine where the pipeline was removed. These results are shown in Fig. 2.1. The elevation and northing and easting coordinates were determined for each sampling location before the field effort began. Two potential sample points were selected at some locations in response to potential problems with utilities or underground lines. These locations were marked A; the decision regarding which point was to be used was made by Y-12 Plant management on the penetration permits issued for subsurface work. Alternate locations were located as close to original locations as possible and were usually within 5 ft. Moving sample locations a short distance from the originally planned locations should not have an impact on project results because a leak would not be localized to a single point and would be expected to show up over at least a small area of pipeline. Sampling locations were again surveyed following the field investigation; these results are presented in Table 1.1.

Geophysical Investigation. A Phase I geophysical investigation was conducted prior to field sampling to determine whether geophysical methods could be used to detect the pipeline. Geophysical methods that were tested included magnetics, electromagnetics, and ground-penetrating radar. Results of the investigation indicated that geophysical methods would not be successful in locating the pipeline and that no additional surveys should be conducted. A complete discussion of the Phase I results is included in a Technical Memorandum transmitted to Energy Systems on July 28, 1992, and is included in this report as Appendix B.

Decontamination and Staging Area. A decontamination and equipment-staging area was established for the ANAP project in a location designated by the Energy Systems Field Coordinator (Fig. 3.1). Mobilization to this area of the Y-12 Plant took place on January 26, 1993. The area selected (one that would not interfere with plant activities) was scanned and found to be free of radiological contamination. Upon mobilization, a temporary, lined equipment-decontamination pad was constructed. Equipment was staged from a small trailer.

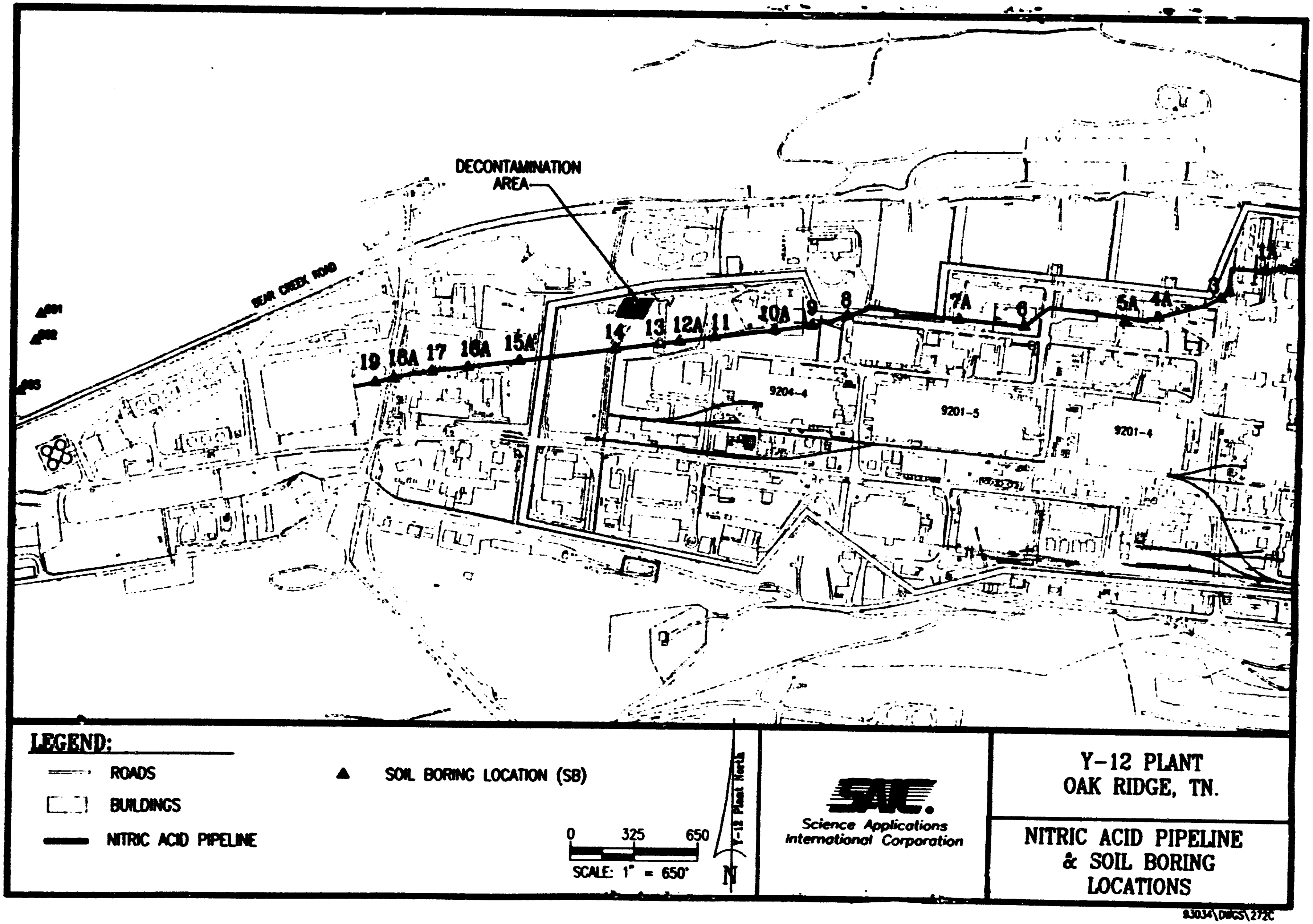


Fig. 3.1. ANAP project decontamination and equipment-staging area.

3.1 SUBSURFACE SOIL SAMPLING

Nineteen locations along ANAP and three background locations were sampled. The three background locations were sampled using hand augers, and samples were collected from different depths at each location (see Table 3.1). Sampling locations and depths were selected to represent the soil horizon that would be encountered along the pipeline. A map showing the geologic formations across the Y-12 Plant indicated that the pipeline was located in the Nolichucky and Dismal Gap Formations. Background soil samples were obtained from both formations and analyzed for nitrates, and the three sample results were averaged to provide one background value for comparison with analytical results along ANAP.

The 19 sampling locations along ANAP were sampled using a hollow-stem auger drilling rig or a hand-held hydraulic-auger drilling machine (Little Beaver™). The first soil sample collected in each borehole was taken from directly beneath the pipeline and was sent to the laboratory for chemical analysis. Subsequent soil samples were collected for lithological identification or were archived for later analysis. A soil sample was collected from each of the 12 boreholes for chemical analyses, and as many as two additional soil samples were collected and archived for potential chemical analyses at a later time.

3.1.1 Hollow-Stem Auger Drilling

Twelve of the 19 borehole locations along the pipeline were drilled using a hollow-stem-auger drilling rig. The drilling rig was set up over the borehole, and an exclusion zone was established around the rig using traffic cones and caution tape. A defined entry and exit corridor was established to control any potential spread of contaminants to clean areas. Dress-down, boot wash, hand wash, and radiological frisking areas were set up at entry and exit points.

Boreholes were drilled using hollow-stem augers. Soil samples were collected using stainless-steel split-spoon samplers. Additional samples were collected from each borehole for lithological identification. The number of samples collected from a borehole was dependent upon the depth of the pipeline, the water table, and the point of auger refusal. All boreholes were terminated at the water table or at auger refusal (at bedrock).

Topography across the site is undulating, ranging from 992.69 ft MSL at location SB006 to 1019.30 ft MSL at location SB016A. Borehole depths ranged from 14.5 ft in borehole SB011 to 26 ft in borehole SB005A. Bedrock was encountered at depths from ~13 ft in borehole SB006 to 26 ft in borehole SB005A; depth to bedrock conforms to topography. The water table, when encountered, tends to be directly above the bedrock surface. Moist, damp, and wet zones were encountered above bedrock in some boreholes; however, this is believed to be perched and not representative of the water table surface. Table 3.1 gives the drilling method, total depth, intervals sampled, and sample status for each of the boreholes. Well logs were developed for each of the boreholes installed using hollow-stem augers and are included in Appendix C.

3.1.2 Hydraulic Auger Drilling

Because of problems relating to access for the drilling rig, 7 of the 19 borehole locations were drilled using a hydraulic auger. The exclusion zone and contamination reduction zone were established for the hydraulic auger in the same manner as for the drilling rig.

Table 3.1. Borehole drilling and sampling information

Borehole no.	Drilling method	Total depth (ft)	Sample interval (ft)	Sample type
SB001A[a]	Little Beaver™	8	2–4	Lab[b]
SB002	Little Beaver™	12	5–5.5	Lab
			11.5–12	Arch[c]
SB003	Little Beaver™	9	3.5–4	Lab
SB004A	Drill rig	22	8–10	Lab
			11–13	Lith[d]
			14–16	Lith
			17–19	Arch
			20–23	Lith
SB005A	Drill rig	26	8–10	Lab
			15–17	Lith
			20–22	Arch
			25–26	Lith
SB006	Drill rig	13	2.5–4.5	Lab
			5–7	Lith
			8–10	Arch
			11–13	Lith
SB007	Little Beaver™	8.5	4.5–5	Lab
SB008	Little Beaver™	6	5–5.5	Lab
SB009	Drill rig	23	8–10	Lab
			11–13	Lith
			14–16	Lith
			16–18	Arch
			21–23	Arch
SB010A	Drill rig	23	4.5–6.5	Lab
			8–10	Lith
			11–13	Arch
			14–16	Lith
			17–19	Lith
			21–23	Arch
SB011	Drill rig	14.5	10.5–12.5	Lab
SB012A	Little Beaver™	4.5	4.5–5	Lab
SB013	Little Beaver™	2	0.5–1	Lab
SB014	Drill rig	18	7–9	Lab
			10–12	Lith
			13–15	
			16–18	Lith
SB015A	Drill rig	17	4–6	Lab
			7–9	Lith
			10–12	Arch
			13–15	Lith

Table 3.1 (continued)

Borehole no.	Drilling method	Total depth (ft)	Sample interval (ft)	Sample type
SB016A	Drill rig	18	8–10	Lab
			11–13	Lith
			14–16	Lith
			16–18	Arch
SB017	Drill rig	18	10–12	Lab
			13–15	Lith
			16–18	Arch
SB018A	Drill rig	16	4–6	Lab
			8–10	Lith
			14–16	Arch
SB019	Drill rig	17	2–6	Lab
			7–9	Lith
			10–12	Lith
			12–14	Arch
			15–17	Lith
001[e]	Hand auger	2.5	2–2.5	Lab
002[e]	Hand auger	4.8	4–4.8	Lab
003[e]	Hand auger	5.8	5–5.8	Lab

[a] A = Alternate sample location.
[b] Lab = Sample collected and sent to laboratory for analysis.
[c] Arch = Sample collected for chemical analysis and archived.
[d] Lith = Sample collected for lithological identification.
[e] 001 = Background samples.

Hydraulic auger drilling uses a solid-stem auger; therefore, samples were collected using hand augers. From six of the boreholes, one sample each was collected and sent to the laboratory. From the remaining borehole drilled with the hydraulic auger, two samples were collected; one was sent to the laboratory, and one was archived for potential analyses at a later time. No lithologic samples were collected in any of the hydraulic auger boreholes. Because of the limited ability of the hydraulic auger to penetrate the lithologic formations encountered, the total depths of the boreholes it drilled were less than those produced by the drill rig.

3.2 LITHOLOGY

Lithologic samples were described for 11 boreholes. Lithologic logs were prepared for these boreholes and are included in Appendix C. No lithology samples were collected in boreholes drilled with the Little Beaver™. Lithology across the site was very similar, and the 11 borehole logs were consistent with conditions encountered at all borehole locations. A cross section detailing the lithology along the pipeline is shown in Fig. 3.2; the location of the cross section is shown in Fig. 3.3.

Lithology encountered during the subsurface investigation consisted of fill material, clay-rich saprolite, and weathered shale bedrock. Lithologic character was consistent across the site. The fill material was several feet thick and consisted mainly of gravel. The clayey saprolite ranged to ~24 ft in thickness; it was difficult to determine whether this was indigenous material or had been brought in as fill. Boreholes were terminated upon encountering the weathered shale bedrock (resulting in auger refusal) or at the water table. The water table was encountered in only eight boreholes and ranged in depth from 4.5 to 25 ft bgs. Water was encountered at 10 ft in borehole 16, but the borehole was dry from below 10 ft to its termination at 18 ft.

3.3 HEALTH AND SAFETY

SAIC provided health and safety support during all on-site operations. On-site health and safety activities included surveillance of field activities for compliance with applicable Occupational Safety and Health Administration standards and the site-specific Health and Safety Plan (SAIC 1992b), monitoring for employee exposure to contaminants, and interaction with Y-12 Health and Safety officials.

Prior to any on-site activity, all personnel were required to have completed 40 h of training and to have received a medical examination in accordance with 29 CFR 1910.120. Before entering the exclusion zone, employees were required to don a hard hat, chemical-protective clothing (such as Tyvek™ coveralls), and chemical-protective gloves and boots. Employees were also required to be fit-tested for respiratory protective equipment. Adequate respiratory protective equipment was kept on site throughout the project, although project activities did not require its use.

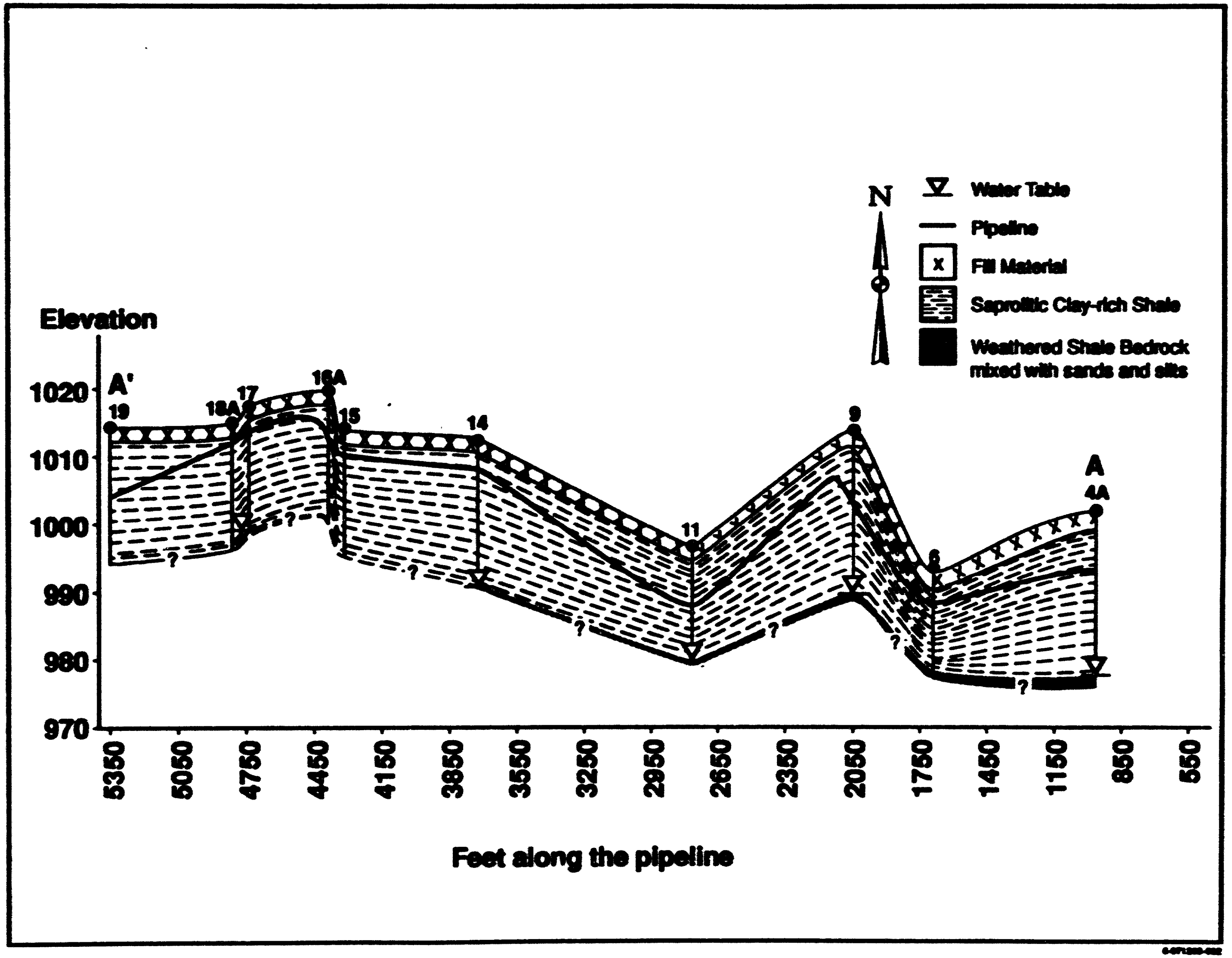


Fig. 3.2. Lithologic cross-section A-A' along the nitric acid pipeline.

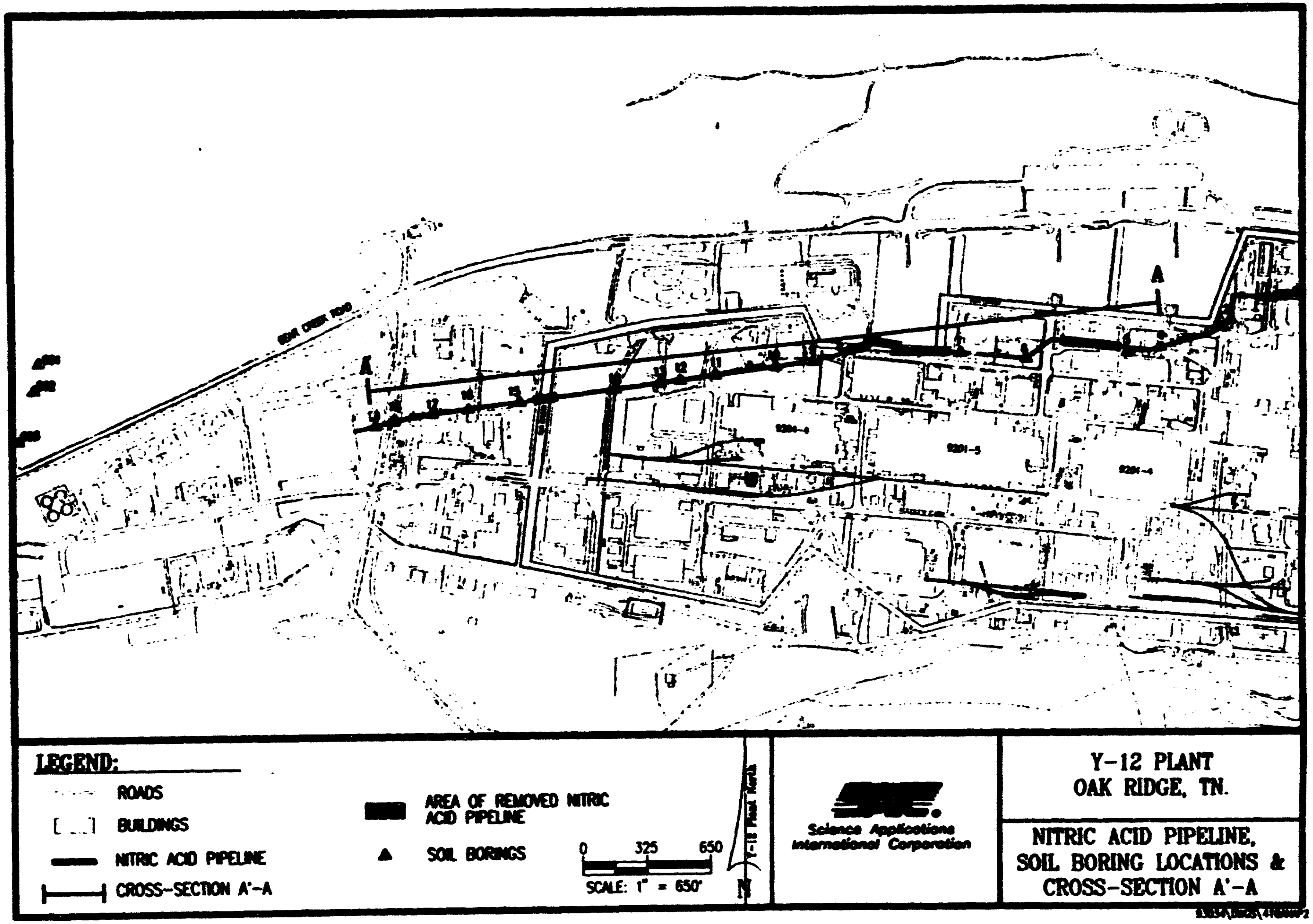


Fig. 3.3. Location of lithologic cross-section A-A' along the nitric acid pipeline.

Monitoring for exposure to specific contaminants, including organic vapors, ionizing radiation, and mercury vapor, was performed during all intrusive sampling. Instrumentation used and target contaminants are listed in Table 3.2. Instruments were calibrated or calibration was checked daily prior to use. Records of these calibrations were entered in the daily logbook.

Table 3.2. Monitoring instruments and COPCs for the nitric acid pipeline area

Monitoring instrument	COPCs
Jerome Mercury Vapor Indicator	Mercury vapor
HNu Datalogger 101	Organic vapors
Foxboro Organic Vapor Analyzer	Organic vapors
Victoreen 190	Beta/gamma radioactivity
Victoreen 450	Alpha radioactivity

Daily background levels for all monitoring instruments were taken at the decontamination area prior to field activities. Background levels for beta/gamma radioactivity at the decontamination site remained within 30 to 80 counts per minute. Background levels for alpha radioactivity were <5 counts per minute. Airborne organic and mercury vapor background levels were below detection limits for the monitoring equipment.

Monitoring was performed in the employee breathing zones and in close proximity to the sample material and cuttings. Readings were also taken from the auger boreholes to determine the level of potential off-gassing from buried sources.

One area contained elevated levels of organic vapors. Monitoring in borehole SB016 indicated the presence of organic vapors at up to 100 ppm at a depth of 8 to 10 ft bgs. The levels of organic vapors in this area remained below the action level of 20 ppm in employee breathing zones. Employees were instructed to avoid direct or prolonged contact with the sample material. Samples of the material were collected for volatile organic compound (VOC) analysis. Sample results are discussed in Sect. 4.3.

Elevated levels of beta/gamma radiation at 300 counts per minute were detected at borehole SB015. The material was sandy fill taken from directly beneath the parking lot asphalt. Samples taken from deeper soils indicated that levels of radioactivity were at or below background. Sustained levels of radioactivity above background levels were not detected at any other borehole locations. Levels of alpha radiation did not exceed background levels.

Airborne mercury vapor was detected in several areas during sampling operations; however, the detected levels, varying from 0.005 to 0.009 ppm, did not exceed the action level of 0.1 ppm.

Exposure to excessive levels of noise around the drilling rig was not considered a concern by the site health and safety officer during sampling activities. However, the steam cleaning equipment used during decontamination procedures was suspected of producing noise levels above the standards set by the Occupational Safety and Health Administration or the American Conference of Governmental Industrial Hygienists. The employees performing the steam cleaning were instructed to wear hearing protection during these operations.

At the request of the Y-12 Plant Safety Department, operations were suspended for 1 day to replace a frayed cable on the drill rig. Sampling with the repaired drill rig resumed the following day. A smaller portable drilling device was used in several areas to avoid contact with overhead power lines.

There were no incidents of employee overexposure to a contaminant, nor were there any reportable on-the-job injuries or illnesses.

3.4 QUALITY ASSURANCE

The ANAP project was conducted under the provisions of the QAPjP, which included sections on field and laboratory quality assurance (QA)/quality control (QC). The QAPjP complied with EPA *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA 1980), American National Standards Institute/American Society of Mechanical Engineers NQA-1 guidelines, Energy Systems' *Environmental Restoration Division Quality Assurance Program Plan* (Energy Systems 1992), and the SAIC Quality Assurance Program Plan and Quality Assurance Administrative Procedures (SAIC 1993), which describes procedures, documentation, records, audits, and corrective actions.

The QAPjP seeks to mitigate potential adverse impacts on the plant's and the public's environment, safety and health, and property. The objective of the plan is to create an appropriate QA program whose personnel have sufficient authority to identify problems; to initiate, recommend, or provide solutions to quality problems; to verify solutions; and to ensure that further work is not completed until proper disposition of a nonconformance or deficiency.

3.4.1 Field QA

The field QAPjP was initiated with a readiness review to ensure that all work plans and standard operating procedures were approved and controlled, that all assigned personnel were trained, that the site logistics were handled, that the laboratory was ready to accept samples, and that the QA system was implemented. Soil samples were collected at UEFPC OU 2 and were packed, shipped, handled, and stored using the prescribed procedures of the QAPjP. Sample containers and sampling devices were decontaminated, and entries were made in the logbooks or on the data forms.

The quality of the field records was checked by double entry and verification of entered data. The field notebooks were dual-stored, with one copy kept in a fireproof cabinet. Additional entries concerning archived samples were made after field activities were completed. Logbooks will be sent to the Central Records Facility after final disposition of archived samples. Sample custody was documented from the time of collection to data reporting, and samples were labeled with the required information.

All scheduled calibration was performed, and where malfunction of equipment was suspected, the equipment was removed from service. Calibration data were maintained in the instrument logbook. Data validation, which included screening, checking, auditing, flagging, certifying, and reviewing the data, was completed. Four types of QC samples—trip blanks, equipment rinsate blanks, field blanks, and field splits—were taken. No corrective action was required.

Field audits were conducted by SAIC QA, Energy Systems ER QA, and DOE. Findings and observations were issued as a result of each audit; copies are included in Appendix D. None of the audit results were considered to have affected the project or project data usability, and all audit findings were corrected.

3.4.2 Laboratory QA

The Laboratory QAPjP defined the procedures to be followed in the custody, analysis, and handling of data used in the RI of UEFPC OU 2. The standards used for determining data quality are those found in *Data Quality Objectives for Remedial Response Activities* (EPA 1987). Level III data quality was maintained; it provided low detection limits, a wide range of calibrated analyses, matrix recovery information, laboratory process control information, and known precision and accuracy. The purpose of the analyses of the samples was to confirm the presence or absence of contaminants in the soil and to quantify the organic, inorganic, and radiological compounds in the soil and groundwater.

Samples were analyzed using the methods and protocols found in *Test Methods for Evaluating Solid Wastes, 3rd Edition* (EPA 1986); *Methods for Chemical Analysis of Water and Wastes* (EPA 1983); and *Environmental Measurement Laboratory Procedures Manual* (DOE 1990). Chain-of-Custody procedures were followed.

All measuring and test equipment were calibrated at the prescribed intervals against nationally recognized standards or those found in the operating manual for the instrument. There were no documented calibration failures. All calibration data were maintained in the instrument logbook. Preventive maintenance of the equipment was performed and entered into the logbook.

The following laboratory QC procedures were used to check sample preparation and analysis and to monitor laboratory performance: method blank, calibration/continuing calibration blank, sample container cleaning blanks, laboratory duplicates, matrix spikes, calibration standards, and performance evaluation samples.

During the process of laboratory analysis, QC checks were employed to ensure that results were precise, accurate, complete, representative, and comparable. Data quality was documented and accountability information was obtained from each laboratory. Statistical validity was tested, and documentation verified that parameter estimates were defensible and that the estimates from each laboratory were quantified.

Throughout the period of laboratory analysis, internal QC checks were made to ensure the technical competence of the staff, appropriate equipment and instruments, good sampling practices, good measurement practices, project procedures, inspection, documentation, and training. The precision and accuracy criteria of the analyzed parameters of the laboratory's results were subjected to a statistical evaluation. Precision was assessed through separate analyses of duplicate samples. Accuracy was assessed by splitting samples, spiking one of them, and then analyzing the portions.

Periodic audits of laboratory activities were performed according to the audit plan, with the use of written procedures and checklists by persons having no direct responsibility for the audited activities. The purposes of the audits were to ensure that the project was implemented in accordance with specified requirements, to assess the project's effectiveness, to identify nonconformances, and to verify that identified deficiencies were corrected. The audit records are kept in the project files.

SAIC performed the data validation using data screening, checking, auditing, flagging, certification, and review. Records of all the data are kept in the SAIC Central Records Facility.

4. ANALYTICAL SAMPLE RESULTS

Nineteen soil samples were originally submitted to the laboratory to be analyzed for metals, nitrate/nitrite, VOCs, and isotopic uranium. Three background soil samples were collected and submitted to the laboratory for nitrate/nitrite analysis. In addition, field duplicate, field blank, rinsate, and trip blank samples were also submitted. Level C data deliverables were required for all analyses (*Requirements for Quality Control of Analytical Data for the Environmental Restoration Program*, Energy Systems ES/ER/TM-16). The following subsections present the analytical sample results.

Two methods were used to evaluate the analytical results. To determine whether the pipeline had leaked, analytical results were compared to naturally occurring background levels of site constituents. This comparison could not be performed with a high degree of statistical significance for two reasons. First, background levels were determined with limited data sets; therefore, the background "population" of the site has not been well defined. Second, the high number of values below the detection limit in the ANAP analytical results makes comparison difficult. In the case of nitrate/nitrite, background levels could not be defined.

Because of the difficulties in establishing background level comparisons, analytical results are also compared with health-based action levels. For the most part, these action levels are derived from 40 *CFR* 264, 265, 270, and 271 (EPA 1990b). Table 4.1 lists the EPA action levels for chromium, nickel, and nitrate and the Nuclear Regulatory Commission (NRC) action level for uranium. Comparisons with the action levels help indicate whether further action under CERCLA should be taken.

Table 4.1. RCRA-based action levels

Chemical	Action level	Basis for action level
Chromium	400 mg/kg	RCRA, Subpart S, child soil ingestion[a]
Nickel	2,000 mg/kg	RCRA, Subpart S, child soil ingestion
Nitrate	128,000 mg/kg	RCRA, Subpart S, method using the nitrate reference dose of 1.6[b]
Uranium	35 pCi/g	Nuclear Regulatory Commission Branch technical position, based on multiple pathway exposure

[a] EPA 1990b.
[b] EPA 1993a.

Table 4.2 shows a summary of chemicals that were detected in the soil samples. The table does not include sample results that were rejected (R) by the data validator.

4.1 METALS

There were 19 pipeline soil samples analyzed for 27 metal constituents to evaluate pipeline leakage. Metals were analyzed by SW-846 methods; 25 elements were analyzed by Method 6010 (inductively coupled plasma), arsenic was analyzed by Method 7060 [graphite furnace atomic absorption (GFAA)], and lead was analyzed by Method 7421 (GFAA). Two

Table 4.2. Summary of chemicals detected in soil samples from the nitric acid pipeline area[a]

Parameter	Proportion of results >detection limit[b]	Maximum result >detection limit	Minimum result >detection limit	Mean result[c]	Standard deviation[c]	Location and depth of maximum
			Metals (mg/kg)			
Aluminum	19/19	39600	19200	30040	5956	SB015 4.0–6.0 ft
Arsenic	15/19	3.7	0.86	1.773	1.092	SB006 2.5–4.5 ft
Barium	19/19	469	55.5	165.5	121.6	SB011 10.5–2.5 ft
Beryllium	19/19	1.7	0.51	1.089	0.3394	SB006 2.5–4.5 ft
Calcium	19/19	45100	317	13580	15980	SB017 10.0–12.0 ft
Chromium	19/19	56.3	24.4	40.59	8.121	SB006 2.5–4.5 ft
Cobalt	19/19	36.1	5.9	15.8	7.132	SB011 10.5–12.5 ft
Copper	19/19	29.7	7.4	18.87	6.292	SB005 8.0–10.0 ft
Iron	19/19	51700	24300	33780	6606	SB011 10.5–12.5 ft
Lead	16/16	75.1	2.8	21.29	23.33	SB012 4.5–5.0 ft
Lithium	19/19	34.8	14.3	23.83	6.142	SB019 2.0–6.0 ft
Magnesium	19/19	18800	1550	6753	4900	SB005 8.0–10.0 ft
Manganese	19/19	1950	94.4	648.9	526	SB011 10.5–2.5 ft
Molybdenum	1/19	14	14	1.445	3.041	SB018 4.0–6.5 ft
Nickel	19/19	53	14.5	29.76	11.74	SB006 2.5–4.5 ft
Phosphorus	19/19	884	84	416.1	227.6	SB011 10.5–12.5 ft
Potassium	19/19	7530	1890	4888	1695	SB006 2.5–4.5 ft
Silicon	19/19	845	369	570.2	129.6	SB002 5.0–5.5 ft
Sodium	5/19	126	75.1	52.4	37.47	SB001 2.0–2.5 ft

Table 4.2 (continued)

Parameter	Proportion of results >detection limit[b]	Maximum result >detection limit	Minimum result >detection limit	Mean result[c]	Standard deviation[c]	Location and depth of maximum
Strontium	19/19	70.6	5.2	20.87	16.81	SB010 4.5–6.5 ft
Vanadium	19/19	38.5	24.2	31.55	4.4	SB015 4.0–6.0 ft
Zinc	19/19	118	27.6	60.83	25.35	SB001 2.0–2.5 ft
Inorganic analyses (mg-N/kg)						
Nitrate/Nitrite	14/19	32	0.51	3.812	8.355	SB017 10.0–12.0 ft
Radiological parameters (pCi/g)						
^{234}U	19/19	13	0.53	2.783	3.507	SB001 2.0–2.5 ft
^{235}U	7/19	0.75	0.075	0.1651	0.195	SB001 2.0–2.5 ft
^{238}U	19/19	5	0.71	1.754	1.199	SB018 4.0–6.5 ft
Volatile organic compounds (μg/kg)						
Acetone	1/3	64	64	24.5	34.23	SB016 8.0–10.0 ft

[a] Samples with 'R' validation flags were not included.
[b] Radionuclide concentrations less than the counting uncertainty were considered not detected.
[c] Results less than the detection limit were set to one half the detection limit for the calculation of the mean and standard deviation (except for radionuclides).
Source: Output of program ANAP03.SAS on September 7, 1993, from the ANAP project data base.

duplicate soil samples also were analyzed. Sample depths ranged from 0.5 to 12.5 ft bgs and corresponded to the depth of the bottom of the pipeline.

4.1.1 Sample Results

Sample results for metals are presented in Table 4.3. Sample results were compared with background sample results presented in the *Annual Report on the Background Soil Characterization Project on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 1993). Results from samples taken in the Nolichucky Formation were used because most of the pipeline is located in this formation. Background sampling locations and metals results are given in Appendix E.

Each element was compared to the highest value listed for that element in the results for background sampling locations shown in Appendix E. Although metal analyses were not originally considered in the SOW as an indication of pipeline leakage, chromium and nickel, which are primary component substances of the pipeline, were considered to be potentially good metal indicators of a pipeline leak. It was believed that concentrated nitric acid would dissolve the pipeline over time, releasing chromium and nickel, which would lead to elevated levels of these two metals and would thus provide additional information to identify leaks. The highest chromium level detected was 69.9 mg/kg; the highest nickel result was 53 mg/kg. The chromium and nickel results are within the range of background results, and a pipeline leak is not indicated. The values are also well below RCRA action levels.

Calcium and strontium were found to be slightly above the background values. Both calcium and strontium can occur naturally in the saprolite encountered during drilling. High values for calcium and strontium found at the same sampling locations are not an indication of contamination. Calcium and strontium also exhibit similar geochemical behavior and can be expected to be found together.

Many of the metal values were qualified as estimated (J) because the analyses failed to meet the QC control limits. However, the data are usable and can be compared with the background values, and a conclusion can be obtained.

Both antimony and silver had 13 values rejected (R) and 8 values qualified as not detected (U). The values were rejected as a conservative measure so as not to err in identifying false negatives. The actual values if the metals were present would be around the detection limit of the analytical instrument. Three lead values were rejected (R) because the GFAA instrument was not properly calibrated when the analyses were performed. However, the remaining 18 sample values are usable for comparison with background values.

4.1.2 QA/QC Samples

The QA/QC samples collected for metals analyses consisted of two field blanks and three rinsates. These samples were analyzed for the same elements as were the soil samples. The analytical results are presented in Table 4.4.

Metals were detected in one field blank and in all rinsate samples. The majority of the detected elements were measurable in parts per billion (ppb) and were only slightly above detection limits. Chromium and nickel were detected in only one rinsate sample.

Table 4.3. Sample results for metals in the nitric acid pipeline area

Parameter (mg/kg)	Sample number, location, and date									
	SB001[a] N00101[b] GC[c] 2.0—2.5 ft[d] 02/08/93[e]	SB002 N00201 GC 5.0—5.5 ft 02/08/93	SB003 N00301 GC 3.5—4.0 ft 02/08/93	SB004 N00401 GC 8.0—10.0 ft 02/02/93	SB005 N00501 GC 8.0—10.0 ft 01/29/93	SB006 N00601 GC 2.5—4.5 ft 01/29/93	SB007 N00701 GC 5.5—6.0 ft 02/09/93	SB008 N00801 GC 5.0—5.5 ft 02/08/93	SB009 N00901 GC 8.0—10.0 ft 02/02/93	SB010 N01001 GC 4.5—6.5 ft 01/30/93
Aluminum	24300	30800	26300	29000	36900	36800	19200	24900	33300	36500
Antimony	2.7 U	3 U	2.8 U	2.7 R	2.9 R	2.7 R	2.3 U	2.7 U	2.8 R	3.1 R
Arsenic	2.6	0.15 U	0.08 U	1.5	2.4 J	3.7	2.3	0.3 U	2.8	1.7
Barium	216	67.7	217	259 J	228 J	429 J	99.9	273	104 J	99.7 J
Beryllium	1.1 J	0.68 J	1.2 J	1.3	1.7	1.7	0.84 J	1.2 J	1.2	1.4
Cadmium	0.63 U	0.71 U	0.71 U	0.63 U	0.7 U	0.65 U	0.56 U	0.63 U	0.68 U	0.74 U
Calcium	25800 J	512 J	3030 J	25200 J	27300 J	2720 J	965 J	3880 J	982 J	41700 J
Chromium	33.8	36.1	32.7	38.1	50.1	56.3	24.4	41.7	43.4	39.4
Cobalt	17.4	10.2	24.1	15.3	8.6	16.4	21	17.6	23.4	13
Copper	27.3 J	20.8 J	20.9 J	9.8	29.7	19	9.4 J	19.4 J	18.7	20
Iron	28900	33200	31200	24700	42700	38400	26900	33800	40100	35400
Lead	70.4 J	17.8 J	35.4 J	5.6 J	3.2 R	2.4 R	20.6 J	22.1 J	2.2 R	5.7 J
Lithium	24.1	22	20.8	27.7	34.1	21.7	14.3	22.5	20.7	29.3
Magnesium	5630 J	2340 J	4010 J	13500 J	18800 J	8360 J	1950 J	6990 J	3980 J	8070 J
Manganese	818	153	1470	1140 J	222 J	208 J	785	1450	493 J	573 J
Molybdenum	1.4 U	1.6 U	1.5 U	1.4 U	1.6 U	1.5 U	1.3 U	1.4 U	1.5 U	1.7 U
Nickel	32.9	18.8	33.9	32.5	36.9	53	16.2	45.2	35.8	31.3
Phosphorus	565 J	189 J	434 J	722 J	554 J	585 J	185 J	841 J	347 J	460 J
Potassium	4350	3710	3990	7130	6490	7530	2190	3470	4160	5510
Selenium	19.9 U	22.2 U	20.8 U	19.8 U	22 U	20.3 U	17.4 U	19.9 U	21.3 U	23.2 U
Silicon	647	845	617	420 J	494 J	369 J	621	560	456 J	428 J
Silver	0.82 U	0.92 U	0.86 U	0.82 R	0.91 R	0.84 R	0.72 U	0.82 U	0.88 R	0.96 R
Sodium	126	58.1 U	58.5 U	118	120	62.2 U	32.5 U	58 U	45.9 U	110
Strontium	36.4 J	5.2 J	12.4 J	36.7 J	24.8 J	19.5 J	5.2 J	18.1 J	9 J	70.6 J
Thallium	4.2 U	4.7 U	4.4 U	4.2 U	4.7 U	4.3 U	3.7 U	4.2 U	4.5 U	4.9 U
Vanadium	24.6	33.9	25.7	31.6	35	30.6	25.3	24.2	38.5	33.3
Zinc	118 J	39.6 J	66.2 J	62.9 J	63.8 J	117 J	29.4 J	75 J	68.3 J	63.6 J

Table 4.3 (continued)

Parameter	Sample number, location, and date									
	SB011 N01101 GC 10.5—12.5 ft 01/27/93	SB012 N01201 GC 4.5—5.0 ft 02/09/93	SB012 N01905 OT 4.5—5.0 ft 02/09/93	SB013 N01301 GC 0.5—1.0 ft 02/09/93	SB014 N01401 GC 7.0—9.0 ft 01/28/93	SB015 N01501 GC 4.0—6.0 ft 02/03/93	SB016 N01601 GC 8.0—10.0 ft 02/05/93	SB017 N01701 GC 10.0—12.0 ft 02/03/93	SB018 N01801 GC 4.0—6.5 ft 02/03/93	SB019 N01005 OT 2.0—6.0 ft 02/05/93
Aluminum	32600	20800	19400	35500	31600	39600	35200	27600	24900	28600
Antimony	3 R	2.6 U	2.7 U	2.6 U	2.9 R	2.7 R	2.7 R	2.9 R	3.1 R	2.7 R
Arsenic	1.7	0.86	0.87 U	0.32 U	3.2	1.8	2.7	2.2	1.6	1.7
Barium	469 J	74.9	72.8	83.7	84.5 J	97.5 J	103	99.1 J	55.5 J	81.8
Beryllium	1.3	0.51 J	0.44 J	1.4 J	0.88	1.1	1	0.77	0.68	0.71
Cadmium	0.71 U	0.63 U	0.66 U	0.61 U	0.69 U	0.65 U	0.74 U	0.69 U	0.74 U	0.64 U
Calcium	6790 J	882 J	775 J	317 J	1800 J	1550 J	41200 J	45100 J	21200 J	827 J
Chromium	54.2	29.2	25.8	45.6	36.4	47.3	38.9 J	37.9	39.8	69.9 J
Cobalt	36.1	8.5	7.6	12.3	18.2	16.4	12.1	7.5	5.9	19
Copper	15.1 J	7.4 J	7.2 J	16.9 J	15.5	24	24.7 J	17.9	13.6	39.3 J
Iron	51700	24300	17206	35700	29400	37100	30700	31400	29900	45100
Lead	4.5 J	75.1 J	10.7 J	2.8 J	5.3 J	6.4 J	43	5.3 J	3.8 J	3.8
Lithium	34.5	21.6	21	21.3	15.9	27.9	24.2	19.8	15.6	55.4
Magnesium	9530 J	1550 J	1520 J	4090 J	3320 J	4400 J	6350 J	17000 J	3520 J	2280 J
Manganese	1950 J	144	136	150	652 J	467 J	536	251 J	94.4 J	662
Molybdenum	1.6 U	1.4 U	1.5 U	1.4 U	1.6 U	1.5 U	1.5 U	1.6 U	14	1.4 U
Nickel	48.6	14.5	14.2	39.5	21.3	24.7	29.5	16.7	16.2	22.4
Phosphorus	884	84 J	70 J	459 J	235 J	322 J	302	224 J	217 J	199
Potassium	7100	1890	1980	7320	4190	5340	4690	4140	6130	3270
Selenium	22.2 U	19.6 U	20.5 U	19.2 U	21.6 U	20.4 U	20.3 U	21.6 U	23.2 U	20 U
Silicon	458	725	678	483	624 J	415 J	668	700 J	613 J	709
Silver	0.92 R	0.81 U	0.85 U	0.79 U	0.89 R	0.84 R	0.84 R	0.9 R	0.96 R	0.83 R
Sodium	91.4 U	36.4 U	32.3 U	75.1	56.3 U	70.3 U	93.7 U	78 U	94 U	55.8 U
Strontium	17.8	6.5 J	6.2 J	5.8 J	8.7 J	11.3 J	43.3	29 J	26 J	5
Thallium	4.7 U	4.2 U	4.4 U	4.1 U	4.6 U	4.3 U	4.3 U	4.6 U	4.9 U	4.2 U
Vanadium	32.3	31.6	29.5	27.4	35.3	38.5	34 J	34.8	29.6	41.2 J
Zinc	84.5 J	27.6 J	28.3 J	54.4 J	48.3 J	47.5 J	68.9	44.2 J	38.2 J	46.9

[a]Sampling location.
[b]Sample number.
[c]Sample type.
[d]Sample depth.
[e]Sampling date.

GC = Grab composite sample.
J = Estimated value.
OT = Field duplicate sample.
R = QC indicates that data are unusable (constituent may or may not be present).
U = Constituent was analyzed for but not detected (the number given is the minimum quantitation limit).

Table 4.4. QC sample results for metals in the nitric acid pipeline area

Parameter (µg/L)	Sample number, location, and date				
	SB012[a] N01971[b] FB[c] 02/09/93[d]	SB016 N01071 FB 02/05/93	SB007 N01972 RI 02/09/93	SB019 N01072 RI 02/04/93	SB011 N00173 RI 01/27/93
Aluminum	38.9 U	12.5 U	38.4 U	43.8 U	1590
Antimony	12.2 U	12.2 U	12.2 U	12.2 U	12.2 U
Arsenic	0.75 U	0.66 U	0.66 U	0.66 U	
Barium	1.3 U	1.3 U	1.3 U	1.5	23.8
Beryllium	0.12 R	0.12 R	0.12 R	0.12 R	0.12 R
Cadmium	2.9 U	2.9 U	2.9 U	2.9 U	2.9 U
Calcium	363 R	102 R	250 R	205 R	5710 R
Chromium	2.7 U	2.7 U	2.7 U	2.7 U	42.7
Cobalt	2.3 U	2.3 U	2.3 U	2.3 U	3.7
Copper	1.5 U	1.5 U	1.5 U	1.5 U	4.4 U
Iron	26.4 U	10.3 U	46.5 U	48.1 U	7490
Lead	0.48 R	0.48 R	0.48 R	0.48 R	
Lithium	3 U	3 U	3 U	3 U	3.2
Magnesium	30.1 R	30.1 R	30.1 R	30.1 R	927 R
Manganese	0.72	0.62 U	1.2	0.62 U	82.9
Molybdenum	6.5 U	6.5 U	6.5 U	6.5 U	10.5
Nickel	7.1 U	7.1 U	7.1 U	7.1 U	11.3
Phosphorus	25.1 U	25.1 U	25.1 U	25.1 U	25.1 U
Potassium	982 R	982 R	982 R	982 R	982 R
Selenium	90.9 U	90.9 U	90.9 U	90.9 U	90.9 U
Silicon	1340	17 U	52.1	74.3	2600
Silver	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U
Sodium	631 R	32.9 R	12.1 R	84.9 R	112 R
Strontium	0.99	0.52 U	0.81	0.52 U	10.8
Thallium	19.3 U	19.3 U	19.3 U	19.3 U	19.3 U
Vanadium	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Zinc	14.3 U	4.3 U	21.4	5.9 U	9.6 U

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sampling date.

FB = Field blank sample.
TB = Trip blank sample.
RI = Rinsate sample.
R = QC indicates that data are unusable (constituent may or may not be present).
U = Constituent was analyzed for but not detected (the number given is the minimum quantitation limit).

Aluminum, iron, and silicon were detected at slightly elevated levels (measurable in ppm). Silicon was present at low ppm levels in one field blank sample, and all three elements were present at low ppm levels in one rinsate sample, all measurable in ppm.

It is possible that the detected elements measurable in low ppb were impurities in the organic-free water used to collect the sample. The silicon detected in ppm also could have come from the organic-free water. The iron and aluminum results, however, might be attributable to the equipment from which the rinsate sample was collected. The rinsate sample showing these results was taken from the cutting head of the lead auger fly following the initial decontamination, before any samples were collected. The first sample collected after the rinsate was at sampling location SB011. This sample showed the highest analytical result of all the soil samples for iron, but this result was below the background level. Aluminum was also detected in sample SB011 but not at the highest detected level for all the samples and below the background level. Subsequent rinsate samples showed much lower values for iron and levels below detection limits for aluminum.

4.2 NITRATE/NITRITE

Nineteen soil samples collected at various locations along ANAP and three background soil samples collected from a remote area at the Y-12 Plant were analyzed for nitrate/nitrite by EPA Method 353.3. The background soil sample results were all less than the reportable limit of 0.5 μg/g (Table 4.5). The qualifiers "UJ" indicate that because of a QC deviation, the reportable limit for these background soil samples may or may not be as noted. All the nitrate/nitrite analytical results for the pipeline samples received a "J" flag due to QA/QC problems (i.e., no method blank, problems with the matrix spike). These data, however, were acceptable for the objectives of this project and could be used for its purposes.

4.2.1 Sample Results

It was determined for the ANAP project that any nitrate/nitrite result along the pipeline at greater than twice the analytical reportable limit might suggest leakage from the pipeline. Because nitrate/nitrite was not detected in background samples above the reportable limit, a value of twice the reportable limit (1.0 μg/g) was used as a surrogate background value. Nitrate/nitrite results for five samples and one field duplicate sample exceeded the nitrate/nitrite surrogate background value.

The results are presented in Table 4.5. A summary of the results is presented below:

Chemical parameter	Frequency of detection	Range of detected values		Average detected value (μg/g)[a]	Background concentration (μg/g)[b]	RCRA Subpart S action level (μg/g)[c]
		Minimum (μg/g)	Maximum (μg/g)			
Nitrate/nitrite	14/19	<0.5	52[d]	3.8	<0.5	128,000

[a] This is the average concentration determined assuming non-detects equals one-half the reportable limit.

[b] This is the background concentration from sample locations SB001, SB002, and SB003.

[c] This is the RCRA health-based action level assuming a 16-kg child ingests 0.2 g soil/d (EPA 1990b) and a reference dose of 1.6 mg/kg/d (EPA 1993a).

[d] One QC duplicate sample exceeded the maximum value at 52 μg/g.

Table 4.5. Sample results for nitrate/nitrite in the nitric acid pipeline area

Parameter (µg/g)	Soil borehole samples: sample number, location, and date						
	SB001[a] N00101[b] GC[c] 2.0—2.5 ft[d] 02/08/93[e]	SB002 N00201 GC 5.0—5.5 ft 02/08/93	SB003 N00301 GC 3.5—4.0 ft 02/08/93	SB004 N00401 GC 8.0—10.0 ft 02/02/93	SB005 N00501 GC 8.0—10.0 ft 01/29/93	SB006 N00601 GC 2.5—4.5 ft 01/29/93	SB007 N00701 GC 5.5—6.0 ft 02/09/93
Nitrate/Nitrite (NO_3/NO_2-N)	0.67 J	0.57 J	0.5 UJ	1.3 J	0.96 J	0.84 J	0.5 UJ
	SB008 N00801 GC 5.0—5.5 ft 02/08/93	SB009 N00901 GC 8.0—10.0 ft 02/02/93	SB010 N01001 GC 4.5—6.5 ft 01/30/93	SB011 N01101 GC 10.5—12.5 ft 01/27/93	SB012 N01201 GC 4.5—5.0 ft 02/09/93	SB012 N01905 OT 4.5—5.0 ft 02/09/93	SB013 N01301 GC 0.5—1.0 ft 02/09/93
Nitrate/Nitrite (NO_3/NO_2-N)	0.5 UJ	0.78 J	10 J	1.1 J	0.5 UJ	0.5 UJ	0.5 UJ
	SB014 N01401 GC 7.0—9.0 ft 01/28/93	SB015 N01501 GC 4.0—6.0 ft 02/03/93	SB016 N01601 GC 8.0—10.0 ft 02/05/93	SB017 N01701 GC 10.0—12.0 ft 02/03/93	SB018 N01801 GC 4.0—6.5 ft 02/03/93	SB019 N01005 OT 2.0—6.0 ft 02/05/93	SB019 N01901 GC 2.0—6.0 ft 02/05/93
Nitrate/Nitrite (NO_3/NO_2-N)	0.7 J	0.8 J	0.51 J	32 J	0.94 J	52 J	20 J

	Background samples: sample number, location, and date		
	BKG01 B00001 GC 26.0—34.0 in. 01/22/93	BKG02 B00002 GR 50.0—58.0 in. 01/22/93	BKG03 B00003 GR 62.0—70.0 in. 01/22/93
Nitrate/Nitrite (NO_3/NO_2-N)	0.5 UJ	0.5 UJ	0.5 UJ

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sample depth.
[e] Sampling date.

GC = Grab composite sample.
OT = Field duplicate sample.
GR = Grab sample.
J = Estimated value.
U = Constituent was analyzed for but not detected (the number given is the minimum quantitation limit).

This summary indicates that the average nitrate value is slightly above the reportable limit of 0.5 μg/g. Because no nitrate was detected in the background samples, the site-related concentrations are above the site background level. Figure 4.1 shows detected nitrate concentrations along ANAP. The only sampling location where nitrate is noticeably above site background levels is location SB0019, near the point where the pipeline discharged into the S-3 Ponds. Although nitrate was not detected in the site background samples, it is a fairly ubiquitous chemical in the environment, especially in farming areas. Site levels are relatively low compared with many farming areas and do not suggest a leak of high-concentration nitric acid.

Nitrate is not a potent chemical toxicant. EPA has calculated a reference dose (RfD) for nitrate using dose-response data from animal studies. The RfD is the dose above which harmful health effects could be seen. Toxic responses were seen only at very high dose levels, suggesting a nitrate RfD of 1.6 mg/kg/day (EPA 1993a). This RfD is as much as three to four orders of magnitude greater than RfDs for many metals, indicating that nitrate is much less toxic than most regulated inorganics. Using the nitrate RfD and assuming that a 16-kg child ingests 200 mg of soil per day, the acceptable soil concentration is 128,000 mg/kg (or μg/g). Nitrate concentrations detected along the pipeline are well below the health-based action level.

In conclusion, these low levels of nitrates/nitrites suggest that no leakage has occurred from the pipeline, and a comparison with the health-based action levels suggests that detected concentrations are well below any level of concern.

4.2.2 QA/QC Samples

Two field-blank and three equipment-rinsate samples were collected; the results are presented in Table 4.6. An analysis of these QC samples provided information on any possible nitrate/nitrite contamination resulting from field sampling. All results were below the 0.1-mg/L detection limit; therefore, field-blank and equipment-rinsate samples exhibited no nitrate/nitrite contamination.

Table 4.6. QC sample results for nitrate/nitrite in the nitric acid pipeline area

Parameter (mg/L)	Sample number, location, and date				
	SB012[a] N01971[b] FB[c] 02/09/93[d]	SB019 N01071 FB 02/05/93	SB007 N01972 RI 02/09/93	SB010 N01072 RI 02/04/93	SB011 N00173 RI 01/27/93
Nitrate/Nitrite (NO_3/NO_2-N)	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U

[a] Sampling location. RI = Rinsate sample.
[b] Sample number. FB = Field blank sample.
[c] Sample type. U = Constituent was analyzed for but not detected
[d] Sampling date. (the number given is the minimum quantitation limit).

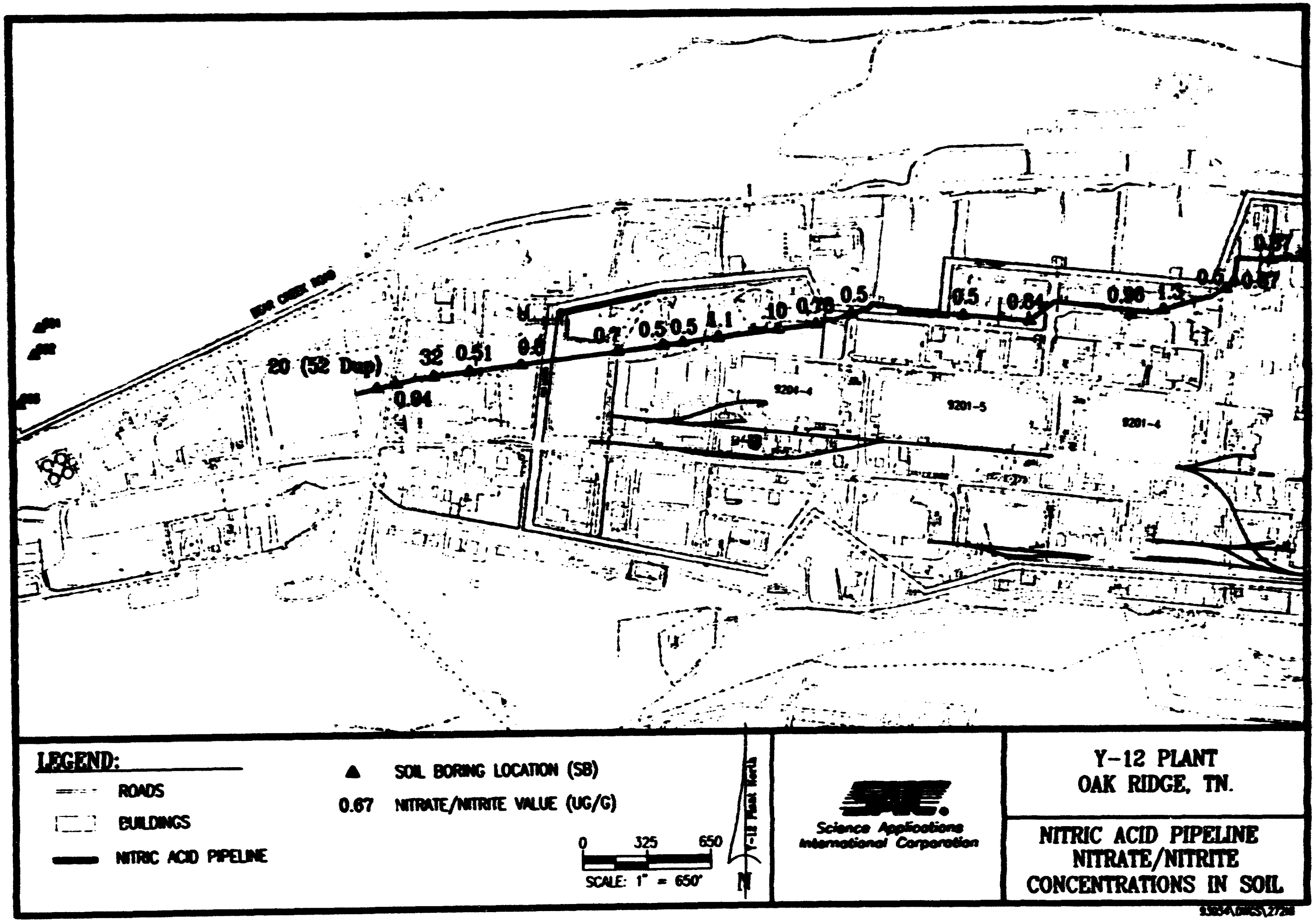


Fig. 4.1. Detected nitrate concentrations along ANAP.

4.3 VOLATILE ORGANIC COMPOUNDS

Soil samples were collected at locations SB007, SB010, and SB016 and analyzed for VOCs by methods indicated in the EPA Contract Laboratory Program SOW (EPA 1990c). Sample results are presented in Table 4.7. The samples taken at locations SB007 and SB010 were collected to determine whether VOCs are present. The sample taken at location SB016 was collected in response to readings on organic vapor monitoring equipment.

4.3.1 Sample Results

No positive results were detected in sample SB007. Sample SB010 contained one tentatively identified compound (TIC), which was thought to be 2-propanol and was detected at 91 μg/kg. The detection of 2-propanol was probably attributable to the sampling equipment, which was subjected to a 2-propanol rinse as part of the decontamination procedure.

Results from sampling location SB016 indicated the presence of acetone (a common laboratory contaminant) at 64 μg/kg and 11 TICs at levels ranging from 48 to 330 μg/kg. Some of the compounds listed as TICs are fragrance chemicals commonly associated with soaps. A review of plant utility drawings showed that sewer and drain lines were present in the immediate vicinity of SB016. It is possible that the drain and sewer lines are the source of some of the TICs. Attributing any of the TICs to the pipeline would be difficult because it is not known which (if any) organic compounds were sent through the pipeline. In addition, if the TICs were from a pipeline leak, high levels of uranium and nitrate would have been expected at this location, and these constituents were not found. Energy Systems ER Division notified plant personnel of the nature of contamination found in this borehole.

The detection limits for sample SB016 were significantly higher than for samples SB007 and SB010 because of differences in the amount of sample used. The laboratory indicated that only 1 g of sample was used for SB016, whereas 5 g were used for SB007 and SB010. The lower sample weight for SB016 resulted in a proportionally higher detection limit than for SB007 and SB010.

4.3.2 QA/QC Samples

The QA/QC samples collected for VOC analyses consisted of two field blanks, two rinsates, and three trip blanks. These samples were analyzed for the same compounds as were the soil samples. The analytical results are presented in Table 4.8.

Methylene chloride was detected at 3 ppb in one rinsate sample; no other VOCs were detected in any other QC samples. At this low level of detection, the presence of methylene chloride may be attributable to laboratory contamination. Three TICs were detected in the rinsate samples (Table 4.8). The presence of propanol might be explained by the propanol rinse used during decontamination procedures.

4.4 ISOTOPIC URANIUM

Nineteen soil samples collected at various locations along ANAP were analyzed for isotopic uranium (^{234}U, ^{235}U, ^{238}U) by EPA Method 908.0. Historical data for background soil samples were averaged to provide a value for comparison with analytical results. It was

Table 4.7. Sample results for volatile organic compounds in the nitric acid pipeline area

Parameter (µg/kg)	Sample number, location, and date					
	SB007[a] N00701[b] GC[c] 5.5—6.0 ft[d] 02/09/93[e]		SB010 N01003 GR 21.0—23.0 ft 01/30/93		SB016 N01601 GC 8.0—10.0 ft 02/05/93	
Acetone	7	UJ	12	U	64	
Benzene	13	U	12	U	62	U
Bromodichloromethane	13	U	12	U	62	U
Bromoform	13	U	12	U	62	U
Bromomethane	13	U	12	U	62	U
2-Butanone	4	UJ	7	UJ	62	U
Carbon disulfide	13	U	12	U	62	U
Carbon tetrachloride	13	U	12	U	62	U
Chlorobenzene	13	U	12	U	62	U
Chloroethane	13	U	12	U	62	U
Chloroform	13	U	12	U	62	U
Chloromethane	13	U	12	UJ	62	U
Dibromochloromethane	13	U	12	U	62	U
1,1-Dichloroethane	13	U	12	U	62	U
1,2-Dichloroethane	13	U	12	U	62	U
1,1-Dichloroethene	13	U	12	U	62	U
cis-1,2-Dichloroethene	13	U	12	U	62	U
trans-1,2-Dichloroethene	13	U	12	U	62	U
1,2-Dichloropropane	13	U	12	U	62	U
cis-1,3-Dichloropropene	13	U	12	U	62	U
trans-1,3-Dichloropropene	13	U	12	U	62	U
Ethylbenzene	13	U	12	U	62	U
2-Hexanone	13	U	12	U	62	U
4-Methyl-2-pentanone	13	U	12	U	62	U
Methylene Chloride	13	U	12	U	62	U
Styrene	13	U	12	U	62	U
1,1,2,2-Tetrachloroethane	13	U	12	U	62	U
Tetrachloroethene	13	U	12	U	62	U
Toluene	13	U	12	U	62	U
1,1,1-Trichloroethane	13	U	12	U	62	U

Table 4.7 (continued)

Parameter (μg/kg)	Sample number, location, and date		
	SB007[a] N00701[b] GC[c] 5.5—6.0 ft[d] 02/09/93[e]	SB010 N01003 GR 21.0—23.0 ft 01/30/93	SB016 N01601 GC 8.0—10.0 ft 02/05/93
1,1,2-Trichloroethane	13 U	12 U	62 U
Trichloroethene	13 U	12 U	62 U
Vinyl chloride	13 U	12 UJ	62 U
Xylene, (meta-, para-)	13 U	12 U	62 U
Xylene, (ortho-)	13 U	12 U	62 U
Tentatively identified compounds			
Decane			48 J
Diethyl benzene			170 J
Ethyl cyclohexane			310 J
2-Propanol		91 J	
Unknown dimethyl heptanol			330 J
Unknown ethyl dimethyl benzene			140 J
Unknown ethyl methyl benzene			180 J
Unknown methyl(methylethyl)-benzene			170 J
Unknown methyl(methylethyl)-cyclopentane			110 J
Unknown methyl nonene			90 J
Unknown methyl propyl benzene			180 J
Unknown trimethyl heptane			140 J

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sample depth.
[e] Sampling date.

GC = Grab composite sample.
GR = Grab sample.
J = Estimated value.
U = Constituent was analyzed for but not detected (the number given is the minimum quantitation limit).

Table 4.8. QC sample results for volatile organic compounds in the nitric acid pipeline area

Parameter (µg/kg)	SB012[a] N01971[b] FB[c] 02/09/93[d]	SB016 N01071 FB 02/05/93	SB007 N01972 RI 02/09/93	SB014 N01072 RI 02/04/93	TB TB0002 TB 02/04/93	TB TB0003 TB 02/05/93	TB TB0004 TB 02/09/93
	Sample number, location, and date						
Acetone	2 UJ	10 U	10 U	10 U	6 UJ	3 UJ	2 UJ
Benzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	3 UJ	3 UJ	4 UJ	5 UJ	5 UJ	3 UJ	3 UJ
Carbon disulfide	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Table 4.8 (continued)

Parameter (µg/kg)	Sample number, location, and date						
	SB012[a]	SB016	SB007	SB014	TB	TB	TB
	N01971[b]	N01071	N01972	N01072	TB0002	TB0003	TB0004
	FB[c]	FB	RI	RI	TB	TB	TB
	02/09/93[d]	02/05/93	02/09/93	02/04/93	02/04/93	02/05/93	02/09/93
Methylene chloride	10 U	10 U	10 U	3 J	10 U	10 U	10 U
Styrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 U
Xylene, (meta-, para-)	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylene, (ortho-)	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tentatively identified compounds							
Propanol				7.3 J			
2-Propanol			270 UJ				
Trimethyl silanol			7 UJ				

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sampling date.

RI = Rinsate sample
TB = Trip blank sample
FB = Field blank sample.
J = Estimated value.
U = Constituent was analyzed for but not detected (the number given is the minimum quantitation limit).

determined that any uranium detected along ANAP at levels greater than 3 times the background value might suggest leakage from the pipeline. The average uranium background values and action limits (three times background), reported in pCi/g, are summarized below:

Parameter	Average background value (pCi/g)	Action limit[a] (pCi/g)
^{234}U	1.37	4.11
^{235}U	0.112	0.336
^{238}U	1.46	4.38

[a] The action limit is three times background.

4.4.1 Sample Results

Concentrations of ^{234}U and ^{235}U in three samples and concentrations of ^{238}U in one sample exceeded the action limits. The results are presented in Table 4.9; however, a summary is presented below.

Chemical parameter	Frequency of detection	Range of detected values		Average detected value (pCi/g)[a]	Background concentration (pCi/g)[b]	NRC action level (pCi/g)[c]
		Minimum (pCi/g)	Maximum (pCi/g)			
^{234}U	19/19	0.53	13	2.8	1.37	35
^{235}U	19/19	0.009	0.75	0.16	0.112	35
^{238}U	19/19	0.71	5	1.7	1.46	35

[a] This is the average concentration determined assuming non-detects equal to one-half the detection limit.

[b] This is the background concentration from sampling locations SB001, SB002, and SB003.

[c] This is from the NRC Branch technical position paper "Disposal or On-Site Storage of Residual Thorium or Uranium (either as natural ores or without daughters present) from Past Operations."

This table indicates that average detected uranium values are comparable to background concentrations. The one exception is the maximum detected concentration of ^{234}U, at 13 pCi/g. This value was detected at sampling location SB001, which is nearest to the production operations and to the location of a past leak where soil removal occurred. The 13-pCi/g detection raises the average concentration slightly above the background concentration. Much higher soil uranium concentrations would be expected if a leak had occurred along the pipeline.

The NRC established a soil action level of 35 pCi/g for uranium based on an evaluation of exposure to uranium via multiple exposure pathways and achieving the 100-mrem dose limit for exposures to the general public (10 *CFR* 20). All detections at the site of each uranium isotope are below this action level. Figure 4.2 is a histogram showing ^{238}U concentrations in soil samples compared with background concentrations and the NRC action level. Figure 4.3 shows maximum concentrations of all uranium isotopes compared with the NRC action level.

In reviewing the low levels of uranium activity associated with this study, it is not possible to assign or designate a pipeline leak based on the variations observed in the data. Enrichment or depletion at these levels would also be difficult to interpret, especially within the context of the various Y-12 operations.

Table 4.9. Sample results for isotopic uranium in the nitric acid pipeline area

Parameter (pCi/g)	Sample number, location, and date											
	SB001[a] N00101[b] GC[c] 2.0—2.5 ft[d] 02/08/93[e]		SB002 N00201 GC 5.0—5.5 ft 02/08/93		SB003 N00301 GC 3.5—4.0 ft 02/08/93		SB004 N00401 GC 8.0—10.0 ft 02/02/93		SB005 N00501 GC 8.0—10.0 ft 01/29/93		SB006 N00601 GC 2.5—4.5 ft 01/29/93	
^{234}U	13+/-1.0	J	1.1+/-0.28	J	11+/-0.99	J	1.4+/-0.36	J	0.76+/-0.28	J	0.88+/-0.24	J
^{235}U	0.75+/-0.24	J	0.009+/-0.051	J	0.43+/-0.20	J	0.11+/-0.098	J	0.15+/-0.12	J	0.075+/-0.069	J
^{238}U	2.3+/-0.42	J	1.1+/-0.27	J	2.9+/-0.50	J	3.0+/-0.51	J	0.71+/-0.26	J	0.82+/-0.22	J
	SB007 N00701 GC 5.5—6.0 ft 02/09/93		SB008 N00801 GC 5.0—5.5 ft 02/08/93		SB009 N00901 GC 8.0—10.0 ft 02/02/93		SB010 N01001 GC 4.5—6.5 ft 01/30/93		SB011 N01101 GC 10.5—12.5 ft 01/27/93		SB012 N01201 GC 4.5—5.0 ft 02/09/93	
^{234}U	0.90+/-0.29	J	1.7+/-0.39	J	1.1+/-0.31	J	1.0+/-0.28	J	0.81+/-0.26	J	0.99+/-0.30	J
^{235}U	0.035+/-0.080	J	0.15+/-0.12	J	0.13+/-0.10	J	0.045+/-0.066	J	0.059+/-0.068	J	0.015+/-0.047	J
^{238}U	0.99+/-0.29	J	1.1+/-0.30	J	0.72+/-0.24	J	0.87+/-0.25	J	0.81+/-0.25	J	1.1+/-0.31	J
	SB012 N01905 OT 4.5—5.0 ft 02/09/93		SB013 N01301 GC 0.5—1.0 ft 02/09/93		SB014 N01401 GC 7.0—9.0 ft 01/28/93		SB015 N01501 GC 4.0—6.0 ft 02/03/93		SB016 N01601 GC 8.0—10.0 ft 02/05/93		SB017 N01701 GC 10.0—12.0 ft 02/03/93	
^{234}U	1.2+/-0.32	J	0.53+/-0.23	J	1.1+/-0.31	J	3.7+/-1.5	J	3.5+/-1.3	J	1.2+/-0.48	J
^{235}U	0.12+/-0.10	J	0.032+/-0.085	J	0.034+/-0.058	J	0.28+/-0.42	J,DL	0.17+/-0.28	J	0.042+/-0.092	J
^{238}U	1.3+/-0.33	J	0.83+/-0.28	J	0.97+/-0.28	J	2.4+/-1.2	J	3.2+/-1.1	J	1.5+/-0.52	J
	SB018 N01801 GC 4.0—6.5 ft 02/03/93		SB019 N01005 OT 2.0—6.0 ft 02/05/93		SB019 N01901 GC 2.0—6.0 ft 02/05/93							
^{234}U	5.5+/-2.1	J	2.5+/-1.3	J	2.7+/-0.63	J						
^{235}U	0.49+/-0.58	J,DL	0.33+/-0.43	J,DL	0.13+/-0.14	J						
^{238}U	5.0+/-1.8	J	3.3+/-1.4	J	3.0+/-0.64	J						

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sample depth.
[e] Sampling date.

GC = Grab composite sample.
J = Estimated value.
OT = Field duplicate sample.
DL = Detection limit not met.

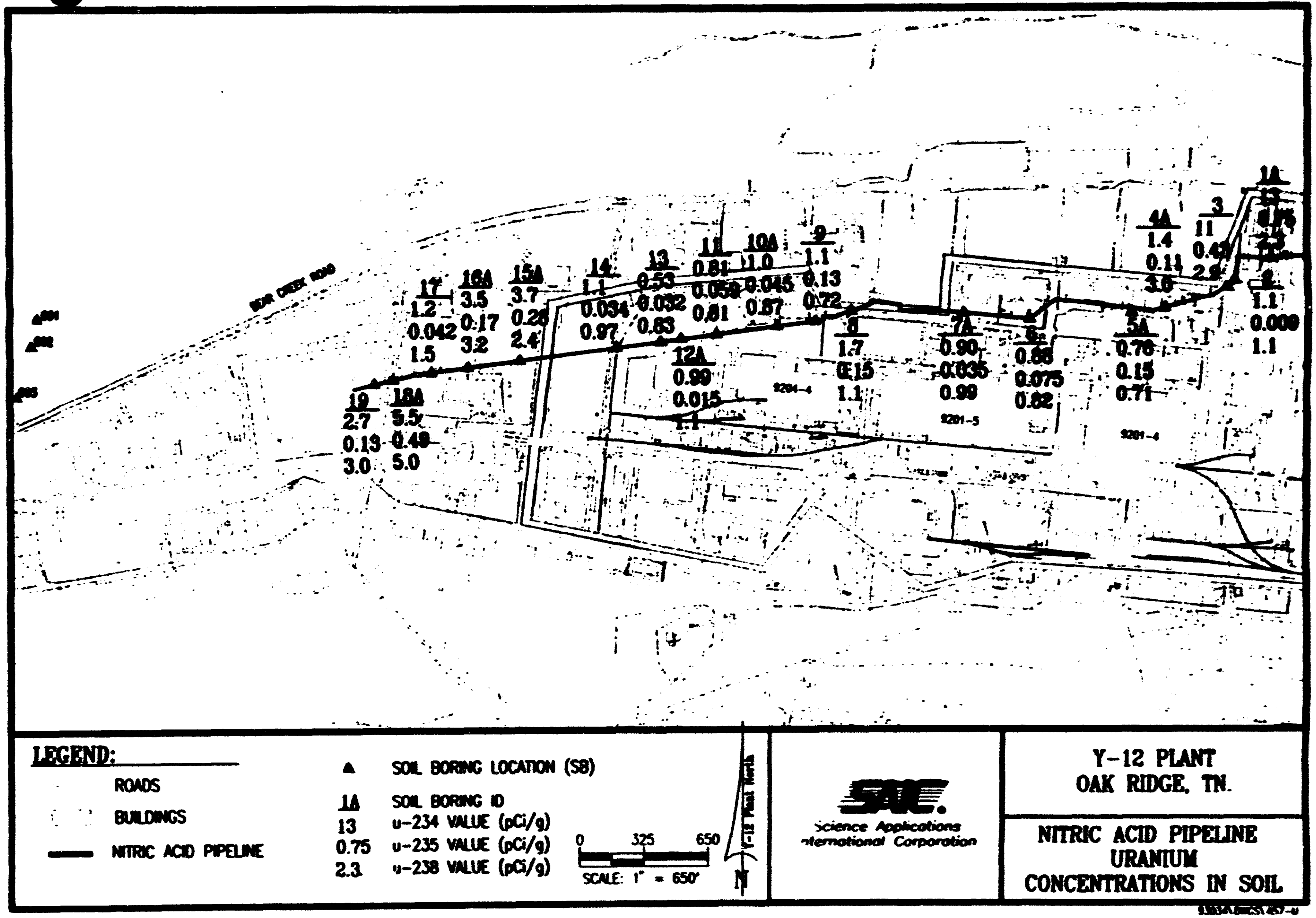


Fig. 4.2 ANAP soil sampling results for uranium compared with background concentrations and the NRC action level.

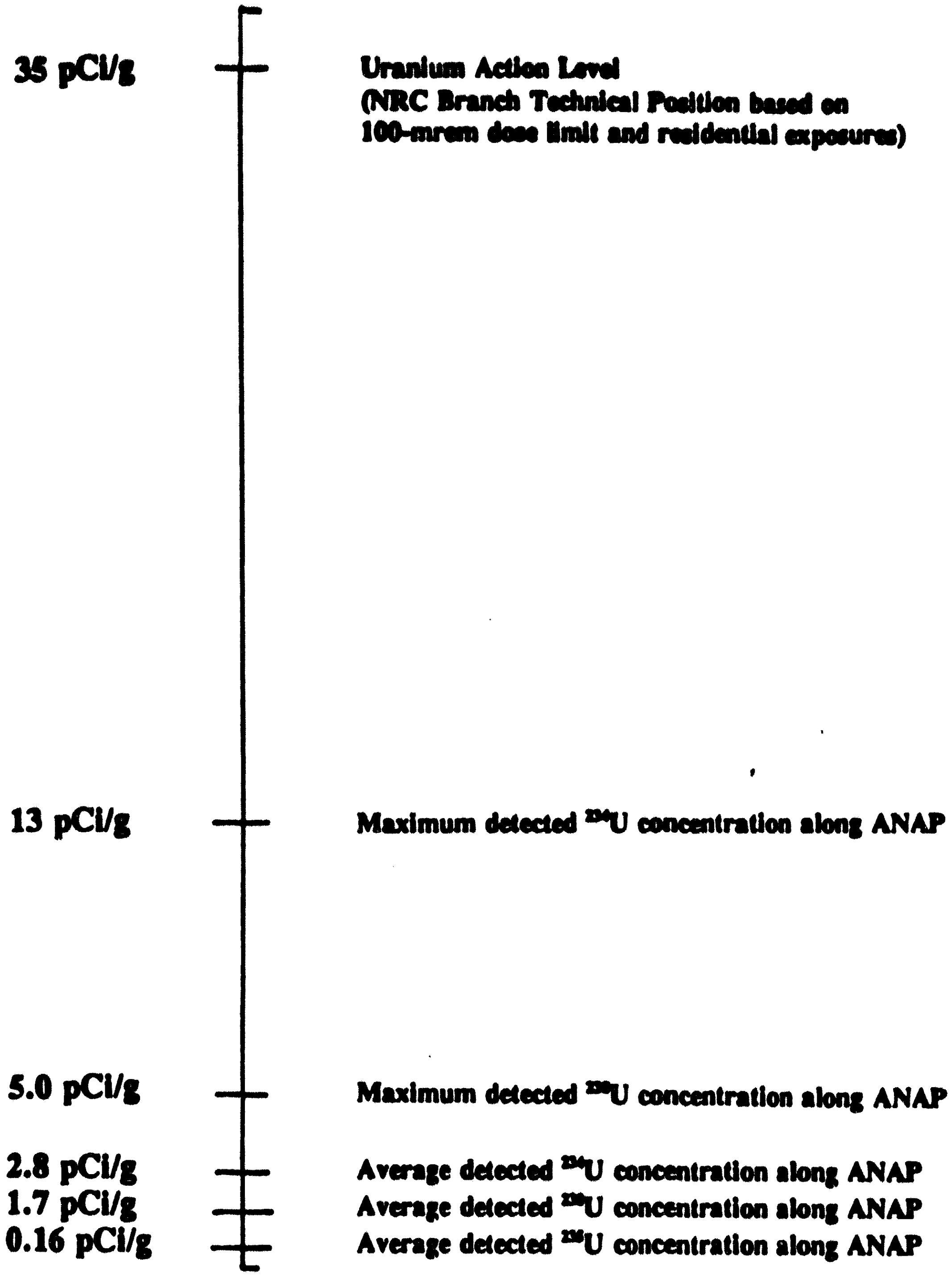


Fig. 4.3. Comparison of uranium levels along ANAP with the uranium action level.

The average activity ratio of ^{235}U to ^{238}U for the pipeline samples analyzed was 0.093 ± 0.081. The ratio for the background sample was 0.077. Multiple background samples were not determined; therefore, an estimate of the background ratio variability was not made. However, all individual sample ratios fall within a 3-sigma range of the average ratio, as does the background ratio.

4.4.2 QA/QC Samples

Two field-blank and three equipment-rinsate samples were collected; the results are presented in Table 4.10. Analyses of these QC samples provided information on any possible ^{234}U, ^{235}U, or ^{238}U contamination resulting from field sampling. The QC samples produced isotopic uranium results having relatively large error limits because the counts were close to background levels.

Table 4.10. QC sample results for isotopic uranium in the nitric acid pipeline area

Parameter (pCi/L)	Sample number, location, and date									
	SB012[a] N01971[b] FB[c] 02/09/93[d]		SB019 N01071 FB 02/05/93		SB007 N01972 RI 02/09/93		SB010 N01072 RI 02/04/93		SB011 N00173 RI 01/27/93	
^{234}U	0.21+/-0.11	J	0.027+/-0.057	J,DL	0.036+/-0.046	J,DL	0.081+/-0.075	J	0.081+/-0.064	J
^{235}U	0.014+/-0.024	J	0.018+/-0.035	J	0.014+/-0.022	J	0.041+/-0.046	J,DL	0.014+/-0.022	J
^{238}U	0.014+/-0.024	J	0.032+/-0.042	J,DL	0.054+/-0.050	J	0.072+/-0.056	J,DL	0.041+/-0.045	J,DL

[a] Sampling location.
[b] Sample number.
[c] Sample type.
[d] Sampling date.

RI = Rinsate sample.
J = Estimated value.
FB = Field blank sample.
DL = Detection limit not met.

5. HUMAN HEALTH BASELINE RISK ASSESSMENT

5.1 INTRODUCTION

The overall objective of a Human Health Baseline Risk Assessment (BRA) evaluation process is to obtain information necessary for making remediation decisions. A quantitative analysis of the inorganic (metal), organic, and radionuclide analytes found in various media can be used to characterize the potential risks posed to human health associated with exposure to these contaminants. The results of a BRA are used to (1) document and evaluate risks posed to human health; (2) determine the need for remedial action; (3) determine chemical concentrations protective of current and future human receptors; and (4) help select and compare various remedial alternatives (Energy Systems 1993a).

The BRA for exposure to soils surrounding ANAP is presented in this chapter. The human health risk assessment methodology used in the risk evaluation is based on the *Risk Assessment Guidance for Superfund* (RAGS) (EPA 1989a), and the assessment described herein follows the organization of the standard risk assessment processes described in RAGS (EPA 1989a). First, the soil data were evaluated to determine data usability for the risk assessment, then soil contaminants to be considered in the BRA were identified. [This process is referred to as the selection of contaminants of potential concern (COPCs).] Next, the representative concentrations for those soil contaminants included in the risk assessment were determined. Following this step, an assessment of the exposure potential was performed, and exposure pathways were identified. Subsequently, exposure was estimated quantitatively, and the toxicity of the soil COPCs was determined. The results of the exposure and toxicity assessments were brought together, and they are summarized in the risk characterization section.

To ensure a comprehensive evaluation of the risk posed to human health from exposure to the soils associated with ANAP and to ensure risk information supportive of project objectives, both (1) the current most reasonable and most likely exposure scenario and (2) a future reasonable maximum exposure scenario were evaluated. Because the location of the pipeline is within the operational Y-12 Plant and because the pipeline is buried underground (at a depth from 0.5 to 14 ft), construction workers are the most likely receptors of ANAP soils. The exposure pathways that were evaluated for the construction worker were incidental ingestion of the soil, inhalation of dust, dermal contact with the soil, and external exposure to radionuclides in the soil.

An upper-bound on the risk to human receptors was evaluated using residential parameters. Because ANAP is within the operational Y-12 Plant, such a conservative scenario is unlikely. However, the intent of this evaluation was to provide managers with potential risks that are unlikely to underestimate exposure to future receptors of ANAP soils. The four primary and most direct routes/pathways of exposure (dermal contact with the soil, incidental ingestion of the soil, inhalation of dust, and external exposure to radionuclides in the soil) were evaluated. The food chain was not evaluated for this OU because (1) large uncertainties were associated with the required modeling of food chain pathways; (2) contaminants are beneath the surface; and (3) the location of the pipeline is within the operational area of the Y-12 Plant. The food chain pathways are not completed exposure routes for the industrial worker or construction worker.

The following sections describe the methodology used in evaluating the ANAP soil analytical data, physical characteristics, potential pathways, and receptors for the quantification of the potential risk to human health from exposure to the ANAP COPCs.

5.2 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

5.2.1 General ANAP Data Collection Considerations

From 1951 to 1983, ANAP was used to transport waste effluent (nitric acid with depleted uranium in solution) from uranium recovery process operations from several Y-12 Plant buildings (Chap. 2) to the S-3 Ponds. The majority of the pipeline runs through the Y-12 Plant protected area. The 1- to 3-in.-diam stainless steel pipeline is ~4800 ft in length and is buried 0.5 to 14 ft below ground (average depth of 5 ft). In 1983, ANAP was flushed and many sections were plugged with grout/concrete; some sections were also removed/renovated when in the path of Y-12 Plant construction. (See Chap. 2 of this RI for details.) ANAP has many turns, bends, welded joints, and low points where possible leaks and/or accumulation could have occurred. Therefore, the purpose of the soil sampling along the pipeline was to determine whether leakage occurred and to identify the levels of contamination present in the surrounding soils.

No historical soil data specifically related to monitoring ANAP were available. Specific soil sampling information can be found in the *Sampling and Analysis Plan (SAP) for the Abandoned Nitric Acid Pipeline* (Energy Systems 1993b). In addition, the RI work plan was developed in the *RCRA Facility Investigation Plan for Group 4* (Energy Systems 1990) and a revision document to the RI (Energy Systems 1991a). These two documents were used in the development of the SAP.

Nineteen biased (i.e., biased toward likely leakage points) soil sampling locations were identified where uranium, nickel, chromium, and leachable nitrogen served as indicators of leaks. Uranium was the main COPC transported via ANAP; chromium and nickel are components found in stainless steel (the pipeline is constructed of stainless steel). For purposes of this BRA, the soil samples taken directly below the pipeline at each of the 19 sampling locations were used to evaluate risk to human receptors (current construction worker and future resident). The soil sampling and analysis guidance for collecting samples (Kimbrough, Long, and McMahon 1990), technical approach, sampling locations, numbering and documentation, QA/QC, analytical procedures, and analysis techniques are described in the Sampling and Analysis Plan (SAP) (Energy Systems 1993b); also refer to Sect. 3.4 of this RI. Three background samples were collected for nitrogen analysis only; note, however, that background levels for analytes detected in the ANAP soils were also compared with the results from the *Background Soil Characterization Project for the Oak Ridge Reservation* (Energy Systems 1993c).

5.2.2 General ANAP Data Evaluation Considerations

All soil data considered for use in the BRA were provided to the Energy Systems Risk Analysis Section by SAIC via electronic files. Details of the validation process can be found in the *Site Characterization Summary of the Abandoned Nitric Acid Pipeline* (Energy Systems 1993d) and in Chap. 4 of this RI.

Validated data (100% validation) were evaluated by the Energy Systems Risk Analysis Section for the BRA by the methods described in RAGS (EPA 1989a). Data with a (1) J were treated as detected analytes and were included in the BRA data set; (2) U were treated as nondetected analytes, and the reported detection limit was used as the concentration value; (3) UJ were treated as data flagged with U; (4) J, DL were treated as data flagged with J; and (5) R were rejected from the BRA data set. When an analyte was not detected (U or UJ) in any of the soil samples, a separate data set (i.e., a nondetected analytes data set) was created and evaluated. This is discussed in Sect. 5.2.3.10.

5.2.3 ANAP Soil Data Evaluation

The validated data for the ANAP soil samples are summarized and tabulated in the *Site Characterization Summary of the Abandoned Nitric Acid Pipeline* (Energy Systems 1993d) and in Chap. 4 of this RI. The soil data included in this BRA consist of inorganic (metals) and radionuclide analyses of soil samples from 19 sampling locations along ANAP. Organic analyses (i.e., analyses for VOCs) of soil samples from three sampling locations were reported.

5.2.3.1 Data preparation

The data received from SAIC were read into a Statistical Analysis System data set, and the data qualifier evaluation, discussed in Sect. 5.2.2, was performed. The following analyses/evaluations were performed in accordance with RAGS (EPA 1989a) for the process of selecting the COPCs to be evaluated quantitatively in this BRA.

5.2.3.2 Outliers

The statistical method used to identify outliers in the ANAP soil data set was based on the outer fences method (Tukey 1977). The 25th and 75th percentile for each analyte was calculated for analytes with at least one detected value. An inner quartile range was then determined (75th percentile minus 25th percentile) for each analyte. This range was then multiplied by three and added to the 75th percentile; the subsequent value is the upper outlier limit (Tukey 1977). Similarly, the lower outlier limit was calculated as the 25th percentile minus three times the inner quartile range. If an individual observed analyte concentration was within the lower and upper outlier limits, it was not considered to be a statistical outlier. Nine outliers were identified and are listed in Appendix F, Table F.1; however, no reasons were found to eliminate or segregate any of these outliers from the BRA data set.

5.2.3.3 Original samples compared with associated blanks

For 2 out of 19 ANAP sample locations, both an original sample and a field blank were taken. Two criteria [based on RAGS (EPA 1989a)] were used to evaluate the reported analyte concentrations: (1) if the concentration of the analyte in the sample was at least five times greater than the maximum concentration detected in the blank, then the analyte concentration was not changed from the reported value and (2) if the concentration of the analyte in the sample was greater than the concentration found in the blank but less than five times the concentration in the blank, then the analyte concentration was changed to reflect the concentration reported in the blank, and a nondetect qualifier (U) was also added to the data set for these species. Based on these criteria, the Energy Systems Risk Analysis Section made appropriate changes to the original sample analyte concentrations, and the changes are reported in Appendix F, Table F.2.

For common laboratory contaminants such as acetone, 2-butanone, methylene chloride, toluene, and phthalate esters, if the concentration of the analyte in the sample was at least 10 times greater than the associated blank maximum concentration detected in the blank, then the analyte concentration was not changed from the reported value [similar to criteria (1) in the preceding paragraph]. Note, no common laboratory contaminants were detected in the blank samples. In addition, three trip blank samples were taken; no detected analyte concentrations were reported for these samples. Therefore, no original sample versus trip blank comparison was performed (EPA 1989a).

5.2.3.4 Original samples compared with duplicate samples

For situations in which an original soil sample and a duplicate soil sample were available (2 out of 19), the difference in analyte concentrations between the duplicate and the original sample was calculated for each analyte (i.e., sample analyte concentration minus duplicate analyte concentration); an average difference was then determined for each analyte. A statistical test (t-test) was performed to determine whether these average differences were significantly different from zero at the 95% confidence level (95% CL).

For one analyte (selenium), the average concentration difference was determined to be statistically different from zero at the 95% CL (Appendix F, Table F.3). Although the selenium concentration difference was significantly dissimilar from zero at the 95% CL, it was not significant at the 97% CL, and no other reasons for this relatively large variation were found. Therefore, it was not handled any differently than the other analytes that passed the statistical test at the 95% CL. The duplicate soil samples were considered only in the context of QA/QC and, therefore, were not included in the BRA data set.

5.2.3.5 Tentatively identified compounds

TICs are analytes not included on the target analyte list or on the target compound list and for which both the identity and concentration are questionable. TICs for the ANAP soil data set were found in two original samples and two rinsates and are listed in Appendix F, Table F.4. According to RAGS (EPA 1989a), when only a few TICs are present, compared to target compound list and target analyte list chemicals, and when historical and/or site-specific information about such analytes are not available, the TICs are generally not included in the risk evaluation.

As reported in Appendix F, Table F.4, only one identifiable TIC (2-propanol) was present in more than 10% of the 10 possible VOC samples. The 10 VOC samples included 3 original samples, 2 field blanks, 2 rinsates, and 3 trip blanks. This analyte was identified in only 2 out of 10 VOC samples. Table F.4 in Appendix F lists the minimum, maximum, and mean concentrations for 2-propanol and the other TICs. Because the number of TICs were relatively few and dose/response information was not available for 2-propanol, it was not included in the BRA data set. Several unidentified TICs are present in 10% of the VOC samples; however, because the identities were unknown, they could not be included in the BRA data set. No further evaluation of TICs was performed.

5.2.3.6 Summary statistics

Tables 5.1a, 5.1b, 5.2a, and 5.2b list the summary statistics for the ANAP soil samples; a normal distribution was assumed. These tables include the (1) analyte type (radionuclide,

Table 5.1a. ANAP summary statistics—detected analytes that can be evaluated quantitatively[a]

Analyte	Frequency of detection	Minimum detected value	Maximum detected value	Mean value	Upper 95% confidence limit on mean	Representative concentration[b]
			Radionuclides (pCi/g)			
^{234}U	18/19	5.30E-01	1.30E+01	2.74E+00	4.15E+00	4.15E+00
^{235}U	18/19	9.00E-03	7.50E-01	1.65E-01	2.43E-01	2.43E-01
^{238}U	19/19	7.10E-01	5.00E+00	1.75E+00	2.23E+00	2.23E+00
			Nitrate/Nitrite (mg/kg)			
Nitrate	14/19	5.10E-01	3.20E+01	3.88E+00	7.19E+00	7.19E+00
Nitrite	14/19	5.10E-01	3.20E+01	3.88E+00	7.19E+00	7.19E+00
			Metals (mg/kg)			
Arsenic	15/19	8.60E-01	3.70E+00	1.80E+00	2.22E+00	2.22E+00
Barium	19/19	5.55E+01	4.69E+02	1.65E+02	2.14E+02	2.14E+02
Beryllium	19/19	5.10E-01	1.70E+00	1.09E+00	1.22E+00	1.22E+00
Chromium VI	19/19	2.44E+01	5.63E+01	4.06E+01	4.38E+01	4.38E+01
Manganese	19/19	9.44E+01	1.95E+03	6.49E+02	8.58E+02	8.58E+02
Molybdenum	1/19	1.40E+01	1.40E+01	2.15E+00	3.29E+00	3.29E+00
Nickel	19/19	1.45E+01	5.30E+01	2.98E+01	3.44E+01	3.44E+01
Nickel (salts)	19/19	1.45E+01	5.30E+01	2.98E+01	3.44E+01	3.44E+01
Strontium	19/19	5.20E+00	7.06E+01	2.09E+01	2.76E+01	2.76E+01
Vanadium	19/19	2.42E+01	3.85E+01	3.15E+01	3.33E+01	3.33E+01
Zinc	19/19	2.76E+01	1.18E+02	6.08E+01	7.09E+01	7.09E+01
			Organics (mg/kg)			
Acetone	1/3	6.40E-02	6.40E-02	2.77E-02	8.09E-02	6.40E-02

[a] These are analytes with at least one detected value that have a slope factor and/or a reference dose.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Table 5.1b. ANAP summary statistics—detected analytes that can be evaluated qualitatively[a]

Analyte	Frequency of detection	Minimum detected value	Maximum detected value	Mean value	Upper 95% confidence limit on mean	Representative concentration[b]
			Metals (mg/kg)			
Aluminum	19/19	1.92E+04	3.96E+04	3.00E+04	3.24E+04	3.24E+04
Calcium	19/19	3.17E+02	4.51E+04	1.36E+04	1.99E+04	1.99E+04
Cobalt	19/19	5.90E+00	3.61E+01	1.58E+01	1.86E+01	1.86E+01
Copper	19/19	7.40E+00	2.97E+01	1.89E+01	2.14E+01	2.14E+01
Iron	19/19	2.43E+04	5.17E+04	3.38E+04	3.64E+04	3.64E+04
Lead	16/16	2.80E+00	7.51E+01	2.13E+01	3.15E+01	3.15E+01
Lithium	19/19	1.43E+01	3.48E+01	2.38E+01	2.63E+01	2.63E+01
Magnesium	19/19	1.55E+03	1.88E+04	6.75E+03	8.70E+03	8.70E+03
Phosphorus	19/19	8.40E+01	8.84E+02	4.16E+02	5.07E+02	5.07E+02
Potassium	19/19	1.89E+03	7.53E+03	4.89E+03	5.56E+03	5.56E+03
Silicon	19/19	3.69E+02	8.45E+02	5.70E+02	6.22E+02	6.22E+02
Sodium	5/19	7.51E+01	1.26E+02	7.59E+01	8.72E+01	8.72E+01

[a] These are analytes with at least one detected value that do not have a slope factor and a reference dose.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Table 5.2a. ANAP summary statistics—nondetected analytes that can be evaluated quantitatively[a]

Analyte	Frequency of detection	Minimum nondetected value	Maximum nondetected value	Mean value[b]	Upper 95% confidence limit on mean[b]	Representative concentration[c]
Metals (mg/kg)						
Antimony	0/7	2.30E+00	3.00E+00	2.67E+00	2.83E+00	3.00E+00
Cadmium	0/19	5.60E-01	7.40E-01	6.69E-01	6.89E-01	7.40E-01
Selenium	0/19	1.74E+01	2.32E+01	2.07E+01	2.13E+01	2.32E+01
Silver	0/7	7.20E-01	9.20E-01	8.20E-01	8.65E-01	9.20E-01
Organics (mg/kg)						
1,1,2,2-Tetrachloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
1,1,2-Trichloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
1,1-Dichloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
1,1-Dichloroethene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
1,2-Dichloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
1,2-Dichloropropane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
2-Butanone	0/3	4.00E-03	6.20E-02	2.43E-02	7.94E-02	6.20E-02
4-Methyl-2-pentanone	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Benzene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Bromodichloromethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Bromoform	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Bromomethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Carbon disulfide	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Carbon tetrachloride	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Chlorobenzene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Chloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Chloroform	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Chloromethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Dibromochloromethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Ethylbenzene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Methylene chloride	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Styrene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Tetrachloroethene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Toluene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Vinyl Chloride	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02

Table 5.2a (continued)

Analyte	Frequency of detection	Minimum nondetected value	Maximum nondetected value	Mean value[b]	Upper 95% confidence limit on mean[b]	Representative concentration[c]
Xylene, (ortho-)	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
cis-1,2-Dichloroethene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
trans-1,2-Dichloroethene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02

[a] These are analytes with all nondetected concentrations that have a slope factor and/or a reference dose.
[b] The detection limit concentrations were used in these calculations (EPA 1989a).
[c] The representative concentration was assigned as the maximum nondetected concentration (EPA 1989a).

Table 5.2b. ANAP summary statistics—nondetected analytes that can be evaluated qualitatively[a]

Analyte	Frequency of detection	Minimum nondetected value	Maximum nondetected value	Mean value[b]	Upper 95% confidence limit on mean[b]	Representative concentration[c]
			Metals (mg/kg)			
Thallium	0/19	3.70E+00	4.90E+00	4.40E+00	4.52E+00	4.90E+00
			Organics (mg/kg)			
1,1,1-Trichloroethane	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
2-Hexanone	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Trichloroethene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
Xylene, (meta-, para-)	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
cis-1,3-Dichloropropene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02
trans-1,3-Dichloropropene	0/3	1.20E-02	6.20E-02	2.90E-02	7.72E-02	6.20E-02

[a] These are analytes with all nondetected concentrations that do not have a slope factor and a reference dose.
[b] The detection limit concentrations were used in these calculations (EPA 1989a).
[c] The representative concentration was assigned as the maximum nondetected concentration (EPA 1989a).

nitrate/nitrite, metal, and organic); (2) number of detected concentrations per number of observations (i.e., frequency of detection); (3) minimum, maximum, and mean concentrations; (4) upper 95% confidence limit (UCL95) on the mean; and (5) representative concentration. The representative concentration was determined according to RAGS (EPA 1989a), by comparing the UCL95 to the maximum detected value; the smaller of these two values is reported as the representative concentration.

Separate tables are given for detected (Tables 5.1a and 5.1b) and nondetected (Tables 5.2a and 5.2b) analytes. Note that, to be on the nondetected analyte list, a chemical had to be a nondetect in all analyses (e.g., the frequency of detection has to be zero); it is a chemical that was analyzed for but was not detected at the detection limit of the analytical method used for its analysis. The representative concentration for a nondetected analyte is the maximum reported value (i.e., the maximum reported detection limit) (EPA 1989a).

Essential nutrients including calcium, copper, iron, magnesium, phosphorus, potassium, silicon, and sodium (Dunne 1990) have little or no adverse effects at the detected levels reported in this study, and these nutrients are not expected to have been used in any of the ANAP operations (Table 5.1b). They have been included in the summary statistics for the purpose of reporting all of the available information but are not considered to be COPCs.

5.2.3.7 Comparison with background soil samples

Many naturally occurring soil constituents also occur as site-related contaminants (i.e., they are detected during the sampling and analysis process along with the site contaminants). Therefore, site-related contaminants must be differentiated from background constituents to ensure that risk management decisions are based on risk posed by contaminants and not risk from background constituents. This aspect of the COPC selection process was carried out by using the results from the *Background Soil Characterization Project for the Oak Ridge Reservation* (Energy Systems 1993c). Data collected during the site investigation of a specific hazardous waste site (e.g., ANAP) were compared to background data to identify COPCs. In most cases, an analyte detected in soil was assumed to be related to site activities and was, therefore, a COPC; however, if the detected analyte concentration was found to be less than the background concentration, it was not considered a COPC. Guidance from the EPA suggests that a concentration of two orders of magnitude above the background concentration indicates a COPC (EPA 1990a).

Analytes reported in the summary statistics (Tables 5.1a, 5.1b, 5.2a, and 5.2b) were compared with those analytes found in naturally occurring background soil on the Oak Ridge Reservation (ORR) in the Dismal Gap and Nolichucky formations (Energy Systems 1993c). (Refer to Appendix F, Table F.5a.) Approximately two-thirds of the pipeline is in the Dismal Gap formation, and one-third is in the Nolichucky formation. The median ANAP analyte concentration for each analyte was compared to the upper and lower 95% confidence bound (UCB95 and LCB95) on the median of the Background Soil Characterization Project data. Analytes with a median concentration (1) between the LCB95 and UCB95, for either the Dismal Gap or the Nolichucky formations, or (2) below the Dismal Gap or Nolichucky LCB95, were not considered to be significantly different from ORR background (i.e., analytes with median concentrations less than the UCB95 for Dismal Gap or Nolichucky were not evaluated in this BRA). Arsenic, barium, cobalt, copper, iron, lead, manganese, and vanadium were eliminated from the quantitative evaluation (i.e., the quantitative COPCs list for this BRA) based on this background comparison; these chemicals were not associated with the

ANAP activities. For arsenic, lead, and manganese, the ANAP median concentrations were less than the LCB95 concentrations for the Background Soil Characterization Project. Note that, to be conservative, the maximum detected values for arsenic, barium manganese, and vanadium were compared with the residential ingestion of soil preliminary remediation goals (PRGs). These maximum analyte concentrations were far below PRGs at a hazard index of 1.0. Furthermore, based on the preceding criteria [i.e., (1) and (2)], ^{234}U and ^{238}U are within/below background concentrations on the ORR (Table F.5a of Appendix F); however, because these uranium isotopes are known to be related to the ANAP site operations, they were included as COPCs for this BRA.

Three background soil samples were taken, specifically for this ANAP project, from a remote area at the Y-12 Plant (Energy Systems 1993b and 1993d). These background samples were analyzed for nitrate/nitrite only (see Sect. 1.2). Comparisons of the ANAP soil data to these three background samples (Appendix F, Table F.5b) indicate ANAP nitrate/nitrite concentrations greater than background [i.e., the ANAP data 95% confidence intervals and the background data 95% confidence intervals do not overlap (EPA 1990a)]. Because the ANAP nitrate/nitrite concentrations are greater than background and because these analytes are related to the ANAP site operations, they were included as quantitative COPCs for this BRA.

5.2.3.8 Toxicity screening of COPCs

A concentration-toxicity screen was applied to the ANAP data set (for analytes with at least one detected value) using guidance in RAGS (EPA 1989a). The objective of this screening procedure was to identify those analytes most likely to contribute significantly to the risks and hazard indices [hazard index (HI)] (i.e., those analytes with a negligible contribution to the total adverse health effects posed by site contaminants were identified and eliminated from the COPC list). For the ingestion and inhalation toxicity values [RfDs and slope factors (SFs)], a toxicity score was calculated for each analyte by multiplying the analyte's maximum detected concentration by the toxicity value (i.e., conc. × SF and conc. × 1/RfD). Each individual analyte's toxicity score was summed to obtain a total chemical score. A ratio of the specific analyte toxicity score to this total chemical score approximated the relative risk (or HI) for each analyte. Analytes with a relative risk of <5% (<5% for all available toxicity scores) were not considered further (as COPCs) in this BRA.

The results of the toxicity screening can be found in Appendix F, Table F.6. (Strontium, zinc, and acetone were eliminated from the quantitative COPC list for this BRA based on the preceding criteria.) The following should be noted about the results:

1. Although nitrate and nitrite could have been eliminated using this technique, these analytes are related to the ANAP site operations and were included as COPCs for this BRA.
2. Because beryllium is the only nonradionuclide COPC with an oral SF in this data set, no valid toxicity screening comparisons could be made for carcinogenic risk from exposure via ingestion or dermal contact; therefore, beryllium was not eliminated from the quantitate COPC list for this BRA.
3. Toxicity scores for radionuclides could not be compared with those for inorganics and organics because the toxicity score units were different [see RAGS for guidance (EPA 1989a)].

4. Because uranium isotopes are related to the ANAP site operations, no toxicity screening was performed, and these isotopes are included on the quantitative COPC list for this BRA.

5.2.3.9 Summary of background comparison, toxicity screening, and essential nutrient results

Table 5.3 summarizes/lists those analytes that were eliminated from the COPC list because of (1) a comparison with background data (Sect. 5.2.3.7), (2) the toxicity screening assessment results (Sect. 5.2.3.8), or (3) their use as essential nutrients in the human body (Dunne 1990).

5.2.3.10 Comparison of nondetected analyte concentrations with preliminary remediation goals

Summary statistics for the nondetected ANAP analytes are shown in Table 5.2. The analytes in this table are not believed to be associated with the ANAP process. For the nondetected analytes that could be evaluated quantitatively (Table 5.2a) (i.e., SFs and/or RfDs are available), comparisons were made with PRGs. PRGs are protective of human health, comply with ARARs, and are used in the selection of remedial alternatives (EPA 1991a). The maximum reported concentration for each nondetected ANAP analyte (Table 5.2a) was compared with the noncarcinogenic (HI = 1.0) and carcinogenic (risk = 1.0E-04 and risk = 1.0E-06) residential (ingestion of soil pathway) PRGs (refer to Appendix F, Table F.7). Residential PRGs were used in order to be conservative. For each comparison (Appendix F, Table F.7), the ANAP analyte concentrations were well below the target PRG concentrations; therefore, these nondetected analytes were not considered further in this BRA.

The nondetected ANAP analytes for which a PRG comparison could not be made because no toxicity values (SFs nor RfDs) were currently available are listed in Appendix F, Table F.8. These analytes were not believed to be associated with ANAP processes and, therefore, were not considered further in this BRA.

5.2.4 Summary of Contaminants of Potential Concern

Table 5.4 lists the detected (at least one detected value) COPCs to be evaluated quantitatively in this BRA and their representative concentrations; complete summary statistics can be found in Table 5.1a. Identification of these COPCs was based on the methodology from RAGS (EPA 1989a), and the number of COPCs that could be quantitatively evaluated was limited by the availability of chemical-specific EPA-approved toxicity information (SFs and RfDs).

Uranium and nitrate/nitrite are the main COPCs associated with the ANAP process. The analytical laboratory did not distinguish between nitrate and nitrite (i.e., one concentration was reported as nitrate/nitrite). However, because nitrate and nitrite have different toxicity values (RfDs), they were evaluated separately in this BRA.

Chromium and nickel are components found in stainless steel and can be used as indicators of leaks in the pipeline; therefore, the inorganics listed in Table 5.4 include chromium VI, nickel, and nickel salts. The analytical laboratory reported detected concentrations for total chromium and total nickel found in the ANAP soils, and although

Table 5.3. ANAP analytes eliminated from the COPC list

Analyte	Frequency of detection	Representative concentration[a]	Reason analyte is not on COPC list[b]
		Metals (mg/kg)	
Arsenic	15/19	2.22E+00	B
Barium	19/19	2.14E+02	B
Calcium	19/19	1.99E+04	E
Cobalt	19/19	1.86E+01	B
Copper	19/19	2.14E+01	B, E
Iron	19/19	3.64E+04	B, E
Lead	16/16	3.15E+01	B
Magnesium	19/19	8.70E+03	E
Manganese	19/19	8.58E+02	B
Phosphorus	19/19	5.07E+02	E
Potassium	19/19	5.56E+03	E
Silicon	19/19	6.22E+02	E
Sodium	5/19	8.72E+01	E
Strontium	19/19	2.76E+01	T
Vanadium	19/19	3.33E+01	B
Zinc	19/19	7.09E+01	T
		Organics (mg/kg)	
Acetone	1/3	6.40E-02	T

[a] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

[b] B = Based on comparison of ANAP data with data from the Background Soil Characterization Project (Energy Systems 1993c); E = Essential nutrient (EPA 1989a; Dunne 1990); and T = Based on toxicity screening (EPA 1989a).

Table 5.4. COPCs for ANAP that will be evaluated quantitatively[a]

Analyte	Frequency of detection	Representative concentration[b]
	Radionuclides (pCi/g)	
^{234}U	18/19	4.15E+00
^{235}U	18/19	2.43E-01
^{238}U	19/19	2.23E+00
	Nitrate/Nitrite (mg/kg)	
Nitrate	14/19	7.19E+00
Nitrite	14/19	7.19E+00
	Metals (mg/kg)	
Beryllium	19/19	1.22E+00
Chromium VI	19/19	4.38E+01
Molybdenum	1/19	3.29E+00
Nickel	19/19	3.44E+01
Nickel (salts)	19/19	3.44E+01

[a] The analytes evaluated quantitatively in this BRA have at least one detected value; these analytes also have EPA-approved slope factors and/or reference doses.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

chromium and nickel are believed to exist as species of low toxicity, the analytical data cannot substantiate this belief. Therefore, to ensure that human health would be protected, these metals were assumed to be in their most toxic forms (i.e., chromium VI and nickel salts) for the purposes of this BRA. Because quantitative toxicity information was available for the less toxic nickel form (i.e., metallic nickel), nickel (metal) was also evaluated in this BRA for the purpose of comparison with the nickel (salts) results.

Beryllium and molybdenum are not believed to be associated with the ANAP processes and therefore are not believed to be COPCs. However, no statistical tests/analyses allowed them to be eliminated from the COPC list for this BRA.

Table 5.5 lists the COPCs (with at least one detected value) for ANAP that could only be evaluated qualitatively in this BRA (i.e., no current EPA-approved SFs or RfDs were available for these analytes). Aluminum and lithium are not expected to have been used in any of the ANAP operations, but they were considered qualitatively in Sect. 5.4 of this BRA.

Table 5.5. COPCs for ANAP that will be evaluated qualitatively[a]

Analyte	Frequency of detection	Representative concentration[b]
	Metals (mg/kg)	
Aluminum	19/19	3.24E+04
Lithium	19/19	2.63E+01

[a] The analytes evaluated qualitatively in this BRA have at least one detected value; however, no approved toxicity values (i.e., slope factors or reference doses) are currently available.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

5.3 EXPOSURE ASSESSMENT

In an exposure assessment, the risk assessor combines information about site characteristics and site-related data with exposure assumptions to determine or estimate the magnitude, frequency, and duration of present and future pathways of potential human exposure to site contaminants. These results are obtained by accomplishing the following tasks:

- characterizing the exposure setting,
- identifying exposure pathways, and
- quantifying exposures.

5.3.1 Characterization of Exposure Setting

Characterization of the exposure setting involves identifying the general physical characteristics of the site (e.g., climate, vegetation, soil types) and the characteristics of the populations on or near the site. This characterization ensures that all potential contaminant migration pathways and potential receptors are evaluated in the risk assessment. Details of the physical and environmental characteristics of the Y-12 Plant and the ANAP site can be found in Chap. 2 of this RI and in the *RCRA Facility Investigation Plan for Group 4 at the Oak Ridge Y-12 Plant* (Energy Systems 1990); a brief discussion follows.

The Y-12 Plant facility consists of ~32 ha (800 acres) and is located along the northeastern boundary of the ORR, adjacent to the city of Oak Ridge. The presence of unauthorized persons at the Y-12 Plant is currently controlled and security precautions currently limit access to the controlled area (exclusion zone/protected area).

ANAP was used to transport waste effluent from uranium recovery process operations from several Y-12 Plant buildings (e.g., Buildings 9206, 9212, and 9215) to the S-3 Ponds. The pipeline is ~4800 ft in length and is buried 0.5-14 ft below ground (at an average depth of 5 ft), and the majority of the pipeline runs through the protected area of the Y-12 Plant. Approximately two-thirds of the pipeline is located in the Dismal Gap formation, and one-third is in the Nolichucky formation.

Because the location of the pipeline is within the operational Y-12 Plant facility, and because the pipeline is buried underground (at a depth from 0.5 to 14 ft), construction workers are the most reasonable and most likely receptors of ANAP soils. Although such a conservative scenario is unlikely, a hypothetical future residential land use scenario was evaluated; children are sensitive subpopulations under the residential scenario.

5.3.2 Identification of Exposure Pathways

Exposure pathways of concern were identified by evaluating all the components (source, transport medium, exposure point, potential receptors, and routes of exposure) necessary to complete the potential exposure pathway. For an exposure pathway to be considered complete, each of these components had to be identified and linked to each of the other components. Routes of exposure and potential receptors were crucial in identifying the validity of an exposure pathway.

In this BRA for ANAP, potential health effects from exposure to soils surrounding ANAP were considered. The potential pathways related to the on-site resident scenario and the on-site construction worker scenario, for exposure to contaminants in the ANAP soil, were evaluated.

To ensure a comprehensive evaluation of the risk to human health from exposure to the soils associated with ANAP and to ensure risk information supportive of project objectives, both the current most reasonable (and most likely) exposure scenario and the future hypothetical reasonable maximum exposure scenario were evaluated. Because the location of the pipeline is within the operational Y-12 Plant facility and because the pipeline is buried underground (at a depth from 0.5 to 14 ft), construction workers are the most reasonable and most likely receptors of ANAP soils. The exposure pathways that were evaluated for the construction worker included incidental ingestion of soil, inhalation of dust, dermal contact with the soil, and external exposure to radionuclides in the soil.

Risks determined for a hypothetical future residential receptor are conservative and unlikely to underestimate exposure to ANAP soils. The four primary and most direct routes/pathways of exposure (dermal contact with the soil, incidental ingestion of the soil, inhalation of dust, and external exposure to radionuclides in the soil) were evaluated. The food chain pathway was not evaluated for ANAP because of the large number of uncertainties and the modeling that would be required for the food chain pathway.

Note: Since the average depth of the pipeline is 5 ft, a resident's exposure to soils would happen if he/she dug to this depth to build a basement to a house and leveled/used the remaining dirt/soil for the yard. The conceptual site model for exposure to ANAP soils for both the construction worker and the hypothetical resident is shown in Fig. 5.1 (with this residential home builder scenario assumed).

5.3.3 Quantification of Exposure

Exposure, in the context of risk posed to human health, is defined as the direct contact of a person with a chemical or physical agent. To quantify exposure, one must determine exposure concentrations and calculate chemical intakes for the various exposure pathways identified for the site. The potential exposure pathways and exposure concentrations for ANAP soils were considered quantitatively and are discussed in this section.

Exposure to contaminants was evaluated quantitatively by developing the chronic daily intake (CDI) of a chemical (also termed "intake" or "dose" for external exposure to radionuclides). For this ANAP BRA, the CDI is the amount of a contaminant that an individual could take into his/her body per day via ingestion, inhalation, or dermal contact; dose was the total exposure to radionuclides. The first consideration in deriving the CDI was the methodology employed in the development of an exposure concentration, which is the amount of each chemical in the various media to which receptors are exposed. To calculate the CDI, the exposure concentration was evaluated in the context of the scenario, exposure pathway, and chemical-specific exposure variables, such as duration of exposure and intake rate. Once the CDIs for the various pathways were determined, risk and HIs were calculated. The quantification of exposure and calculation of the CDI for the hypothetical resident and the construction worker are discussed in Sects. 5.3.3.1 and 5.3.3.2, respectively.

The potential direct exposure pathways associated with the hypothetical on-site residential land use scenario and the construction worker scenario are (1) incidental ingestion of soil, (2) dermal contact with soil, (3) inhalation of dust, and (4) external exposure to the radionuclides in the soil. The representative concentrations of the COPCs (Table 5.4) are the concentrations used to quantify exposures via these soil-related pathways.

Tables 5.6a, b, c, and d and Tables 5.7a, b, c, and d list the exposure variables associated with each exposure route considered for the on-site resident and the on-site construction worker, respectively; the equations used to calculate the CDIs are also given in these tables. The variables used in each exposure equation have been derived from standard intake rates, skin surface areas, and adherence factors (EPA 1989a, 1989b, 1991a, 1991b, 1992a).

5.3.3.1 Derivation of CDIs for the residential scenario

The hypothetical residential exposure scenario considered in this BRA is conservative, especially when the location of the pipeline is considered. As a result of the statistical data evaluation process described in Sect. 5.2, the set of ANAP COPCs (soil concentration data) to be used in this BRA was compiled (Table 5.4). The maximum concentration value, of the UCL95 concentration versus the maximum reported concentration, was assumed to be representative of the analyte concentration (titled "representative concentration" in the

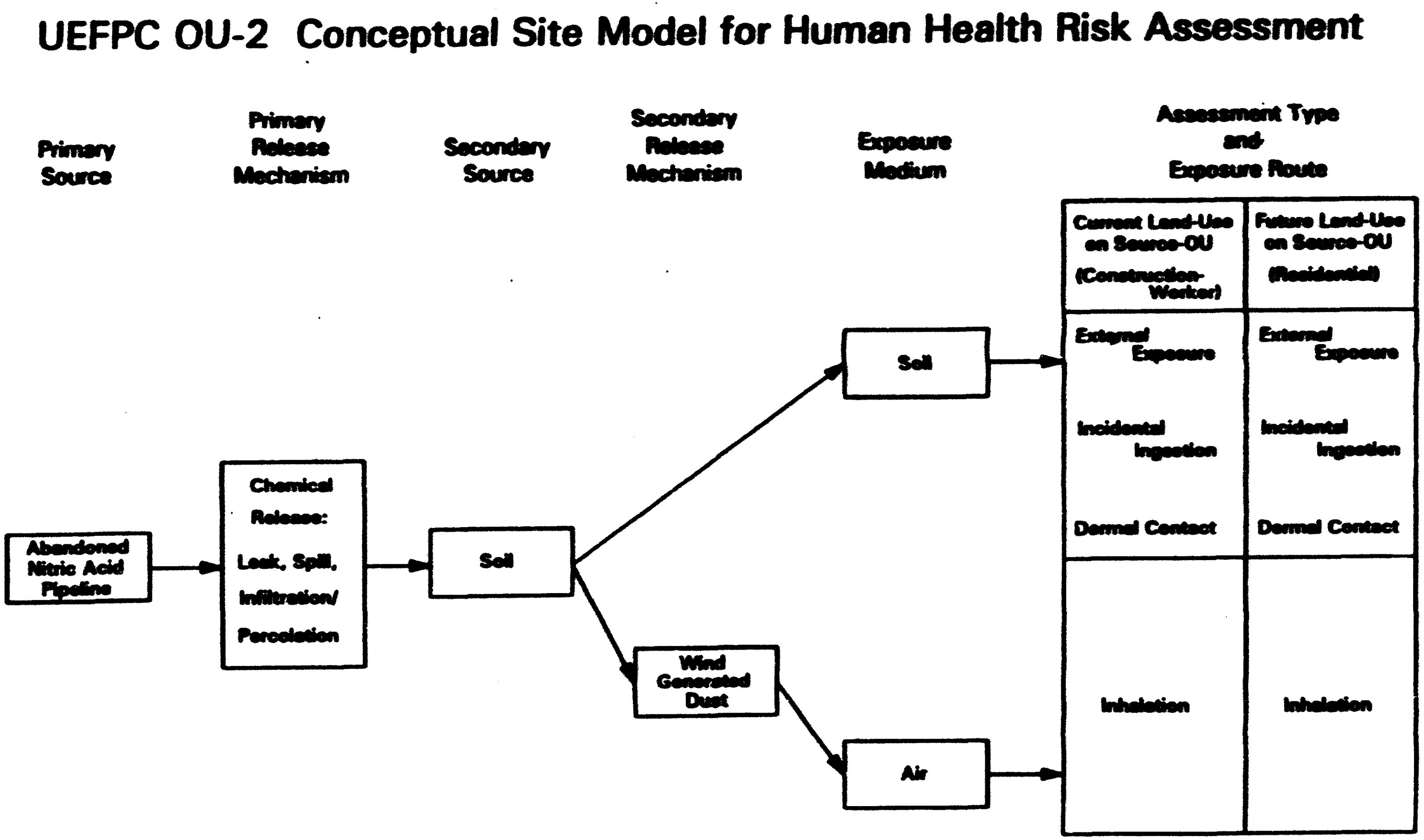


Fig. 5.1. UEFPC source OU 2 conceptual site model for human receptors.

Table 5.6a. On-site resident exposure scenario—ingestion

Variable	Value used	Explanation/source
Residential ingestion scenario		
Chronic daily intake (mg/kg-d) = $[CS \times FI \times EF/AT] \times [(ED_c \times IR_c/BW_c) + (ED_a \times IR_a/BW_a)]$		
Intake (pCi) = $CS \times CF \times EF \times [(ED_c \times IR_c) + (ED_a \times IR_a)]$		
CS = Concentration in soil	Chemical-specific (mg/kg; pCi/g)	Concentration is obtained from the data in Table 5.4
IR_c = Ingestion rate	0.0002 kg/d	Child rate (Sect. 6, RAGS, EPA 1989a)
IR_a	0.0001 kg/d	Adult rate (Sect. 6, RAGS, EPA 1989a)
CF = Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
FI = Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF = Exposure frequency	350 d/year	OSWER Directive 9285.6-03 (EPA 1991b)
ED_c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED_a	24 years	
BW_c = Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW_a	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Table 5.6b. On-site resident exposure scenario—dermal contact

Variable	Value used	Explanation/source
	Residential dermal contact scenario	
Chronic daily intake (mg/kg-d) =	$[CS \times CF \times AF \times ABS \times EF/AT]$ $\times [(SA_c \times ED_c/BW_c) + (SA_a \times ED_a/BW_a)]$	
CS = Concentration in soil	Chemical-specific (mg/kg)	Concentration is obtained from data in Table 5.4
CF = Conversion factors	10^{-6} kg/mg and 10^4 cm^2/m^2	Necessary to convert to appropriate units
SA_c = Available surface area	0.18 m^2/d	50th percentile surface area for head, hands, forearms, and lower legs; for a child
SA_a	0.53 m^2/d	and for an adult, respectively (Dermal Exposure Assessment, EPA 1992a)
AF = Adherence factor	1.00 mg/cm^2	Adherence factor for soil, (EPA Region IV, New Interim Guidance, 2/11/92)
ABS = Absorption factor	0.001 (unitless) 0.01 (unitless)	Equivalent to 0.1% for inorganics and 1.0% for organics (EPA Region IV, New Interim Guidance, 2/11/92)
EF = Exposure frequency	350 d/year	OSWER Directive (EPA 1991b)
ED_c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration
ED_a	24 years	(OSWER Directive, EPA 1991b)
BW_c = Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW_a	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 30 years	Averaging time for noncarcinogens
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a, EPA 1991b)

Table 5.6c. On-site resident exposure scenario—inhalation

Variable	Value used	Explanation/source
Residential inhalation scenario		
Chronic daily intake (mg/kg-d) = $[(CS \times IR \times EF)/(AT \times PEF)] \times [(ED_c/BW_c) + (ED_a/BW_a)]$		
Intake (pCi) = $CS \times CF \times IR \times (1/PEF) \times EF \times [ED_c + ED_a]$		
CS = Concentration in soil	Chemical-specific (mg/kg; pCi/g)	Concentration is obtained from the data in Table 5.4
IR = Inhalation rate	20 m^3/d	OSWER Directive 9285.6-03 (EPA 1991b)
CF = Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
PEF = Particulate emission factor	4.63E+09 m^3/kg	RAGS Part B (EPA 1991a)
EF = Exposure frequency	350 d/year	OSWER Directive 9285.6-03 (EPA 1991b)
ED_c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED_a	24 years	
BW_c = Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW_a	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Table 5.6d. On-site resident exposure scenario—external exposure

Variable	Value used	Explanation/source
Residential external exposure scenario		
Dose (pCi-year/g) = CS × (1-Se) × Te × [ED_c + ED_a]		
CS = Concentration in soil	Chemical-specific (pCi/g)	Concentration is obtained from the data in Table 5.4
ED_c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED_a	24 years	
Se = Gamma shielding factor (unitless)	0.2	RAGS Part B, EPA 1991a; Sect. 4.1.2 (default value)
Te = Gamma exposure time factor (unitless)	1.0	RAGS Part B, EPA 1991a; Sect. 4.1.2 (default value, 24 h/24 h)

Table 5.7a. On-site construction worker exposure scenario—ingestion

Construction worker ingestion scenario

Chronic daily intake (mg/kg-d) = (CS × IR × FI × EF × ED)/(BW × AT)

Intake (pCi) = CS × CF × IR × EF × ED

Variable	Value used	Explanation/source
CS = Concentration in soil	Chemical-specific (mg/kg; pCi/g)	Concentration is obtained from the data in Table 5.4
IR = Ingestion rate	0.00048 kg/d	OSWER Directive 9285.6-03; Attachment B (EPA 1991b)
CF = Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
FI = Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF = Exposure frequency	20.4 d/year	Estimated; 73 d/event and 7 events in 25 years (refer to Sect. 5.3.3.2)
ED = Exposure duration	25 years	(OSWER Directive, EPA 1991b)
BW = Body weight	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 25 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Table 5.7b. On-site construction worker exposure scenario—dermal contact

Construction worker dermal contact scenario

Chronic daily intake (mg/kg-d) = (CS × CF × AF × ABS × SA × EF × ED)/(BW × AT)

Variable	Value used	Explanation/source
CS = Concentration in soil	Chemical-specific (mg/kg)	Concentration is obtained from data in Table 5.4
CF = Conversion factors	10^{-6} kg/mg and 10^{4} cm^2/m^2	Necessary to convert to appropriate units
SA = Available surface area	0.316 m^2/d	50th percentile surface area for head, hands, and forearms; for an adult (Dermal Exposure Assessment, EPA 1992a)
AF = Adherence factor	1.00 mg/cm^2	Adherence factor for soil (EPA Region IV, New Interim Guidance, 2/11/92)
ABS = Absorption factor	0.001 (unitless) 0.01 (unitless)	Equivalent to 0.1% for inorganics and 1.0% for organics (EPA Region IV New Interim Guidance, 2/11/92)
EF = Exposure frequency	20.4 d/year	Estimated; 73 d/event and 7 events in 25 years (refer to Sect. 5.3.3.2)
ED = Exposure duration	25 years	(OSWER Directive, EPA 1991b)
BW = Body weight	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 25 years	Averaging time for noncarcinogens (EPA 1989a, EPA 1991b)
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a, EPA 1991b)

Table 5.7c. On-site construction worker exposure scenario—inhalation

Construction worker inhalation scenario

Chronic daily intake (mg/kg-d) = [CS × IR × (1/PEF) × EF × ED]/(BW × AT)

Intake (pCi) = CS × CF × IR × (1/PEF) × EF × ED

Variable	Value used	Explanation/source
CS = Concentration in soil	Chemical-specific (mg/kg; pCi/g)	Concentration is obtained from the data in Table 5.4
IR = Inhalation rate	29.2 m^3/d	Exposure Factors Handbook (EPA 1989b); 4 h moderate and 4 h heavy activity
CF = Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
PEF = Particulate emission factor	4.63E+09 m^3/kg	RAGS Part B (EPA 1991a)
EF = Exposure frequency	20.4 d/year	Estimated; 73 d/event and 7 events in 25 years (refer to Sect. 5.3.3.2)
ED = Exposure duration	25 years	(OSWER Directive, EPA 1991b)
BW = Body weight	70 kg	Adult (Sect. 6, RAGS, EPA 1989a)
AT = Averaging time	365 d/year × 25 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 d/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Table 5.7d. On-site construction worker exposure scenario—external exposure

Variable	Value used	Explanation/source
	Construction worker external exposure scenario	
	Dose (pCi-year/g) = CS × (1-Se) × Te × ED	
CS = Concentration in soil	Chemical-specific (pCi/g)	Concentration is obtained from the data in Table 5.4
ED = Exposure duration	25 years	(OSWER Directive, EPA 1991b)
Se = Gamma shielding factor (unitless)	0.1	Estimated; RAGS Part B, EPA 1991a; Sect. 4.1.2
Te = Gamma exposure time factor (unitless)	0.33	RAGS Part B, EPA 1991a; Sect. 4.1.2 (8 h/24 h)

tables) and was used in all calculations of the CDI (as well as dose, risk, and HI). This upper confidence limit was used to ensure that the exposure concentrations were not underestimated. Refer to Sect. 5.2 for a complete statistical evaluation of the data and the list of COPCs evaluated quantitatively in this BRA.

Table 5.6 lists the exposure variables associated with each exposure route considered for the on-site residential scenario. For this BRA, CDIs were calculated for an adult person who was exposed for 6 years as a child and for 24 years as an adult (to give a 30-year exposure duration), and the resident was assumed to be exposed to soil contaminants for 350 d/year for 30 years. A 6-year exposure duration was evaluated for the "young child" portion of the person's life, which accounts for receptors with high intake rates relative to body weight. A 24-year exposure duration was assumed for the "adult" portion of the person's life. For example, for the soil ingestion pathway, a child ingestion rate (200 mg/d) and body weight (15 kg) were assumed for 6 years, while an adult ingestion rate (100 mg/d) and body weight (70 kg) were assumed for 24 years.

Table 5.8 lists the CDIs for ingestion, inhalation, and dermal contact with COPCs in the ANAP soil (Table 5.4); doses are listed for external exposure to radionuclides in the ANAP soil. The table is divided by analyte type (i.e., radionuclide, nitrate/nitrite, and metals), and the exposure concentration used in the CDI calculation is termed "representative concentration."

5.3.3.2 Derivation of CDIs for the construction worker scenario

The most likely (and most reasonable) exposure scenario considered in this BRA was the on-site construction worker who could be exposed to the ANAP soils during construction of industrial buildings or during the placement of underground utility lines. In this section, the ANAP COPCs identified in Sect. 5.2 (Table 5.4) were used in the calculation of CDIs, and the UCL95 is assumed to be representative of the analyte concentration.

Table 5.7 lists the exposure variables associated with each exposure route considered for the on-site construction worker scenario. For this BRA, CDIs were calculated for an adult person who would be exposed to soil contaminants for 20.4 d/year for 25 years. The exposure frequency of 20.4 d/year was estimated (by a Y-12 Plant construction project manager) by determining (1) an approximate duration of exposure during construction of a Y-12 Plant building (100 × 250 ft) and (2) the approximate number of buildings that could reasonably be expected to be built along the pipeline.

Several portions of ANAP have been removed for the construction of a new office building, cooling tower basin, control house, pipelines, and security facility. Of the remaining portion of the pipeline, steep slopes prevent building construction. These areas are (1) south of Building 9103; (2) between Buildings 9110 and 9119; (3) between Stations 46+50 and 49+68; and (4) between Stations 26+50 and 29+00.

To be as conservative as possible in estimating the number of large buildings that could be built along the remaining portions of ANAP, it was assumed that temporary buildings; trailers; and several small, heavily constructed (i.e., reinforced concrete) buildings would be demolished in order to provide space for the construction of new buildings. Considering this, a total of seven buildings could conceivably be constructed on the location of ANAP. Assuming assumes that each building would be similar (or smaller) in size to Building 9113

Table 5.8. Chronic daily intakes for ANAP COPCs—residential scenario[a]

Analyte	Representative concentration[b] (pCi/g; mg/kg)	Carcinogenic effects (CDI)[a] Ingestion (pCi; mg/kg-d)	Carcinogenic effects (CDI)[a] Dermal (mg/kg-d)	Carcinogenic effects (CDI)[a] Inhalation of dust (pCi; mg/kg-d)	Carcinogenic effects (CDI)[a] External exposure (pCi-y/g)	Noncarcinogenic effects (CDI)[a] Ingestion (mg/kg-d)	Noncarcinogenic effects (CDI)[a] Dermal (mg/kg-d)	Noncarcinogenic effects (CDI)[a] Inhalation of dust (mg/kg-d)
				Radionuclides				
^{234}U	4.15E+00	5.2E+03	—	1.9E-01	1.0E+02	—	—	—
^{235}U	2.43E-01	3.1E+02	—	1.1E-02	5.8E+00	—	—	—
^{238}U	2.23E+00	2.8E+03	—	1.0E-01	5.4E+01	—	—	—
				Nitrate/Nitrite				
Nitrate[c]	7.19E+00	1.1E-05	2.5E-07	3.2E-10	—	2.6E-05	5.8E-07	7.4E-10
Nitrite[c]	7.19E+00	1.1E-05	2.5E-07	3.2E-10	—	2.6E-05	5.8E-07	7.4E-10
				Metals				
Beryllium	1.22E+00	1.9E-06	4.3E-08	5.4E-11	—	4.5E-06	1.0E-07	1.3E-10
Chromium VI	4.38E+01	6.9E-05	1.5E-06	1.9E-09	—	1.6E-04	3.6E-06	4.5E-09
Molybdenum[c]	3.29E+00	5.2E-06	1.1E-07	1.4E-10	—	1.2E-05	2.7E-07	3.4E-10
Nickel[c]	3.44E+01	5.4E-05	1.2E-06	1.5E-09	—	1.3E-04	2.8E-06	3.5E-09
Nickel (salts)[c]	3.44E+01	5.4E-05	1.2E-06	1.5E-09	—	1.3E-04	2.8E-06	3.5E-09

[a] For radionuclides, the units for chronic daily intake are pCi for the ingestion and inhalation pathways, and the units are pCi-y/g for the external exposure pathway. For all other analytes, the units for chronic daily intake are mg/kg-d for the ingestion, dermal, and inhalation pathways.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[c] CDIs for carcinogenic effects of these analytes are given because HEAST/IRIS (EPA 1993b, 1993c) lists them as NA (i.e., no data available or data inconclusive) under the EPA classification.

(100 × 250 ft) and that one new utility crossing would be necessary for each building constructed, a conservative estimate of construction worker exposure is 73 d/event (event = construction of one building).

A conservative estimate for worker exposure to ANAP soils during construction of a 100 × 250 ft building is 68 d, from excavation and grading for the foundation to installing the first floor steel frame. An estimate for exposure to ANAP soils during typical underground utility construction is ~5 d, from trench excavation to utility installation and testing. To be conservative, if one assumes that all 7 buildings were constructed within 25 years (the default exposure duration for a worker) and the receptor (construction worker) was exposed to the ANAP soils during construction of all the buildings, the exposure per year would be 20.4 d [(73 d/event × 7 events)/25 years = 20.4 d/year].

Table 5.9 lists CDIs for ingestion, inhalation, and dermal contact with COPCs in the ANAP soils (Table 5.4); doses are listed for external exposure to radionuclides in the ANAP soil. The tables are divided by analyte type (i.e., radionuclide, nitrate/nitrite, and metals), and the exposure concentration used in the CDI calculation is termed "representative concentration."

5.3.4 Identification of Uncertainties

Some uncertainties are associated with the exposure pathway equations, exposure parameters (Tables 5.6 and 5.7), land use, and sampling and analysis of the ANAP soils. As discussed previously, two land-use scenarios were chosen in order to get an upper and a lower bound on the risks/HIs to human receptors. For the four primary exposure pathways chosen for analysis in this BRA, numerous exposure parameters were used in the calculations that each have uncertainty (EPA 1989a) associated with them. Most exposure parameters are conservative and therefore err on the conservative side (i.e., protecting the receptor). There are uncertainties associated with the inhalation of dust pathway; although EPA-approved default values were used in the inhalation pathway CDI calculations, modeling results were used in developing these default parameters (EPA 1989a, 1991a).

5.3.5 Summary of Exposure Assessment

Two land-use scenarios were evaluated for this BRA: a conservative hypothetical residential future land use and a more likely current exposure scenario of a construction worker. Both land uses were evaluated to ensure a comprehensive evaluation of the risk posed to human health from exposure to the soils associated with ANAP and to provide risk information supportive of project objectives.

For both the construction worker and the residential scenarios, the four primary and most direct routes/pathways of exposure that were evaluated included incidental ingestion of soil, inhalation of dust, dermal contact with the soil, and external exposure to radionuclides in ANAP soils. Because of the location of the pipeline and because of the large number of uncertainties and modeling associated with the food chain pathways, the evaluation of the biouptake/food chain pathways for ANAP soils was not considered.

Table 5.9. Chronic daily intakes for ANAP COPCs—construction worker scenario[a]

Analyte	Representative concentration[b] (pCi/g; mg/kg)	Carcinogenic effects (CDI)[a]: Ingestion (pCi; mg/kg-d)	Carcinogenic effects (CDI)[a]: Dermal (mg/kg-d)	Carcinogenic effects (CDI)[a]: Inhalation of dust (pCi; mg/kg-d)	Carcinogenic effects (CDI)[a]: External exposure (pCi-y/g)	Noncarcinogenic effects (CDI)[a]: Ingestion (mg/kg-d)	Noncarcinogenic effects (CDI)[a]: Dermal (mg/kg-d)	Noncarcinogenic effects (CDI)[a]: Inhalation of dust (mg/kg-d)
Radionuclides								
^{234}U	4.15E+00	1.0E+03	—	1.3E-02	3.1E+01	—	—	—
^{235}U	2.43E-01	6.0E+01	—	7.8E-04	1.8E+00	—	—	—
^{238}U	2.23E+00	5.5E+02	—	7.2E-03	1.7E+01	—	—	—
Nitrate/Nitrite								
Nitrate[c]	7.19E+00	9.9E-07	6.5E-09	1.3E-11	—	2.8E-06	1.8E-08	3.6E-11
Nitrite[c]	7.19E+00	9.9E-07	6.5E-09	1.3E-11	—	2.8E-06	1.8E-08	3.6E-11
Metals								
Beryllium	1.22E+00	1.7E-07	1.1E-09	2.2E-12	—	4.7E-07	3.1E-09	6.2E-12
Chromium VI	4.38E+01	6.0E-06	4.0E-08	7.9E-11	—	1.7E-05	1.1E-07	2.2E-10
Molybdenum[c]	3.29E+00	4.5E-07	3.0E-09	5.9E-12	—	1.3E-06	8.3E-09	1.7E-11
Nickel[c]	3.44E+01	4.7E-06	3.1E-08	6.2E-11	—	1.3E-05	8.7E-08	1.7E-10
Nickel (salts)[c]	3.44E+01	4.7E-06	3.1E-08	6.2E-11	—	1.3E-05	8.7E-08	1.7E-10

[a] For radionuclides, the units for chronic daily intake are pCi for the ingestion and inhalation pathways, and the units are pCi-y/g for the external exposure pathway. For all other analytes, the units for chronic daily intake are mg/kg-d for the ingestion, dermal, and inhalation pathways.

[b] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[c] CDIs for carcinogenic effects of these analytes are given because HEAST/IRIS (EPA 1993b, 1993c) lists them as NA (i.e., no data available or data inconclusive) under the EPA classification.

5.4 TOXICITY ASSESSMENT

5.4.1 Toxicity Information and EPA Guidance for Noncarcinogens

Noncarcinogenic effects were evaluated by comparing an exposure experienced over a specified time period (e.g., 30 years) with an RfD [or reference concentration (RfC)] derived for a similar exposure period. The RfDs available for the COPCs present in ANAP soils are given in Table 5.10. To evaluate the noncarcinogenic effects from exposure to COPCs in ANAP soil, the HI [the ratio of the exposure dose (i.e., CDI and/or dose from Tables 5.8 and 5.9) to the RfD] was calculated for each COPC. This noncarcinogenic HI assumes that, below a given level of exposure (i.e., the RfD), even sensitive populations are unlikely to experience adverse health effects. If the exposure level (CDI) exceeds this threshold (i.e., if CDI/RfD exceeds 1.0), there may be concern for potential systemic health effects. The level of concern does not necessarily increase linearly as the HI approaches or exceeds unity; the HI is not a percentage or probability.

Chronic RfDs were developed for protection from long-term exposure to a chemical (7 years to a lifetime); subchronic RfDs were used to evaluate short-term exposure (2 weeks to 7 years) (EPA 1989a). Note that the numerical values derived for chronic and subchronic RfDs/RfCs are often identical, as is the case for the ANAP COPCs, with the exception of nitrate, for which no subchronic RfD was available (EPA 1993b, 1993c). For the purposes of this BRA, chronic RfDs were used for the assessment of the on-site resident and construction worker. Although the exposure for the on-site construction worker is short [20.4 d/year × 25 years = 510 d (or 1.4 years)], to be conservative, the chronic RfDs were used because subchronic RfDs were not available for all COPCs.

5.4.2 Toxicity Information and EPA Guidance for Carcinogens

For carcinogens, risks were estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen (i.e., the term "incremental" refers to excess individual lifetime cancer risk). Cancer risk from exposure to contamination is expressed as excess cancer risk (i.e., cancer incurred in addition to normally expected rates of cancer development). An excess cancer risk of 1.0E-06 indicates one person in one million is predicted to incur cancer from exposure to this contamination level over a 70-year lifetime. Based on their property of emitting ionizing radiation, all radionuclides are human carcinogens.

To evaluate the carcinogenic risk posed by exposure to ANAP COPCs in soil, the risk was calculated for each COPC [the multiplication of the exposure dose (i.e., CDI and/or dose from Tables 5.8 and 5.9) by the SF, which is a chemical-specific value based on carcinogenic dose-response data]. Excess cancer risks falling between 1.0E-06 and 1.0E-04 are within the EPA range of concern, and cancer risks above 1.0E-04 are considered unacceptable by the EPA (1989a). Because the SFs are the upper 95% confidence limit on the probability of a carcinogenic response, the carcinogenic risk estimate represents an upper confidence bound estimate. Therefore, there is only a 5% probability that the actual risk will be higher than the estimate presented, and the actual risk may well be less than the estimate. Slope factors used in the evaluation of risk posed by exposure to ANAP COPCs are listed in Tables 5.11 and 5.12.

Table 5.10. Toxicity information for the ANAP noncarcinogenic COPCs

Chemical	Chronic oral RfD[a,b] (mg/kg-d)	Confidence level[a]	%GI[c] absorp.	%GI source	Chronic oral RfD absorbed[d] (mg/kg-d)	Chronic inhale. RfD	RfD basis (vehicle)	Critical effect	Uncertainty factor[a]; modifying factor
					Inorganics				
Beryllium	5.0E-03[a]	Low	5	—	2.5E-04	ND[e]	intra-tracheal	reduced weight	UF=100; MF=1
Chromium VI	5.0E-03[a]	Low	10.6	[f]	5.3E-04	ND	oral (water)	hepatotoxicity, nephrotoxicity, dermatitis	UF=500; MF=1
Molybdenum	5.0E-03[a]	Medium	ND	—	5.0E-03	ND	oral	swelling, gout-like symptoms	UF=30; MF=1
Nickel	2.0E-02[a]	ND	ND	—	2.0E-02	ND	oral	reduced weight	UF=100[f]; MF=3[f]
Nickel (salts)	2.0E-02[h]	Medium	5	[i]	1.0E-03	ND	oral	reduced weight	UF=300; MF=1
Nitrate	1.6E+00	High	ND	—	1.6E+00	ND	ND	—	UF=1;MF=1
Nitrite	1.0E-01	High	ND	—	1.0E-01	ND	oral (water)	methemoglobinemia	UF=1;MF=10

[a] Based on Integrated Risk Information System (IRIS) (EPA 1993b).
[b] Based on Health Effects Assessment Summary Tables (HEAST) (EPA 1993c).
[c] GI = Gastrointestinal (%GI = percent gastrointestinal absorption).
[d] The chronic and subchronic RfD for nickel salts were assigned the same RfD value as nickel metals.
[e] ND = No data available or data inconclusive.
[f] ATSDR 1987–1990.
[g] The absorbed RfD = (RfD × %GI absorption); the absorbed RfD is used for dermal pathway calculations. RfD absorbed = RfD (i.e, %GI = 100) when the %GI absorption value is unknown (ND) and when the %GI is greater than 80.
[h] BEIAS 1993.
[i] Owen 1990.

Table 5.11. Toxicity information for the ANAP carcinogenic COPCs

Chemical	Oral slope factor[a]	Inhalation slope factor[a]	EPA class[b]	ICRP lung class[c]	Type of cancer	SF basis/ SF source[d]
Inorganics [$(\text{mg/kg-d})^{-1}$]						
Beryllium	4.3E+00[d] 8.6E+01[e]	8.4E+00	B2	—	tumors	Intratracheal/ IRIS/HEAST
Chromium VI	ND[f]	4.1E+01	A	—	tumors	IRIS/HEAST
Molybdenum	ND	ND	ND	—	ND	ND
Nickel	ND	ND	ND	—	ND	ND
Nickel (salts)	ND	ND	ND	—	ND	ND
Nitrate	ND	ND	ND	—	ND	ND
Nitrite	ND	ND	ND	—	ND	ND
Radionuclides [$(\text{pCi})^{-1}$]						
^{234}U	1.6E-11	2.6E-08	A	Y	various	HEAST
^{235}U	1.6E-11	2.5E-08	A	Y	various	HEAST
^{238}U	2.8E-11	5.2E-08	A	Y	various	HEAST

[a] The radionuclide oral and inhalation slope factors include contributions from daughter products.

[b] The EPA Weight of Evidence Classification System for Carcinogenicity was used to characterize the extent to which available data indicate that an agent is a human carcinogen: A = human carcinogen; B1 or B2 = probable human carcinogen (B1 indicates that limited data on humans are available and B2 indicates sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen; D = not classifiable as to human carcinogenicity; E = evidence of noncarcinogenicity for humans.

[c] This is the lung clearance classification recommended by the International Commission on Radiological Protection: Y = year; W = week; D = day; G = gas.

[d] Based on Integrated Risk Information System (IRIS) (EPA 1993b) or Health Effects Assessment Summary Tables (HEAST) (Radionuclides—EPA 1992b; Inorganics—EPA 1993c), and oral (ingestion) slope factors. The oral SF for beryllium can be found in IRIS (EPA 1993b).

[e] The absorbed slope factor (8.6E+01) is used for the dermal contact pathway calculations; the absorbed SF = (SF/%GI); the % gastrointestinal absorption (%GI) is 5% for beryllium (Owen 1990).

[f] ND = No data available or data inconclusive.

5.4.3 Estimation of Toxicity Values for Dermal Exposure

Oral RfDs and SFs are often adjusted for evaluation of the dermal exposure pathway (EPA 1989a). It is conservative, in terms of risk/HI to human health, to adjust the toxicity values in the manner described in the following discussion. Most RfDs/SFs are expressed as the amount of substance administered per time and body weight; however, dermal exposure to chemicals in soil and water is expressed as absorbed doses.

Table 5.12. Toxicity information for external exposure to the ANAP radionuclide COPCs

Chemical	External exposure slope factor[a,b] (g/pCi-y)	ICRP lung class[c]	Type of cancer
	Radionuclides		
^{234}U	3.0E-11	Y	Various
^{235}U	2.4E-07	Y	Various
^{238}U	3.6E-08	Y	Various

[a] These factors are based on the Health Effects Assessment Summary Tables (HEAST) (EPA 1992b).

[b] The radionuclide external exposure slope factors include contributions from daughter products.

[c] This is the lung clearance classification recommended by the International Commission on Radiological Protection (ICRP). Y = year; W = week; D = day; and G = gas.

For the dermal assessments in this BRA, the oral RfD/SF for each chemical (ANAP COPCs) was adjusted by the percent gastrointestinal absorption efficiency (%GI) for that chemical. The %GI was known for only a limited number of chemicals. For those chemicals where a %GI was not available in the literature, 100% was assumed. For many chemicals, estimates of %GI were based on qualitative information on the rate and extent of GI absorption; rapid or extensive absorption was assumed to be essentially complete (i.e., %GI = 100%). Wide ranges of %GI values were found for some chemicals and in the absence of chemical-specific absorption data, estimates were made based on data for related chemical structures. Most organic compounds are readily absorbed (i.e., %GI =100) from the GI tract; for this BRA, no adjustments were made to chemicals with %GI ≥80%.

Minor adjustments to the oral RfDs/SFs (used in the dermal assessments only), which favor conservatism, were made for this BRA. The oral RfD was multiplied by the %GI/100, and the SF was divided by the %GI/100 to give the absorbed dose RfD and absorbed dose SF, respectively. These toxicity values (listed in Tables 5.10 and 5.11) were then used in the evaluation of risk posed to human health from exposure to ANAP soils via dermal contact.

5.4.4 Chemicals Without EPA Toxicity Values

Slope factors and RfDs were not available for all known chemicals because their carcinogenicity and/or noncarcinogenic effects have not yet been determined. These chemicals may contribute to carcinogenic and noncarcinogenic effects from exposure to the ANAP soil, but their effect could not be quantified. Furthermore, several chemicals are not indicated by epidemiological studies to be carcinogenic; consequently, these species do not have SFs. A qualitative summary of toxicity information for COPCs (Tables 5.4 and 5.5) for the ANAP soils can be found in Sect. 5.4.6.

5.4.5 Uncertainties Related to Toxicity Information

The methodology used in developing a noncarcinogenic toxicity value (RfD or RfC) involved identifying a threshold level below which adverse health effects would not occur. The RfD/RfC values were generally based on studies of the most sensitive animal species tested and the most sensitive endpoint measured (unless adequate human health data were available). From these studies, the experimental exposure representing the highest dose level tested at which no adverse effects were demonstrated [the no-observed-adverse-effect-level (NOAEL)] was derived; in some cases, only a lowest-observed-adverse-effect-level (LOAEL) was available. The RfD/RfC was derived from the NOAEL (or LOAEL) for the critical toxic effect by dividing the NOAEL (or LOAEL) by uncertainty factors. These factors usually were in multiples of 10, with each factor representing a specific area of uncertainty in the extrapolation of the data. An uncertainty factor of 100 was typically used when extrapolating animal studies to humans; additional uncertainty factors are sometimes necessary when other experimental data limitations are found. Because of the large uncertainties (10–10,000) on some RfD/RfC toxicity values, calculating exact/sharp safe levels of exposure for humans was not possible.

A two-part evaluation took place in the assessment of the carcinogenic potential of a chemical: (1) an evaluation of the likelihood that a chemical is a carcinogen (i.e., a weight-of-evidence assessment) and (2) an evaluation of the quantitative dose-response relationship (i.e., potency factor or SF); uncertainties occured with each evaluation. Based on weight-of-evidence studies using human and laboratory animal research, chemicals fell into one of five groups (EPA 1989a, 1993c): (1) Group A, human carcinogen; (2) Group B, probable human carcinogen; (3) Group C, possible human carcinogen; (4) Group D, not classified as to human carcinogenicity; and (5) Group E, evidence of no carcinogenic effects to humans. The SF for a chemical was a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime; it was derived by applying a mathematical model to extrapolate from a relatively high administered dose (to animals) to the lower exposure levels expected for humans. The SF represents the upper 95% CL on the linear component of the slope of the tumorigenic dose-response curve in the low-dose region. A number of low-dose extrapolation models have been developed, and EPA generally uses the linearized multistage model in the absence of adequate information to support other models.

5.4.6 Summary of Toxicity Information/Profiles for COPCs in ANAP Soils

The purpose of any toxicity assessment is to evaluate the potential for COPCs to cause adverse health effects in exposed individuals. This usually consists of an evaluation of the relationship between the extent of exposure to a particular contaminant and the increased likelihood or severity of adverse health effects as a result of that exposure relative to a baseline. The toxicity assessment generally involves two steps. The first step comprises determining whether exposure to an agent can cause an increase in the incidence of a particular health effect and whether that health effect will occur in humans. The second step involves characterizing the relationship between the received dose of the contaminant and the incidence of adverse health effects in exposed populations.

The chemical-specific information in Sects. 5.4.6.1 and 5.4.6.2 provides general qualitative information as well as a chemical-specific discussion about health effects related to those COPCs evaluated in this BRA. Carcinogenic and noncarcinogenic health effects were considered. Data used in this section are from human and laboratory animal research and from occupational studies to characterize likely health effects resulting from exposure to the COPCs. Refer to the *ORNL/HASRD/BEIAS Toxicity Profiles* report for additional information regarding specific chemicals. Tables 5.10 through 5.12 summarize the toxicity information for the ANAP COPCs.

5.4.6.1 Inorganics

Aluminum. Aluminum is found in abundance in the earth but in small amounts in plant and animal tissue. It can be found in tap water because aluminum sulfate is used in the water purification process and not all the aluminum is filtered out. Aluminum is added to most table salt to prevent caking. It is used in certain antacids. Aluminum is also used in foil, deodorants, baking powder, as an emulsifier in some processed cheeses, and as a bleaching agent to whiten flour (Garrison and Somer 1985). In addition, aluminum has been shown to be suitable for food containers since it is practically insoluble and is not harmful to health when dissolved to a slight degree.

Aluminum is a trace mineral in the human body, but it can be dangerous, even fatal if consumed in excessive amounts. Aluminum has no established function in human nutrition. It weakens the living tissue of the alimentary canal (i.e., the digestive tube from the mouth to the anus). Many of aluminum's harmful effects result from its destruction of vitamins. It binds with many other substances and is never found alone in nature (Dunne 1990).

Aluminum is easily absorbed by the body and is accumulated in the arteries. Highest concentrations are found in the lungs, liver, thyroid, and brain. Usually most of the aluminum taken into the body is ultimately excreted. However, excessive amounts of aluminum can result in symptoms of poisoning including nausea, skin ailments, colic, loss of appetite, excessive perspiration, and loss of energy (Dunne 1990). In addition, aluminum toxicity has been implicated in brain disorders associated with aging, such as Alzheimer's Disease (Garrison and Somer 1985); however, this theory has not been proven.

Beryllium. Pure beryllium is a hard, grayish metal that is present in the earth's crust. It can be found in emissions from coal combustion; in surface water and soil; and in house dust, food, drinking water, and cigarette smoke. Industry employs beryllium in several ways, including in brake systems for airplanes, for neutron monochromatization, as window material for X-ray tubes, and in radiation detectors. Additionally, beryllium compounds are used in manufacturing ceramics and refractories, chemical reagents, and gas mantle hardeners. The highest risk for exposure to beryllium occurs among workers employed in beryllium manufacturing, fabricating, or reclaiming industries. However, people who live near these industries and who are sensitive to extremely low concentrations of beryllium in the air are also at risk. In addition, smokers inhale unusually high concentrations of beryllium, depending on the source of tobacco.

A limited amount of data indicates that the oral toxicity of beryllium is low; however, the inhaled toxicity of beryllium is well documented. Humans inhaling massive doses of beryllium compounds may develop acute berylliosis. Additionally, beryllium and its compounds are presumed to have cancer-causing potential in the human lung when inhaled. The cancer-causing ability has been investigated in workers exposed to beryllium. The degree of harm depends on the amount and duration of exposure. Short-term exposure to beryllium may cause noncarcinogenic health effects, such as acute pneumonitis berylliosis, while long-term exposure may cause lung cancer (ATSDR 1988).

Chromium and Chromium VI. Elemental chromium does not occur in nature but is present in ores—primarily chromite. Chromium exhibits several oxidation states, but the most prominent of these is chromium VI and chromium III. Chromium VI in the environment is man-made as a result of industrial emissions; in solution, chromium VI exists as hydrochromate, chromate, and dichromate ionic species and reacts over time to form chromium III. Chromium VI is much more mobile and toxic than is chromium III. Chromium is useful in glucose and cholesterol metabolism and therefore is an essential element to humans and animals. Nonoccupational exposure to the metal occurs via the ingestion of chromium-containing food and water, whereas occupational exposure occurs via inhalation. Workers are exposed to chromium during its use in the production of dichromate; in the chemical, stainless steel, refractory, and chromium-plating industries; and in the production and use of alloys (BEIAS 1993).

Chromium enters the body through the lungs; gastrointestinal tract; and, to a lesser extent, the skin. Inhalation is the most important route for occupational exposure. Workers exposed to chromium have developed nasal irritation, nasal ulcers, perforation of the nasal septum, and hypersensitivity reactions and "chrome holes" of the skin. Among the general population, contact dermatitis has been associated with the use of bleaches and detergents. Inhalation of chromium compounds has been associated with the development of cancer in workers in the chromate industry. Evidence also suggests an increased risk in developing nasal, pharyngeal, and gastrointestinal carcinomas. Based on sufficient evidence reporting that humans and animals are at risk of developing cancer, chromium VI has been assigned an EPA weight-of-evidence classification of A, human carcinogen (BEIAS 1993).

Lithium. Lithium is found in many minerals and most rocks throughout the earth's crust. Lithium is found in higher concentrations in sedimentary deposits such as clay and shales. Many natural bodies of water contain significant quantities of lithium. It is the lightest solid element and forms ionic salts and covalent bonds producing organolithium compounds. These properties make lithium chemistry of considerable commercial interest. Lithium is used in high energy batteries, organic synthesis, lubricants, lightweight alloys, high temperature heat sinks, and regulator rods in nuclear reactors. Lithium has a high affinity toward oxygen and sulfur and thereby is used as an impurity scavenger during the production of copper and steel. Lithium oxides are used as carbon dioxide absorbents in submarines and spacecraft (Seiler and Helmut 1988).

Lithium and its salts pose little threat from an industrial standpoint. Lithium hydroxide is the most hazardous lithium compound in industrial use. Lithium hydride is of special interest because it produces hydrogen on contact with water. Lithium hydroxide is corrosive, irritating to the respiratory system, and toxic to the skin, causing severe burns. Animal toxicity studies of lithium salts show no symptoms that can be directly identified as lithium-specific (Klassen, Amdur, and Doull 1986).

Lithium is also of medical importance. Natural hot springs were thought to be therapeutic because of their lithium content. Lithium salts were then prescribed for a wide variety of disorders. This view changed in the 1940s when a lithium salt substitute (lithium chloride) for heart patients led to a number of deaths resulting from lithium intoxication. After much investigation into the medical use of the element, lithium carbonate was administered to persons with recurrent affective disorders (typically depression). Because these disorders require long-term treatment, lithium levels must be monitored closely to prevent toxic buildup. Lithium carbonate is now widely used, with divided doses up to 1 g/d.

Toxicity may be caused by psychological changes or dietary changes. Initial and early symptoms are nausea, fine tremor, thirst, fatigue, lethargy, and electrocardiograph changes (T-wave inversion). Long-term effects include hypothyroidism, leukocytosis, edema, and weight gain. Signs of imminent toxicity are vomiting, coarse tremors, slurred speech, and vertigo followed by loss of consciousness, seizures, kidney damages, coma, cardiac arrhythmia, and death. Neurologically depressed infants have been born to pregnant women taking lithium. Nursing infants need to be monitored for lithium toxicity as lithium in breast milk can be excreted from 30% to 100% of maternal intake (Arena 1986).

Molybdenum. Molybdenum is considered an essential trace element that occurs naturally in various ores, the most important being molybdenite, which is converted to molybdenum trioxide for use in ferro- and manganese alloys, chemicals, catalysts, ceramics, and pigments. Metallic molybdenum is used in electronic parts, induction heating elements, and electrodes (BEIAS 1993).

Data documenting molybdenum toxicity in humans are limited. Mild cases of molybdenosis may be clinically identifiable only by biochemical changes such as increased uric acid levels. Excessive intake of molybdenum causes a physiological copper deficiency, and conversely, in cases of inadequate dietary intake of copper, molybdenum toxicity may occur at lower exposure levels. Oral toxicity data and inhalation toxicity data for molybdenum exposure on humans are unavailable, as is information on the oral or inhalation carcinogenicity of molybdenum compounds in humans (BEIAS 1993).

Nickel and Nickel Salts. Nickel is a naturally occurring metal existing in various mineral forms. Nickel may be found throughout the environment including rivers, lakes, oceans, soil, air, drinking water, plants, and animals. Soil and sediment are the primary receptacles for nickel but mobilization may occur depending on physicochemical characteristics of the soil. Nickel is used in a wide variety of metallurgical processes such as electroplating and alloy production, as well as in nickel-cadmium batteries. Some evidence suggests that nickel may be an essential trace element for mammals. As for most metals, the toxicity of nickel is dependent on the route of exposure and the solubility of the nickel compound (BEIAS 1993).

Pulmonary absorption is the major route of concern for nickel-induced toxicity. Toxic effects of oral exposure to nickel usually involve the kidneys with some evidence from animal studies showing a possible development/reproductive toxicity effect. Inhalation exposure to some nickel compounds will cause toxic effects in the respiratory tract and immune system. Asthmatic conditions have also been documented for inhalation exposure to nickel. In addition, sensitivity reactions to nickel are well documented and usually involve contact dermatitis reactions resulting from contact with items such as cooking utensils, jewelry, coins, etc., containing nickel. Epidemiologic studies have shown that occupational inhalation exposure to nickel dust (primarily nickel subsulfide) at refineries has resulted in increased incidence of pulmonary and nasal cancer (BEIAS 1993).

Nitrate/Nitrite. Nitrates occur naturally in soil, water, air, and plant material. The levels of nitrates in soil and water can be increased with the use of commercial nitrogenous fertilizers and the subsequent return of waste from grazing animals. Nitrates find their way into crops in amounts based on the genetic character of the species. Spinach, carrots, and beets contain relatively high levels of nitrates. Environmental and land-management practices also play a roll in nitrate uptake. Nitrogen compounds contained in industrial waste can also be converted to nitrates by the nitrogen cycle and contaminate soil and surface water (WHO 1978).

Nitrites are formed by the action of bacteria during the formation of nitrates. Concentrations in plant, soil, and water are usually low. During storage of vegetables at room temperature, bacteria can convert nitrates to nitrites at high levels (3600 mg/kg) (WHO 1978). Nitrite levels in food are allowed to be 0.01%. Nitrates and nitrites are extensively used to prevent growth of toxic-producing bacteria in meat. *Clostridium botulinum* is one of the bacteria of concern because it causes botulism.

The health risk to humans is based on clinical and epidemiological studies. The main toxic effect of nitrate/nitrite exposure is due to ingestion, causing development of methemoglobinemia (irreversible bonding of oxygen to hemoglobin). Health risks are related to high levels in drinking water and food. In healthy adults, the intake of nitrates and nitrites is harmless. Infants are the most vulnerable group. Intestinal bacteria, such as *Bacillus subtilis*, reduce nitrates to nitrites. Intestinally absorbed nitrite reacts with hemoglobin to form methemoglobin which is converted to oxyhemoglobin by NADH-methemoglobin reductase. However, this enzyme pathway is not developed in infants. Microbes in the infant's intestinal system or food may convert nitrates to nitrites causing methemoglobinemia. The most common way for infants to be exposed to high levels of nitrates is by reconstituting dry milk formula with contaminated water or by feeding infants vegetables stored at room temperature. Nitrate levels of 50 ppm in well water may cause methemoglobin in infants. Nitrates and nitrites in healthy adults are quickly filtered out by the kidneys. Other toxic reactions are vasodilation, loss of blood pressure, cyanosis, vomiting, coma, respiratory failure, and death (Arena 1974).

5.4.6.2 Radionuclides

Radionuclides are unstable atoms of chemical elements that will emit charged particles to achieve a more stable state. These charged particles are termed "alpha and beta radiation" and "neutral gamma rays." Interaction of these charged particles (and gamma rays) with matter will produce ionization events, or radiation, which may cause living cell tissue damage. Because the deposition of energy by ionizing radiation is a random process, sufficient energy may be deposited (in a critical volume) within a cell and result in cell modification or death (ICRP 1991). In addition, ionizing radiation has sufficient energy that interactions with matter will produce an ejected electron and a positively charged ion (known as free radicals) that are highly reactive and may combine with other elements, or compounds within a cell, to produce toxins or otherwise disrupt the overall chemical balance of the cell (EPA 1991c). These free radicals can also react with deoxyribonucleic acid (DNA), causing genetic damage, cancer induction, or even cell death.

Radionuclides are characterized by the type and energy level of the radiation emitted. Radiation emissions fall into two major categories: (1) particulate (electrons, alpha particles, beta particles, and protons) and (2) electromagnetic radiation (gamma and X-rays) (ASTDR 1989a). Therefore, all radionuclides are classified by the EPA as Group A carcinogens based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of humans with cancers induced by high doses of radiation. Alpha particles are emitted at a characteristic energy level for differing radionuclides. The alpha particle has a charge of +2 and a comparably large size. Alpha particles have the ability to react (and/or ionize) with other molecules, but they have very little penetrating power and lack the ability to pass through a piece of paper or human skin. However, alpha-emitting radionuclides are of concern when there is a potential for inhalation or ingestion of the radionuclide. Alpha particles are directly ionizing and deposit their energy in dense concentrations [termed high linear energy transfer (LET)], resulting in short paths of highly localized ionization reactions. The probability of cell damage increases as a result of the increase in ionization events occurring in smaller areas; this may also be the reason for increased cancer incidence caused by inhalation of radon gas. In addition, the cancer incidence in smokers may be directly attributed to the naturally occurring alpha emitter, ^{210}P, in common tobacco products (Hammonds and Hoffman 1992).

Beta emissions generally refer to beta negative particle emissions. Radionuclides with an excess of neutrons achieve stability by beta decay. Beta radiation, like alpha radiation, is directly ionizing but, unlike alpha activity, beta particles deposit their energy along a longer track length (low-LET), resulting in more space between ionization events (Hammonds and Hoffman 1992). Beta-emitting radionuclides can cause injury to the skin and superficial body tissue but are most destructive when inhaled or ingested. Many beta emitters are similar chemically to naturally occurring essential nutrients and will therefore tend to accumulate in certain specific tissues. For example, ^{90}Sr is chemically similar to calcium and, as a result, accumulates in the bones, where it causes continuous exposure. The health effects of beta particle emissions depend on the target organ. Those seeking the bones would cause a prolonged exposure to the bone marrow and affect blood cell formation, possibly resulting in leukemia, other blood disorders, or bone cancers. Those seeking the liver would result in liver diseases or cancer, while those seeking the thyroid would cause thyroid and metabolic disorders. In addition, beta radiation may lead to damage of genetic material (DNA), causing hereditary defects.

Gamma emissions are the energy that has been released from transformations of the atomic nucleus. Gamma emitters and X-rays behave similarly but differ in their origin: gamma emissions originate in nuclear transformations, and X-rays result from changes in the orbiting electron structure. Radionuclides that emit gamma radiation can induce internal and external effects. Gamma rays have high penetrating ability in living tissue and are capable of reaching all internal body organs. Without such sufficient shielding as lead, concrete, or steel, gamma radiation can penetrate the body from the outside and does not require ingestion or inhalation to penetrate sensitive organs. Gamma rays are characterized as low-LET radiation, as is beta radiation; however, the behavior of beta radiation differs from that of gamma radiation in that beta particles deposit most of their energy in the medium through which they pass, while gamma rays often escape the medium because of higher energies, thereby creating difficulties in determining actual internal exposure. For this reason, direct whole-body measurements are necessary to detect gamma radiation, while urine/fecal analyses are usually effective in detecting beta radiation (Hammonds and Hoffman 1992).

People receive gamma radiation continuously from naturally occurring radioactive decay processes going on in the earth's surface, from radiation naturally occurring inside their bodies, from the atmosphere as fallout from nuclear testing or explosions, and from space or cosmic sources. Cesium-137 (from nuclear fallout) decays to ^{137}Ba, the highest contributor to fallout-induced gamma radiation (NCRP 1977). Beta radiation from the soil is a less penetrating form of radiation but has many contributing sources. Potassium-40, ^{137}Cs, ^{214}Pb, and ^{214}Bi are among the most common environmental beta emitters. Tritium is also a beta emitter but contributes little to the soil beta radiation because of the low energy of its emission and its low concentration in the atmosphere (NCRP 1977). Alpha radiation is also emitted by the soil but is not measurable more than a few centimeters from the ground surface. The majority of alpha emissions are attributable to ^{222}Rn and ^{220}Rn and their decay products (NCRP 1977). This contributes to what is called background exposure to radiation (ATSDR 1989a).

The general health effects of radiation can be divided into stochastic (related to dose) and nonstochastic (not related to dose) effects. The risk of development of cancer from exposure to radiation is a stochastic effect. Examples of nonstochastic effects include acute radiation syndrome and cataract formation, which occur only at high levels of exposures (Killough and Eckerman 1983).

Radiation can damage cells in different ways. It can cause damage to DNA within the cell, and the cell either may not be able to recover from this type of damage or may survive but function abnormally. If an abnormally functioning cell divides and reproduces, a tumor or mutation in the tissue may develop. The rapidly dividing cells that line the intestines and stomach and the blood cells in bone marrow are extremely sensitive to this damage. Organ damage results from the damage caused to the individual cells. This type of damage has been reported with doses of 10 to 500 rad (0.1 to 5.0 gray, in SI units). Acute radiation sickness is seen only after doses of >50 rad (0.5 gray), which is a dose rate usually achieved only in a nuclear accident (ATSDR 1989a).

When the radiation-damaged cells are reproductive cells, genetic damage can occur in the offspring of the person exposed. The developing fetus is especially sensitive to radiation. The type of malformation that may occur is related to the stage of fetal development and the cells that are differentiating at the time of exposure. Radiation damage to children exposed in the womb is related to the dose the pregnant mother receives. Mental retardation is a possible effect of fetal radiation exposure (ATSDR 1989a).

The most widely studied population that has had known exposure to radiation is the atomic bomb survivors of Hiroshima and Nagasaki, Japan. Data indicate an increase in the rate of leukemia and cancers in this population. However, the rate at which cancer incidence is significantly affected by low radiation exposures, such as results of exposure to natural background and industrially contaminated sites, is still undergoing study and is uncertain (Hammonds and Hoffman 1992). In studies conducted to determine the rate of cancer and leukemia increase, as well as genetic defects, several radionuclides must be considered.

Uranium-234, -235, -238. Naturally occurring uranium is a lustrous, silver-colored, radioactive, malleable, and ductile metal. Uranium is almost exclusively used as a fuel for nuclear energy; however, it can be used in pigments, ceramics, and photographic chemical processes. The three naturally occurring isotopes of uranium are ^{238}U (>99%), ^{235}U (about 0.72%), and ^{234}U (0.06%). The half-lives of ^{234}U, ^{235}U, and ^{238}U are 2.4E+05 years, 7.0E+07 years, and 4.5E+09 years, respectively. The average concentration of uranium in the earth's crust is between 2 and 4 ppm. Some ores contain more concentrated uranium deposits. These deposits are mined and then the percentage of ^{235}U is increased by an enrichment process. The enriched ^{235}U is more radioactive and of great use as a nuclear reactor fuel or weapon component.

Alpha, beta, and gamma radiation are emitted during the decay of uranium. Loss of alpha particles can give rise to other radioactive elements such as ^{230}Th, ^{226}Ra, ^{222}Rn, and ^{218}Po. Radon is a significant daughter isotope because it is colorless and odorless and, as a gas, can leak into basements or foundations. Significant exposure by inhalation of radon gas can occur unknowingly. Deposition of radon and its daughters onto the lungs exposes them to alpha radiation, increasing the probability of cancer. Radium has been known to produce bone sarcomas in radium dial painters resulting in death. The final decay for ^{238}U and ^{234}U is stable ^{206}Pb, and the final decay for ^{235}U is stable ^{207}Pb (ATSDR 1990).

Uranium may be released into the air by natural processes such as volcanic eruption or resuspension of soil. The combustion of fossil fuels is a potential contamination route. Coal and shale oils have varying levels of uranium depending on ore location. Subsequent burning can concentrate the levels of uranium. Groundwater and surface water releases of uranium are primarily caused by the disposal of uranium mining waste, disposal of nuclear reactor waste, and reactor emissions. Soil naturally contains uranium, but levels may be concentrated by the addition of mining waste and nuclear facility waste. Carrots, potatoes, and other root vegetables contain higher levels of uranium than leafy vegetables. Higher levels of uranium have also been found in cattle that graze near nuclear facilities (ATSDR 1989b).

Concentrated uranium is a highly toxic element both chemically and radiologically. Kidney damage is the primary toxic effect of uranium. Chemical exposure to uranium may cause dermatitis, weight loss, acute necrotic arterial lesions, and possibly liver damage (Sanders 1986). Spontaneous ignition of finely divided uranium at room temperature is a dangerous physical property. Radiological effects are more prominent if uranium is inhaled and subsequently absorbed in the blood stream. Radioactivity in natural uranium is quite low and exists in food, water, and even in human bones. However, exposure to enriched uranium may cause damage to somatic cells resulting in tumors or cause damage to reproductive cells, affecting the next generation. Higher incidences of lung cancer have been observed in uranium mine workers. Exposure to radionuclides with greater specific-activity and a shorter half-life increases the risk for developing cancer (ATSDR 1989b).

5.5 RISK CHARACTERIZATION

The purpose of the risk characterization step of the BRA was to integrate and summarize the information presented in the exposure and toxicity assessments, and it was the final step in the human health risk assessment process. Potential carcinogenic effects were characterized by estimating the probability that an individual would develop cancer over a lifetime from projected intakes (and exposure) and chemical-specific dose-response data (i.e., SFs). Potential noncarcinogenic (systemic) effects were characterized by comparing projected intakes of contaminants to toxicity values (i.e., RfDs). The numerical risk/HI estimates that are presented in this section must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and with the data upon which the risk estimates are based. (Refer to Sects. 5.2, 5.3.4, 5.4.5, and 5.5.5.)

5.5.1 General Considerations for Evaluating Risks to Human Health

The inorganic analytes listed in the tables in this chapter include chromium VI, nickel, and nickel salts. The analytical laboratory reported detected concentrations for *total* chromium and *total* nickel found. Because the concentrations were reported in this form (i.e., no distinction between valences and speciation), it was necessary to assess all types of these analytes, which included the most toxic form of the metals (for example, chromium VI and nickel salts).

The RfD (and concentration) for nickel salts was assumed to be the same as that for metallic nickel; both nickel and nickel salts were evaluated in terms of systemic effects. The total pathway HIs included only one HI value for the pair (i.e., nickel and nickel salts); the most conservative HI values were included in the total pathway HIs (i.e., HIs for nickel salts were included in the pathway totals) to ensure that exposure was not underestimated.

In addition, the analytical laboratory reported concentrations for nitrate/nitrite. Because different RfDs were available for nitrate and nitrite, these analytes were evaluated separately in this BRA; the reported nitrate/nitrite concentration was used for each analyte (i.e., for nitrate and for nitrite). However, the total pathway HIs include only contributions from the most conservative HI (i.e., only the nitrite HIs were included in the total pathway HIs).

5.5.1.1 Methodology for evaluating carcinogens and noncarcinogens

Screening indices (SI) (i.e., risks and HIs) for carcinogens and noncarcinogens, respectively, were calculated for the ANAP COPCs. These SI are based on EPA-approved or -suggested SFs and RfDs. The SF is based on an estimate of the lifetime risk of an incremental cancer incidence per unit of exposure, and the RfD is a level of exposure (threshold) to noncarcinogens below which no adverse health effects are expected to occur.

The SI (risk estimate) for carcinogens was calculated by multiplying the EPA-approved SFs for inorganics, organics, and radionuclides by an estimate of the actual exposure to these contaminants (CDI and/or dose) via external exposure, ingestion, inhalation, or dermal contact. This SI was calculated to indicate the potential of developing excess cancer over a lifetime (EPA 1989a), above and beyond the normal (unavoidable) incidence of developing cancer.

The SI (or HI) for noncarcinogens was calculated by determining the ratio of the CDI for ingestion, inhalation, and dermal contact of a contaminant to the contaminant-specific RfD. This HI assumes that below a given level of exposure (i.e., the RfD) populations are unlikely to experience adverse health effects. Throughout this BRA, the HI represents the CDI/RfD ratio (this ratio is sometimes referred to as a hazard quotient); the "total pathway HI" is the sum of the individual analyte HIs for a pathway.

To estimate the potential risk posed to human health from all contaminants in a particular pathway, the SIs were summed for all contaminants in that pathway (i.e., a cumulative risk). Total pathway risk or total pathway HI was determined from exposure to all contaminants (EPA 1989a). In addition, an overall cumulative risk can be determined by summing the risks from all analytes from all the pathways; summations were conducted separately for carcinogens and noncarcinogens.

5.5.1.2 EPA guidance for carcinogens and noncarcinogens

The constituents detected in ANAP soil samples were evaluated within the context of EPA-approved guidelines (EPA 1989a) for contaminated soils in which there are three regions of concern for carcinogenic risk (risk <1.0E-06, no concern; risk between 1.0E-06 and 1.0E-04, range of concern; and risk ≥1.0E-04, unacceptable) and two areas of concern in terms of systemic risk (HI <1.0, no concern, and HI ≥1.0, concern).

5.5.2 Current Land-Use Conditions—Construction Worker Scenario

5.5.2.1 Carcinogenic risk characterization for the ANAP COPCs

Table 5.13 lists the risk estimates for the exposure of a construction worker to ANAP soil COPCs. The risks for individual analytes (for any pathway) are ≤7.2E-07. The total pathway risks (i.e., the sum of the risks from all analytes in a given pathway) are all ≤1.0E-06, and the total cumulative risk (i.e., the sum of the risks from all analytes across all pathways) is 1.9E-06. The analytes and pathways of exposure that are the main contributors to the total cumulative risk are ^{235}U and ^{238}U (external exposure) and beryllium (ingestion).

Upon comparison of the ANAP COPCs with background soil data (Energy Systems 1993c) (Sect. 5.2.3.7), ^{238}U was found to be below background concentrations on the ORR. (Refer to Appendix F, Table F.5a.) However, because uranium isotopes are known to be related to the ANAP site operations, they were included as COPCs to be evaluated quantitatively in this BRA.

5.5.2.2 Noncarcinogenic risk characterization for the ANAP COPCs

Table 5.14 lists the HI estimates for the exposure of a construction worker to ANAP soil COPCs. The HIs for individual analytes are far less than the EPA guidance of 1.0. The total pathway HIs (i.e., the sum of the HIs from all analytes in that pathway) are also all less than the EPA-guidance of 1.0. The total cumulative HI (i.e., the sum of the HIs from all analytes across all pathways) is 4.7E-03.

5.5.3 Future Land-Use Conditions—Residential Scenario

5.5.3.1 Carcinogenic risk characterization for the ANAP COPCs

Table 5.15 lists the risk estimates for the exposure of a resident to ANAP soil COPCs. The risks for individual analytes are ≤8.2E-06. The total pathway risks (i.e., the sum of the risks from all analytes in that pathway) are all ≤8.4E-06; and the total cumulative risk (i.e., the sum of the risks from all analytes across all pathways) is 1.5E-05. The analytes and pathways of exposure that are the main contributors to the total cumulative risk are ^{235}U and ^{238}U (external exposure) and beryllium (ingestion and dermal contact); these analytes are identified as COCs.

Upon comparison of the ANAP COPCs with background soil data (Energy Systems 1993c) (Sect. 5.2.3.7), ^{238}U was found to be below background concentrations on the ORR. (Refer to Appendix F, Table F.5a.) However, because uranium isotopes are known to be related to the ANAP site operations, they were included as COPCs to be evaluated quantitatively in this BRA. In addition, beryllium is not believed to be associated with site processes, but no statistical tests/analyses, including comparison with background, allowed it to be eliminated from the COPCs list for this BRA.

5.5.3.2 Noncarcinogenic risk characterization for the ANAP COPCs

Table 5.16 lists the HI estimates for the exposure of a resident to the ANAP soil COPCs. The HIs for individual analytes are less than the EPA guidance of 1.0. The total pathway HIs (i.e., the sum of the HIs from all analytes in that pathway) are also all less than the EPA

Table 5.13. Carcinogenic risks for ANAP COPCs—construction worker scenario

Analyte	Representative concentration[a] (pCi/g; mg/kg)	Ingestion risk	Dermal risk	Inhalation risk	External exposure risk	Total risk across all pathways[b]
			Radionuclides			
^{234}U	4.15E+00	1.6E-08	—	3.5E-10	9.3E-10	1.8E-08
^{235}U	2.43E-01	9.5E-10	—	2.0E-11	4.4E-07	4.4E-07
^{238}U	2.23E+00	1.5E-08	—	3.7E-10	6.0E-07	6.2E-07
			Nitrate/Nitrite			
Nitrate	7.19E+00	—	—	—	—	—
Nitrite	7.19E+00	—	—	—	—	—
			Metals			
Beryllium	1.22E+00	7.2E-07	9.5E-08	1.9E-11	—	8.2E-07
Chromium VI	4.38E+01	—	—	3.2E-09	—	3.2E-09
Molybdenum	3.29E+00	—	—	—	—	—
Nickel	3.44E+01	—	—	—	—	—
Nickel (salts)	3.44E+01	—	—	—	—	—
Total pathway risk[c]		7.5E-07	9.5E-08	4.0E-09	1.0E-06	1.9E-06[d]

[a] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[b] The total risk across all pathways is the sum of the ingestion risk, dermal risk, inhalation risk, and external exposure risk for each analyte.

[c] The total pathway risk is the sum of the risks from all analytes for each pathway.

[d] This value is the sum of all risk calculations (i.e., the sum of the risks from all analytes across all pathways).

Table 5.14. Hazard indices for ANAP COPCs—construction worker scenario

Analyte	Representative concentration[a] (pCi/g; mg/kg)	Ingestion HI	Dermal HI	Inhalation HI[b]	Total HI across all pathways[c]
		Radionuclides			
^{234}U	4.15E+00	–	–	–	–
^{235}U	2.43E-01	–	–	–	–
^{238}U	2.23E+00	–	–	–	–
		Nitrate/Nitrite			
Nitrate	7.19E+00	1.7E-06	1.1E-08	–	1.7E-06
Nitrite	7.19E+00	2.8E-05	1.8E-07	–	2.8E-05
		Metals			
Beryllium	1.22E+00	9.4E-05	1.2E-05	–	1.1E-04
Chromium VI	4.38E+01	3.4E-03	2.1E-04	–	3.6E-03
Molybdenum	3.29E+00	2.5E-04	1.7E-06	–	2.5E-04
Nickel	3.44E+01	6.6E-04	4.4E-06	–	6.7E-04
Nickel (salts)	3.44E+01	6.6E-04	8.7E-05	–	7.5E-04
Total pathway HI [d,e]		4.4E-03	3.1E-04	–	4.7E-03[f]

[a] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[b] No data are available for inhalation RfCs; consequently, there were no HIs determined for the inhalation pathway.

[c] The total HI across all pathways is the sum of the ingestion HI, dermal HI, and inhalation HI for each analyte.

[d] The total pathway HI value does not include contributions from nitrate and nickel.

[e] The total pathway HI is the sum of the HIs from all analytes for each pathway.

[f] This value is the sum of all HI calculations (i.e., the sum of all HIs from all analytes across all pathways); this value does not include contributions for nitrate and nickel.

Table 5.15. Carcinogenic risks for ANAP COPCs—residential scenario

Analyte	Representative concentration[a] (pCi/g; mg/kg)	Ingestion risk	Dermal risk	Inhalation risk	External exposure risk	Total risk across all pathways[b]
			Radionuclides			
^{234}U	4.15E+00	8.4E-08	—	4.9E-09	3.0E-09	9.1E-08
^{235}U	2.43E-01	4.9E-09	—	2.8E-10	1.4E-06	1.4E-06
^{238}U	2.23E+00	7.9E-08	—	5.3E-09	1.9E-06	2.0E-06
			Nitrate/Nitrite			
Nitrate	7.19E+00	—	—	—	—	—
Nitrite	7.19E+00	—	—	—	—	—
			Metals			
Beryllium	1.22E+00	8.2E-06	3.7E-06	4.5E-10	—	1.2E-05
Chromium VI	4.38E+01	—	—	7.9E-08	—	7.9E-08
Molybdenum	3.29E+00	—	—	—	—	—
Nickel	3.44E+01	—	—	—	—	—
Nickel (salts)	3.44E+01	—	—	—	—	—
Total pathway risk[c]		8.4E-06	3.7E-06	9.0E-08	3.3E-06	1.5E-05[d]

[a] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[b] The total risk across all pathways is the sum of the ingestion risk, dermal risk, inhalation risk, and external exposure risk for each analyte.

[c] The total pathway risk is the sum of the risks from all analytes for each pathway.

[d] This value is the sum of all risk calculations (i.e., the sum of the risks from all analytes across all pathways).

Table 5.16. Hazard indices for ANAP COPCs—residential scenario

Analyte	Representative concentration[a] (pCi/g; mg/kg)	Ingestion HI	Dermal HI	Inhalation HI[b]	Total HI across all pathways[c]
		Radionuclides			
^{234}U	4.15E+00	–	–	–	–
^{235}U	2.43E-01	–	–	–	–
^{238}U	2.23E+00	–	–	–	–
		Nitrate/Nitrite			
Nitrate	7.19E+00	1.6E-05	3.7E-07	–	1.7E-05
Nitrite	7.19E+00	2.6E-04	5.8E-06	–	2.7E-04
		Metals			
Beryllium	1.22E+00	8.9E-04	4.0E-04	–	1.3E-03
Chromium VI	4.38E+01	3.2E-02	6.7E-03	–	3.9E-02
Molybdenum	3.29E+00	2.4E-03	5.4E-05	–	2.5E-03
Nickel	3.44E+01	6.3E-03	1.4E-04	–	6.4E-03
Nickel (salts)	3.44E+01	6.3E-03	2.8E-03	–	9.1E-03
Total pathway HI[d,e]		4.2E-02	1.0E-02	–	5.2E-02[f]

[a] The representative concentration is the smaller of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean; units are pCi/g for radionuclides and mg/kg for all other analytes.

[b] No data are available for inhalation RfCs; consequently, there were no HIs determined for the inhalation pathway.

[c] The total HI across all pathways is the sum of the ingestion HI, dermal HI, and inhalation HI for each analyte.

[d] The total pathway HI value does not include contributions from nitrate and nickel.

[e] The total pathway HI is the sum of the HIs from all analytes for each pathway.

[f] This value is the sum of all HI calculations (i.e., the sum of all HIs from all analytes across all pathways); this value does not include contributions from nitrate and nickel.

guidance of 1.0. The total cumulative HI (i.e., the sum of the HIs from all analytes across all pathways) is 5.2E-02; therefore, no COCs were identified here.

5.5.4 Risk Characterization Summary

The results of the evaluation of carcinogenic risk (Tables 5.13 and 5.15) and HI (i.e., systemic toxicity) (Tables 5.14 and 5.16) for the ANAP COPCs show no unacceptable (EPA 1989a) risks posed to human health via ingestion, inhalation, dermal contact, nor external exposure to radionuclides in ANAP soils, under either the construction worker or the residential land- use scenarios.

Uranium-235, ^{238}U (external exposure pathway), and beryllium (incidental ingestion of soil pathway) were identified as showing the highest carcinogenic risks. However, even under the conservative residential land-use scenario, individual risks were ≤8.2E-06 for these three COCs. All HI values were very low; the total cumulative HI was 5.2E-02 under the most conservative residential land-use scenario. Note that the ^{238}U median concentration was below background ^{238}U concentrations found on the ORR.

In summary, the total cumulative pathway risk estimates (i.e., the sum of the risks from all analytes across all pathways) for the carcinogenic ANAP COPCs were 1.9E-06 and 1.5E-05 for the construction worker and residential scenarios, respectively. The total cumulative pathway HI estimates for the noncarcinogenic ANAP COPCs were 4.7E-03 and 5.2E-02 for the construction worker and residential scenarios, respectively.

5.5.5 Uncertainty Analysis and Assumptions

Risk assessment as a scientific activity is subject to uncertainty (Table 5.17), although the methodology used in this BRA follows EPA guidelines. The risk evaluation described in this report is also subject to uncertainty pertaining to sampling and analysis, exposure assessment estimations, and availability of toxicological data.

The major assumptions used in this risk assessment were the follwoing: (1) that contaminant concentrations detected and reported by the analytical laboratory are representative of true analyte concentrations in soils (i.e., the analyte concentration remains constant over the sampling and analysis time period); (2) that the intake rates and exposure parameters are representative of actual potentially exposed populations; and (3) that all contaminant exposure and intake are from the site-related exposure media (i.e., no other sources contribute to the receptor's health risk).

Even if these assumptions are true, other areas of uncertainty could apply. The toxicological data (SFs and RfDs) are frequently updated and revised, which can lead to over- or underestimation of risks. These values are often extrapolations from animals to humans, which also induces uncertainties in toxicity values; differences may exist in chemical absorption, metabolism, excretion, and toxic response between animals and humans. EPA takes into account differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize these uncertainties. Other uncertainties associated with toxicological and exposure assessments are discussed in Sects. 5.3.4 and 5.4.5.

For each exposure pathway, assumptions were made about the parameters (e.g., exposure frequency and duration), the routes of exposure, the amount of the contaminated media an

Table 5.17. General uncertainty factors in risk assessment

Uncertainty factor	Effect of uncertainty	Comment
Use of cancer slope factors	May overestimate risks	Slopes are upper 95~~th~~ % confidence limits derived from the linearized model; considered unlikely to underestimate true risk
Risks/doses within an exposure route assumed to be additive	May over- or underestimate risks	Does not account for synergism or antagonism
Toxicity values derived primarily from animal studies	May over- or underestimate risks	Extrapolation from animal to humans may induce error due to differences in pharmacokinetics, target organs, and population variability
Toxicity values derived primarily from high doses; most exposures are at low doses	May over- or underestimate risks	Assumes linearity at low doses; tends to have conservative exposure assumptions
Toxicity values	May over- or underestimate risks	Not all values represent the same degree of certainty; all are subject to change as new evidence becomes available
Effect of absorption	May over- or underestimate risks	The assumption that absorption is equivalent across species is implicit in the derivation of the critical toxicity values; absorption may actually vary with species and age
Effect of applying critical toxicity values to soil exposures	May overestimate risks	Assumes bioavailability of contaminants sorbed onto soils is the same as detected in lab studies; contaminants detected in studies may be more bioavailable
Exposures assumed constant over time	May over- or underestimate risks	Does not account for environmental fate, transport, or transfer that may alter concentration
Metal analysis for total metals only	May overestimate risks	Did not distinguish between valences or speciation; assumed the metal was present in its most toxic form
Not all chemicals at the site have toxicity values	May underestimate risks	These chemicals are not addressed quantitatively
Exposure assumptions	May over- or underestimate risks	Assumptions regarding media intake, population characteristics, and exposure patterns may not characterize exposures

individual could be exposed to, and intake rates for different routes of exposure. In the absence of site-specific data, the assumptions used in this BRA are consistent with EPA guidance (EPA 1989a, 1989b, 1991a, 1991b, 1992a). However, the residential scenario was a conservative exposure estimate with EPA-approved parameters (and default values) that may substantially overestimate the risks. Many exposure variables/parameters recommended by EPA for the residential scenario represent 90th and 95th percentile values. When several of these upper bound values are combined in estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile exposure and, therefore, outside the range that may be reasonably expected.

The risk of increased cancer incidence from exposure to low-level radiation was estimated by application of a risk factor to either the radiation dose or the radionuclide intake. Regardless of the type of risk factor used, the same basic uncertainties remain. These uncertainties are related to the model used for determining the health effects of radiation exposure. The model most frequently used for determining risk of radiation exposure is the linear nonthreshold model, which assumes there is some increased risk for any increment of radiation exposure with no threshold below which effects are not seen. This is the most conservative model for evaluating radiation risk; it uses data from high-dose radiation exposures (such as from the survivors of the atomic bomb) and extrapolates risk from these high exposures to the low-level environment or occupational dose range. The current EPA-recommended radiation risk factors are based on the 1980 National Academy of Sciences Biological Effects of Ionizing Radiation Committee report (BEIR III 1980). The BEIR III recommendations were increased slightly by EPA to reflect recent information on the health effects of exposure to ionizing radiation. In early 1990, the National Academy of Sciences published the results of the most recent studies of the health effects of ionizing radiation, the BEIR V report, which increases the estimates of cancer risk by a factor of 3 to 5 over the BEIR III report. These increases are based primarily on a re-evaluation of the doses received by the atomic bomb victims.

The quality of the analytical data used in a risk assessment depends on the adequacy of the set of procedures that specify how samples were selected and handled (Energy Systems 1993b). Uncertainties associated with the data can include sampling errors, laboratory analysis errors, and data analysis errors. Energy Systems QA/QC procedures (Kimbrough, Long, and McMahon 1990) were used to minimize these uncertainties, which are expected to have a low effect on either overestimating or underestimating the risks.

The more extensive the data base, the more certain are the results of the assessment. The number of soil samples collected to represent ANAP contamination (19 soil samples, all of which were analyzed for inorganics and uranium isotopes and 3 of which were analyzed for organics) was relatively small, and it is unknown how representative the samples are of the entire pipeline. According to EPA guidance (EPA 1992c), a minimum of 20 samples are required to provide consistent estimates of the mean. In calculating the representative concentrations for each ANAP COPC, the UCL95 was used as a conservative estimate of the concentration to minimize the likelihood that exposures would be underestimated; the use of this assumption could have moderately overestimated the risks.

As mentioned previously, in the analyses for metals (total metals only), risks could be overestimated because the metals that are present were conservatively assumed to be in their most toxic forms. Furthermore, not all the ANAP COPCs (Table 5.5) currently have toxicity values; this can lead to an underestimation of total risk because a quantitative analysis of such chemicals was not possible.

In addition, some current analytical methods are limited in their ability to achieve detection limits that are appropriate for use in a risk assessment. Therefore, risks may be overestimated as a result of analyte concentrations being reported at the method detection limit, which may be greater than the concentration at which adverse health effects would occur.

Furthermore, in the absence of information on the toxicity of specific chemical mixtures, additive risks and HIs were assumed (EPA 1989a). Limitations of using this approach for the following: (1) the effects of a mixture of chemicals are generally unknown—it is possible that the interactions could be synergistic or antagonistic; (2) the RfD/RfCs have different accuracy and precision and are not based on the same severity or effect; and (3) HI adaptivity (or CDI adaptivity) is most properly applied to compounds that induce the same effects by the same mechanism. Therefore, the potential for occurrence of noncarcinogenic effects can be overestimated for chemicals that act by different mechanisms and on different target organs.

Limitations of using this additive risk approach for multiple carcinogens include these: (1) the SFs represent the upper 95th percentile estimate of potency; therefore, summing individual risks can result in an excessively conservative estimate of total lifetime cancer risk and (2) the target organs of multiple carcinogens may be different, so the risks would not be additive. In the absence of data, adaptivity for risks and HIs was assumed for this BRA. However, because total risks and HIs are usually driven by a few specific chemicals, segregation of risks and HIs by target organ would not have resulted in significantly different outcomes.

5.6 SUMMARY AND CONCLUSIONS

5.6.1 Contaminants of Potential Concern

Table 5.4 lists the ANAP COPCs that were evaluated quantitatively in this BRA. Unacceptable carcinogenic risks (i.e., risks ≥1.0E-04) and/or noncarcinogenic HIs (i.e., HIs ≥1.0) were not found for any of these analytes.

Uranium-235, ^{238}U, and beryllium were identified as showing the highest carcinogenic risks; however, for these three contaminants of concern, even under the conservative residential scenario, individual risks were ≤8.2E-06 (Table 5.15). In addition, upon comparison of the ANAP COPCs with background soil data (Energy Systems 1993c) (Sect. 5.2.3.7), the ^{238}U median concentration was below ^{238}U background concentrations on the ORR (Appendix F, Table F.5a).

All HI values were low; the total cumulative HI was 5.2E-02 under the most conservative residential scenario (Table 5.16).

5.6.2 Exposure Assessment

Two exposure scenarios—a construction worker scenario and a residential scenario—were evaluated in this BRA, and four primary routes of exposure (ingestion, inhalation, dermal contact, and external exposure) were identified and evaluated in terms of CDI, risk, and HI for each scenario.

Because the location of the pipeline is within the operational Y-12 Plant facility and because the pipeline is buried underground (at a depth from 0.5 to 14 ft), a construction worker was evaluated as the most reasonable and most likely receptor of ANAP soils. An upper-bound on the risk to human receptors was evaluated using residential parameters to provide managers with an estimate of potential risks that are conservative and unlikely to underestimate exposure to future receptors of ANAP soils.

For the three ANAP contaminants of concern that were identified as showing the highest carcinogenic risks (i.e., ^{235}U, ^{238}U, and beryllium) (Sect. 5.6.1), risk from the external exposure pathway (for ^{235}U and ^{238}U) and the ingestion and dermal contact pathways (for beryllium) contributed most to the total cumulative carcinogenic risk.

5.6.3 Toxicity Assessment

No ANAP COPCs were identified as having unacceptable carcinogenic and/or systemic effects to human health, i.e., risk ≥1.0E-04 and/or HI ≥1.0 (EPA 1989a). Both qualitative and quantitative toxicity information for each COPC (Tables 5.4 and 5.5) can be found in Sect. 5.4 of this BRA.

5.6.4 Risk Characterization

The results of the carcinogenic risk (Tables 5.13 and 5.15) and systemic toxicity (i.e., HI) (Tables 5.14 and 5.16) assessments for the ANAP COPCs (Table 5.4) show no unacceptable risks to human health via incidental ingestion of soil, inhalation of dust, dermal contact with the soil, or external exposure to radionuclides in ANAP soils, under either the construction worker or the residential land-use scenario. Note: EPA-approved guidelines (EPA 1989a) for contaminated soils have three regions of concern for carcinogenic risk (risk <1.0E-06, no concern; risk between 1.0E-06 and 1.0E-04, range of concern; and risk ≥1.0E-04, unacceptable) and two areas of concern in terms of systemic risk (HI <1.0, no concern, and HI ≥1.0, concern).

In summary, the total cumulative pathway risk estimates (i.e., the sum of the risks from all analytes across all pathways) for the carcinogenic ANAP COPCs were 1.9E-06 and 1.5E-05 for the construction worker and residential scenarios, respectively. Uranium-234 and ^{238}U (external exposure pathway) and beryllium (incidental ingestion of soil pathway) were the main contributors to the risk. Note that the ^{238}U median concentration was below ^{238}U background concentrations on the ORR but was evaluated in this BRA because it was a site-related COPC. Note also that beryllium is not believed to be related to ANAP operations.

The total cumulative pathway HI estimates for the noncarcinogenic ANAP COPCs were 4.7E-03 and 5.2E-02 for the construction worker and residential scenarios, respectively.

6. CONCLUSIONS AND RECOMMENDATIONS

The objective of this investigation was to determine (1) whether ANAP had leaked, (2) if potential contamination problems existed, and (3) what the risk was to human health from exposure to the contaminated soils. Nineteen biased sampling locations (i.e., biased toward likely leakage points) were selected where uranium, nickel, chromium, and leachable nitrogen served as indicators of the leaks; every attempt was made to collect samples from directly beneath the pipeline. The soils encountered during drilling were very tight clays and saprolite, which inhibit fluid migrations. No gravel base was found in any of the 19 locations, suggesting the possibility that the original pipeline was laid directly on the ground.

Historical information (i.e., visible pipeline breakage during construction and large obvious leaks) indicated that ANAP had leaked; however, contaminated soils were removed because of the threat they would pose to repair workers. Undetected leaks would have been small and most likely located at joints in the pipeline; however, the soil surrounding ANAP would have inhibited contaminant flow and kept these small leaks localized. Therefore, finding a leak of this nature (i.e., very small) would be extremely difficult with a drilling rig and would most likely require unearthing a significant portion of ANAP. However, unearthing (i.e., remediating) large sections of ANAP, in order to characterize the pipeline, would have required an enormous amount of public funds at a point when the risk to human receptors was unknown.

Samples were analyzed for metals, nitrate/nitrite, and uranium isotopes; three samples were analyzed for VOCs. Many of the metals, ^{234}U, and ^{238}U were within background levels found on the ORR; hence, they were not within concentrations indicative of pipeline leakage. Nitrate/nitrite concentrations were above background levels but far below health-based action levels. A pipeline leak would probably have resulted in uranium and nitrate/nitrite levels well above health-based action levels; there were no sample analytical results at levels to suggest a pipeline leak.

The results of the baseline human health risk assessment for the ANAP COPCs show no unacceptable risks to human health via incidental ingestion of soil, inhalation of dust, dermal contact with the soil, or external exposure to radionuclides in the ANAP soils. In summary, the total cumulative pathway risk estimates (i.e., the sum of the risks from all analytes across all pathways) for the carcinogenic ANAP COPCs were 1.9E-06 and 1.5E-05 for the construction worker and residential scenarios, respectively. Uranium-235, ^{238}U, and beryllium were identified as showing the highest carcinogenic risks. The total cumulative pathway HI estimates for the noncarcinogenic ANAP COPCs were 4.7E-03 and 5.2E-02 for the construction worker and residential scenarios, respectively.

In conclusion, this investigation did not demonstrate through visual examination, analytical results, or risk evaluation that ANAP had leaked. Major leaks were previously identified and cleaned up, and minor leaks were difficult to find. The surrounding pipeline soils were tight and impermeable; no gravel base was found for ANAP. The risks to human health from exposure to the ANAP soils are below action levels; therefore, the results of this investigation indicate that a low level of contamination does exist for ANAP; these levels are not such that remediation is warranted.

Additional information concerning the pipeline became available since the drafting of the RI report. This information consists of internal correspondence dated October 7, 1987, that was generated due to the removal of a section of pipeline during the construction of the PIDAS corridor. The correspondence includes analytical sample results for three composite soil samples and one water sample. The water sample was collected from fluid inside the pipeline. Appendix G includes a copy of the internal correspondence with the analytical results, a map showing soil sample locations, and pictures of the pipeline. The analytical results help confirm the findings of the ANAP investigation in that the levels of analytes detected do not warrant further remediation activities. The photographs show the pipeline to be in excellent condition and give no indication that pipeline failure had occurred in this location.

7. REFERENCES

Arena, J. M. 1974. *Poisoning: Toxicology, Symptoms, and Treatments*, Charles C. Thomas-Publisher, Springfield, Illinois.

Arena, J. M. 1986. *Poisoning: Toxicology, Symptoms, and Treatments*, 5th Ed., Charles C. Thomas-Publisher, Springfield, Illinois.

ATSDR (Agency for Toxic Substances and Disease Registry), Public Health Services 1987-1990.

ATSDR 1988. *Toxicological Profile for Beryllium*, U.S. Department of Health and Human Services, Public Health Service, Atlanta, Georgia.

ATSDR 1989a. *Toxicological Profile for Plutonium*, U.S. Department of Health and Human Services, Public Health Service, Atlanta, Georgia.

ATSDR 1989b. *Toxicological Profile for Uranium*, Draft, U.S. Department of Health and Human Services, Public Health Service, Atlanta, Georgia.

ATSDR 1990. *Toxicological Profile for Radon*, U.S. Department of Health and Human Services, Public Health Service, Atlanta, Georigia.

BEIAS (Biomedical and Environmental Information Analysis Section) 1993. *Toxicity Profiles for Contaminants of Concern on the Oak Ridge Reservation*, ES/ER/TM-77, Oak Ridge, Tennessee.

BEIR III (Biological Effects of Ionizing Radiation) 1980. National Academy of Sciences Biological Effects of Ionizing Radiation Committee.

DOE (U.S. Department of Energy) 1990. *Environmental Measurement Laboratory Procedures Manual*, 27th Ed., HASL-300.

DOE 1993. *Annual Report on the Background Soil Characterization Project on the Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-1136, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May.

Dunne, L. J. 1990. *Nutrition Almanac*, Third Edition, Nutrition Search, Inc., John D. Kirschmann, Director, McGraw-Hill Publishing Company.

Energy Systems (Martin Marietta Energy Systems, Inc.) 1990. *RCRA Facility Investigation Plan for Group 4 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, ES/ER-10/V1&D2, Oak Ridge, Tennessee, December.

Energy Systems 1991. *Addendum to the RCRA Facility Investigation for the Group 4 Sites, Upper East Fork Poplar Creek Operable Unit 2: Abandoned Nitric Acid Pipeline*, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, November 30.

Energy Systems 1992. *Environmental Restoration Division Quality Assurance Program Plan*, ES/ER/TM-4/R2, Oak Ridge, Tennessee, August.

Energy Systems 1993a. *Annotated Outlines for Documents Required by FFA and CERCLA for Oak Ridge Reservation Sites*, DOE/OR/01-1077, Oak Ridge, Tennessee.

Energy Systems 1993b. *Sampling and Analysis Plan for the Abandoned Nitric Acid Pipeline*, Y/ER-45, Prepared by SAIC for Martin Marietta Energy Systems, Oak Ridge, Tennessee.

Energy Systems 1993c. *Background Soil Characterization Project for the Oak Ridge Reservation*, DOE/OR/01-1174/V1 and V2, Oak Ridge, Tennessee.

Energy Systems 1993d. *Site Characterization Summary of the Abandoned Nitric Acid Pipeline at the Oak Ridge Y-12 Plant*, Y/ER-114, Oak Ridge, Tennessee.

EPA (U.S. Environmental Protection Agency) 1980. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, QAMS-005/80, Washington, D.C.

EPA 1983. *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79/020, March.

EPA 1986. *Test Methods for Evaluating Solid Wastes, 3rd Edition*, SW-846, Office of Solid Waste and Emergency and Remedial Response, Washington, D.C., November.

EPA 1987. *Data Quality Objectives for Remedial Response Activities: Development Process*, EPA 540/G-87/003, OSWER Directive 9355.0-7B, Office of Emergency and Remedial Response, Washington, D.C., March.

EPA 1989a. *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, Washington, D.C.

EPA 1989b. *Exposure Factors Handbook*, EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C.

EPA 1990a. *Guidance for Data Useability in Risk Assessment*, EPA/540/G-90/008, Directive 9285.7-05, October.

EPA 1990b. 40 *CFR* 264, 265, 270, and 271, "Corrective Action Solid Waste Management Units at Hazardous Waste Management Facilities; Proposed Rule," *Federal Register* 55(145), U.S. Government Printing Office, Washington, D.C.

EPA 1990c. *Contract Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration*, OLM.01.8, March.

EPA 1991a. *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, OSWER Directive 9285.7-01B, Washington, D.C.

EPA 1991b. *Human Health Evaluation Manual, Supplemental Guidance*, "Standard Default Exposure Factors," OSWER Directive 9285.6-03, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1991c. *Test Methods for Evaluating Solid Waste*, SW-846, 3rd Ed., Washington, D.C.

EPA 1992a. *Dermal Exposure Assessment: Principles and Applications*, EPA/600/8-91/011B, Washington, D.C.

EPA 1992b. *Health Effects Assessment Summary Tables*, OERR 9200.6-3303(92-8), Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C.

EPA 1992c. *Supplemental Guidance to RAGS: Calculating the Concentration Term*, Intermittent Bulletin 9285-7-081, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1993a. *Integrated Risk Information System, U.S. Environmental Protection Agency On-Line Database of Toxicity Measures*, Office of Research and Development, Environmental Criteria and Assessment Office, Cincinnati, Ohio, Electronic Mail Account Information via TOXNET, National Library of Medicine, Bethesda, Maryland.

EPA 1993b. *Integrated Risk Information System Database*, Office of Research and Development, Washington, D.C.

EPA 1993c. *Health Effects Assessment Summary Tables*, OHEA ECAO-CIN-909, Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C., March.

Garrison, R. H., Jr. and E. Somer 1985. *The Nutrition Desk Reference*, Keats Publishing, Inc., New Canaan, Conneticut.

Hammonds, J. A. and Hoffman 1992. *Toxicity Profiles for Radionuclides*, SENES Oak Ridge Inc. Center for Risk Analysis, Oak Ridge, Tennessee.

ICRP (International Commission on Radiological Protection) 1991. *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication NO. 60, Pergamon Press, Inc., New York.

Killough, G. G. and K. F. Eckerman 1983. "Internal Dosimetry," *Radiological Assessment*, NUREG/CR-3332, ORNL-5966, pp.7-1-7-98, Eds. J.E. Till and H.R. Meyer, U.S. Nuclear Regulatory Commission, Washington, D.C.

Kimbrough, C. W., L. W. Long, and L. W. McMahon 1990. Environmental Surveillance Procedures Quality Control Program, ESH/Sub/87-21706/1, Rev. 1, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

Klassen, C. D., M. O. Amdur, and J. Doull 1986. *Casarett and Doull's Toxicology: The Basic Science of Poisons*, 3rd Ed., Macmillan Publishing Company, New York.

NCRP (National Council on Radiation Protection) 1977. *Environmental Radiation Measurements*, NCRP Report No. 50, Washington, D.C.

Owen, B. A. 1990. "Literature-derived absorption coefficients for 39 chemicals via oral and inhalation routes of exposure," *Regulatory Toxicology and Pharmacology*, Vol. 11, pp. 237-252.

SAIC (Science Applications International Corporation) 1992a. *Field and Laboratory Quality Assurance Project Plans—Abandoned Nitric Acid Pipeline*, Y/ER-44, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, September.

SAIC 1992b. *Final Health and Safety Plan for the Abandoned Nitric Acid Pipeline*, Y/ER-46, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, September.

SAIC 1992c. *Final Mobilization Plan for Abandoned Nitric Acid Pipeline, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, Y/ER-47, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, September.

SAIC 1993. *Final Sampling and Analysis Plan for the Abandoned Nitric Acid Pipeline*, Rev. 2., Y/ER-45, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.

Sanders, C. L. 1986. *Toxicological Aspects of Energy Production*, Macmillan Publishing Company, New York.

Seiler, H. G. and S. Helmut 1988. *Handbook on Toxicity of Inorganic Compounds*, Marcel Dekker, Inc., New York.

Tukey, J. W. 1977. *Exploratory Data Analysis*, Addison-Wesley Publishing Company, Massachusetts.

WHO (World Health Organization) 1978. *Nitrates, Nitrites, and N-nitroso Compounds*, United Nations Environment Program and the World Health Organization, Geneva, Switzerland.

APPENDIX A

ACTION LEVELS FOR URANIUM AND NITRATE ANALYSIS OF SOIL SAMPLES FOR THE ABANDONED NITRIC ACID PIPELINE

ACTION LEVELS
FOR
URANIUM AND NITRATE ANALYSIS
OF
SOIL SAMPLES
FOR
ABANDONED NITRIC ACID PIPELINE

DRAFT FINAL REPORT

SEPTEMBER 11, 1992

Prepared for

Greg Schank

by

Barney Cornaby, Chuck Hadden, and Donna Leydorf
SAIC

1. INTRODUCTION AND SCOPE

A sampling and analysis plan was designed to characterize the potential effluents from an Abandoned Nitric Acid Pipeline (ANAP) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee. This pipeline transported nitric acid and depleted and enriched uranium from operations in Buildings 9206, 9212, and 9215 to the S-3 Pond. The effluent was kept acidic to prevent metals from precipitating out in the pipeline.

Uranium isotopes for radionuclides and leachable nitrogen are proposed as the primary contaminant indicators. In addition, metals and isotopic uranium will be measured. Samples will be field screened for presence of organic chemicals above background. There are 19 sampling points with 3 possible samples per sampling point, or 57 total samples planned along the approximately 5000-ft pipeline. The pipeline is buried one to many feet below the surface of the soil.

During review [letter of April 2, 1992 from C. S. Brown, Remedial Action Manager, EPA Region IV, Atlanta, GA to W. N. Lingle, U.S. Department of Energy (DOE), Oak Ridge, TN] of the sampling and analysis plan by the U.S. Environmental Protection Agency (EPA), the Agency specified the following:

> The action levels (for uranium and nitrate concentration) which may trigger analysis of archived samples (i.e., samples other than the shallower samples at each of the 19 sample locations) shall be provided by DOE and approved by EPA and the TDEC [Tennessee Department of Environment and Conservation], or DOE may opt to analyze all 57 soil samples in lieu of establishing the action levels.

This report addresses this request for action levels.

2. OBJECTIVE

The objective is to provide an action level for uranium and for nitrate in soils at the ANAP location. Each action level will be used to decide whether analysis of additional samples beyond the one per sampling location will be prudent. It is assumed that the first sample to be analyzed is below the pipeline.

3. TECHNICAL PROCEDURE

Action level is defined as a set level/limit that, if deviated from, results in a specified course of action. In this case, the specified course of action is to analyze additional samples at each sampling point up to (57-19) 38 more soil samples.

A three-part procedure was followed:

1. Are there published values that could be used as action levels?
2. In the absence of published values, are there published procedures that could be used to generate action levels?
3. In the absence of published methods, what rationale could be used to provide action levels?

4. FINDINGS

The findings for each of the three steps are provided below:

1. **Are there any published values for uranium and nitrate in soil that could be used as action levels?**

A. Standards Published for Uranium

Published standards for uranium levels in soil appear in the Nuclear Regulatory Commission (NRC's) *Branch Technical Position* published in 46 F.R. 52061 (October 23, 1981). This document established cleanup standards for decontamination and decommissioning of soil. The standards apply to 1) acceptable levels of remediation to release a site from further obligations, and 2) on-site burial criteria. The published standards establish the following levels:

- for natural uranium, 10 pCi/g,
- for depleted uranium, 35 pCi/g, and
- for enriched uranium, 30 pCi/g.

These numbers have not yet been finally promulgated, but the NRC is using them until a final rule is established. Their use was recently ratified by the NRC in the "Action Plan to Insure Timely Cleanup of Site Decommissioning Management Plan Sites," 57 F.R. 13389 (April 16, 1992). Though not finally codified, the NRC deems these standards "sufficient" and continues to use them. Neither a government agency nor a private party has contested the validity of the standards in court, where they would be strengthened if upheld. The NRC is continuing the rule making process to ensure the acceptance of the standards and expects to promulgate a final rule in 10 C.F.R. Part 20 by late 1994 or 1995. (Telephone conversation with Jerry Swift, U.S. Nuclear Regulatory Commission [(301) 504-2609] August 17, 1992).

There are no other known published values for uranium in soil; there are certain published exposure limits. The first comes from DOE Order 5400.5 and states that for all manmade radionuclides the criterion continuous concentration (CCC) is established at 1 rad/day. The second source is in 40 C.F.R. Section 141.16, which states the cumulative maximum safe dose is 4 mrem/year for manmade radionuclides in the domestic water supply. Another published value appears in the Safe Drinking Water Act (SDWA), which sets a maximum contaminant level (MCL) for manmade radionuclides at 4 mrem/year. [Note: A proposed rule published in 56 F.R. 33050 and filed on July 18, 1991, is expected to become final in April, 1993; it draws a distinction between natural uranium and other radionuclides, setting an MCL of 30 μg/L (30 pCi/L). This is contrasted with the limit for naturally occurring uranium, which is 20 μg/L. All other manmade radionuclides will not exceed 4 mrem/year.]

None of these values is deemed appropriate to provide an action level at the Y-12 ANAP.

B. Standards Published for Nitrate

Linda Houlberg, a specialist in compliance regulations with Martin Marietta Energy Systems, was contacted [at (615) 574-7763] about action levels or ARARs for nitrate. She expressed the opinion that the only levels published were the MCLs for nitrate in groundwater. She indicated that it could be used although that standard is not official. She suggested that Andy Benford at the State Division of Superfund [(615) 741-6287] be contacted since Tennessee has recently drafted some standards for soil cleanup. Ms. Houlberg also gave nitrate numbers found in the Integrated Risk Information System (IRIS). The action level for chronic oral exposure to nitrate is 1.60E + 0 mg/kg/day. The same value is given for subchronic exposure to nitrate in the Health Effects Assessment Summary Tables (HEAST). Ms. Houlberg stated that the IRIS is acceptable in the regulatory world, while the HEAST standards are usually used only as a secondary source of authority. In this case, they are identical so the distinction is not important.

Ms. Houlberg also cited 57 F.R. 21450, a proposed rule dated May 20, 1992, which proposed two ways to identify hazardous waste in soil. The first is the Concentration-Based Exemption Criteria (CBEC) standard, but the list included in the Federal Register does not include nitrate in its total of 200 chemicals. The second method expands the existing list of hazardous chemicals but again does not include nitrate.

Andy Benford of the Tennessee Division of Superfund [(615) 741-6287] was contacted. He stated that the draft rule Tennessee recently filed contains cleanup standards for soil and covers the chemicals present on 90 percent of Superfund sites within the state. He stated that nitrate was not a chemical of concern on these sites and was not deemed of sufficient concern to be put on the state list. He was unaware of any standard at the federal level that would apply to nitrate in soil. Mr. Benford also referred SAIC to the CBEC method which uses a two-tier approach to a specific chemical. First, it examines ingestion by a child with a 10^{-5} (with a cap on the number at 1,000 ppm) or; second, if the TCLP extractable concentration is less than 10 times MCL, the contaminate would not require remediation. (There is no TCLP level given for nitrate so the second method could not apply.)

The only published limits on nitrates appear in the EPA Drinking Water Health Advisories, U.S. Environmental Protection Agency, Office of Drinking Water, *Final Health Advisories*, 52 F.R. 34294 (September 10, 1987), 54 F.R. 7599 (February 22, 1989), and 55 F.R. 29893 (July 23, 1990). For a child, the 1-day advisory level is "NA" (not applicable); the 10-day advisory level is 10,000 μg/L; and for longer term exposures for a child, the level is listed as "NA." All the adult exposure levels for nitrate are listed as "NA."

None of these values is deemed appropriate to provide an action level at the Y-12

ANAP.

2. **If there are no published values, are there published procedures which could be used to generate action levels?**

A. Procedures for Risk-Based Preliminary Remediation Goals for Uranium

It is possible that a remedial goal might also serve as an action goal. Equations for risk-based PRGs for soil under a commercial/industrial scenario are given in Chapter 4 of U.S. EPA *Risk Assessment Guidance for Superfund: Volume I- Human Health Evaluation Manual Part B, Development of Risk-Based Preliminary Remediation Goals*, Office of Emergency and Remedial Action, Publication 9285.7-01B, Dec. 1991 (Hereafter referred to as RAGS Vol.I Part B). The equation used herein was taken from RAGS Vol. I Part B, as modified per memo from Mark Stack, 9/2/92 (SAIC accession number 380.920908.004). Slope factors were taken from the 1992 Heast table update.

Because the assumed soil contaminants are process waste, it is not clear that they would be in secular equilibrium. However, it would be prudent to calculate the concentrations of ^{238}U decay products as though they were in equilibrium with the ^{238}U measured, so values reported for ^{238}U include risk from the decay products. Slope factors are the same for ^{235}U and ^{235}U plus its decay products (^{235}U+D).

The governing equation is:

$$pCi/gsoil = \frac{1\times10^{6}}{[ED \times (ingestion\ term + air\ term + external\ term)]}$$

Definitions of the terms and their values, as well as the steps involved in the calculations, are shown in Attachment A. Default parameter values given by U.S.EPA [RAGS Vol. I Part B and *Health Effects Assessment Summary Tables, Annual Update* (1992)] were used in the calculations. The calculated soil PRG values are:

^{234}U	1.6 pCi/g
^{235}U	0.2 pCi/g
^{238}U	1.4 pCi/g

These PRGs are considerably below the U.S.DOE standards for uranium in soil described in Section 4.1.A above. The numbers are risk-based cleanup goals. The question being addressed in this study is whether a leak occurred in the pipeline, not the limits to which the leak-contaminated soils must be cleaned. Therefore, this approach and these values do not fit the needs and cannot be applied in any reasonable manner.

B. Procedures For Nitrate Risk-Based Preliminary Remediation Goals

The assumption, once again, is that a remedial goal could serve as an action goal. Where no action level exists for a chemical, one can be calculated using the same method found in

RAGs I Part B which is similar to the one used above for uranium. The default equation for nitrate as the chemical of concern, which allows for no site specific information, uses the number from IRIS--1.6 mg/kg per day-- and disregards any information on oral and inhalation cancer slope factors. The calculations cover noncarcinogenic ingestion effects. Since nitrate volatility is low, inhalation effects would be negligible. The results for the various categories of exposure are as follows:

1. Soil, residential: 4.3×10^5 mg/kg;
2. Soil, commercial/industrial: 3.3×10^5 mg/kg.

There appear to be no problems with the formulas nor the underlying assumptions, but the resulting levels appear too high to be of practical value.

3. If there are no published standards or no published method, what rationale could be used to provide action levels?

A. Rationales to Set Uranium Action Levels

Some measurements of uranium levels taken around the Y-12 site could be useful. The Martin Marietta Energy Systems, *Oak Ridge Reservation Environmental Report for 1988*, May 1989, ES/ESH-8/V1, contains some findings of soil concentrations of radionuclides. The method involved taking samples from designated places on the Oak Ridge Reservation and then taking other samples from stations outside the Reservation. Table 1 shows concentrations for ^{234}U, ^{235}U, and ^{238}U from three locations near Y-12. The map in the appendix shows the approximate sampling locations.

Sample concentrations from those sampling stations located near the Y-12 site can be compared with below pipeline samples. If the values are sufficiently different, it would be possible to simply use a factor of χ times the level normally found on the Y-12 site to trigger additional sample analyses for uranium. A factor of 3X the mean of the samples could serve as an action level.

B. Rationales to Set Nitrate Levels

The difficulty with using established standards for nitrate is that nitrate is easily transported in soil. While it may accumulate in the soil, it will more likely undergo denitrification by micro-organisms; it may be taken up by assimilatory reduction; it may be used by micro-organisms as an electron acceptor; it may leach to deeper soil levels or into the groundwater; or it may be transported off-site by run-off. Paul, E. A., and Clark, F. E., *Soil Micro-Biology and Bio-Chemistry, Academic Press, Inc., San Diego. 1989.*

Use of the *Human Health Evaluation Manual* default equation may be questionable for nitrate since it is not "a chemical of concern" for most Superfund sites (telephone conversation with Andy Benford, Tennessee Division of Superfund on August 6, 1992). The State of Tennessee did not even include nitrate in its proposed soil cleanup standards issued on August 4, 1992. Similarly, the State of Oregon, which promulgated rules for environmental cleanup standards in soil that became effective on June 10, 1992, has not included nitrate in its listings. *Environmental Cleanup Rules, Oregon Administrative Rules 340-122-010 - 340-122-110.*

Table 1. 1988 Uranium Concentrations in Soil

		Concentration (pCi/g dry wt)			
Y-12 location	Number of samples	Maximum	Minimum	Average	S.E.
		^{234}U			
40	4	1.1	0.76	0.92	0.077
45	4	5.1	0.73	2.5	0.94
46	4	0.76	0.59	0.68	0.033
Summary		5.1	0.59	1.37	
		^{235}U			
40	4	0.068	0.046	0.055	0.0046
456	4	0.49	0.032	0.22	0.096
46	4	0.070	0.049	0.061	0.0046
Summary		0.49	0.032	0.112	
		^{238}U			
40	4	0.62	0.46	0.53	0.036
45	4	8.6	0.68	3.5	1.7
46	4	0.38	0.32	0.36	0.013
Summary		8.6	0.32	1.46	

S.E. = Standard deviation about the average (as used in Martin Marietta Energy Systems, *Oak Ridge Reservation Environmental Report for 1988*, Volume 2, *Data Presentation*, ES/ESH-8/V2, May 1989, Pages 168 - 170).

Even though the nitrate situation is technically and regulatorily shaky, there is a rationale for providing an action level for nitrate. In the absence of known background data, no comparison can be made between background and under-the-pipeline nitrate measurements. However, a comparison can be made among the under-the-pipeline nitrate measurements. The mean, maximum, minimum and other statistical values would be determined for the 19 samples. When the observed pipeline concentration at a given location exceeds the mean by a factor of 2, then additional samples would be analyzed at that location.

Another more stable chemical--a metal--should be used to set an action level. A comparison can be made between sample concentrations from those sampling stations on the reservation located near the Y-12 site with those samples taken below the pipeline. If the range is sufficiently different, it would be possible to simply use a factor of χ times the level normally found on the Y-12 site to trigger additional sample analyses for the metals.

5. RECOMMENDATIONS FOR ACTION LEVELS

There are neither published values nor published useful methods for recognizing action levels for uranium and nitrates in soil. A systematic search of various sources was made to satisfy most persons that this is, indeed, the case. Therefore, an alternate rationale was developed.

The rationale for uranium is to compare the observed concentration (the sample directly under the pipeline) at each of the 19 sampling locations of the pipeline with observed background concentration. The observed concentrations for the three sampling locations near Y-12 are for the uranium series (see Table 2 below):

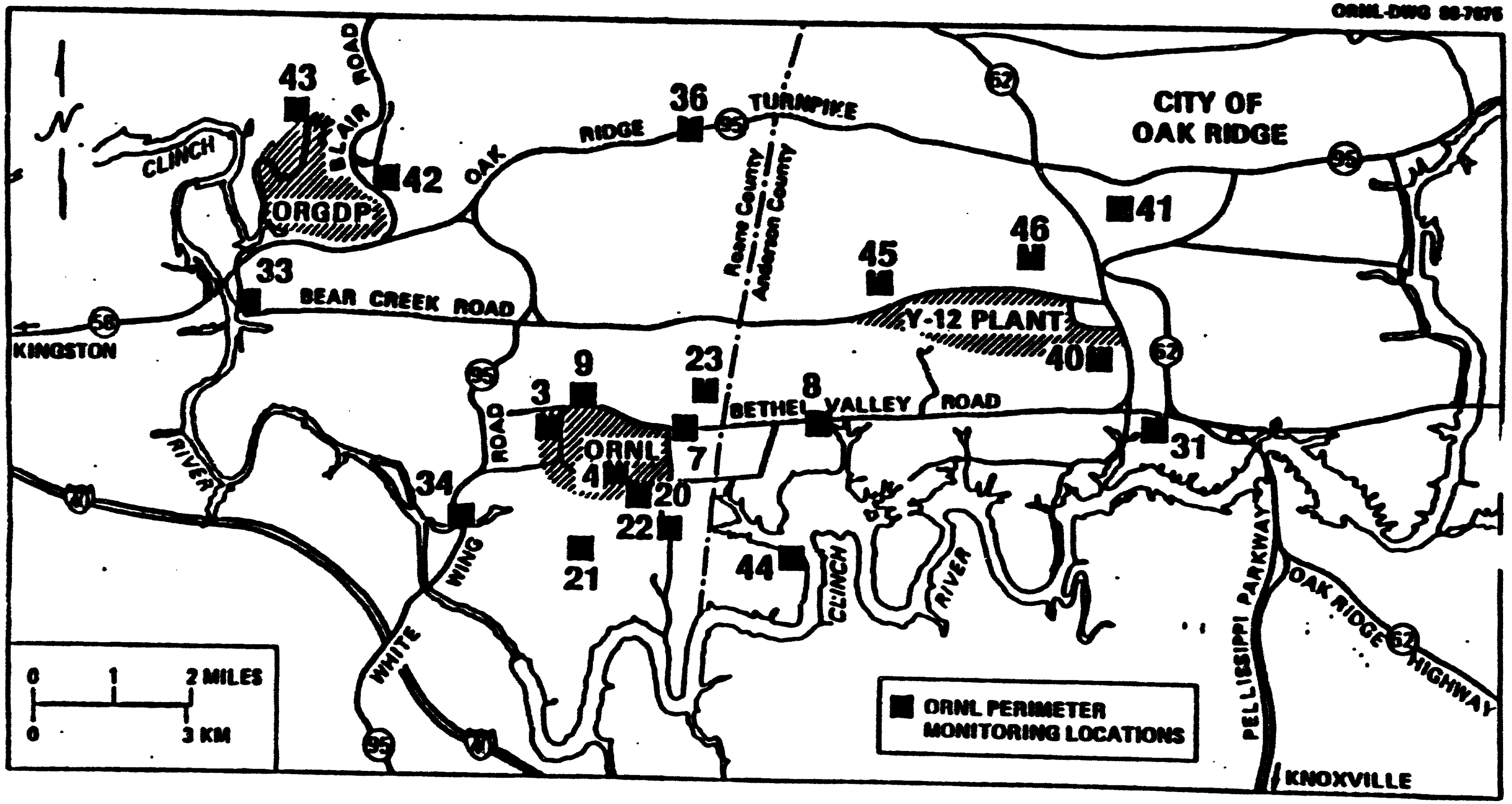
Table 2. Concentration (pCi/g dry wt)

Isotope	Maximum	Minimum	Average
^{234}U	5.1	0.59	1.37
^{235}U	0.49	0.032	0.112
^{238}U	8.6	0.32	1.46

These values can be used until better background measurements become available. When the observed pipeline concentration for uranium radionuclides exceeds the mean by a factor of 3, it is recommended that additional samples be analyzed. Data from the additional samples will better substantiate that particular location actually has a uranium level above background, and, therefore, may represent a leak. [An alternative to the above action is to use an action level that is a factor of 0.1 of the maximum observed background concentration.]

There is a recommended action level for nitrate. Even though this compound is ubiquitous in the environment, and nitrogen dynamics are so varied that it is possible that most nitrates may have washed into the groundwater, there is a possible action level. Because there are no known measurement data for nitrates in soil near Y-12, the rationale requires results of the 19 samples. When the observed pipeline concentration at a given location exceeds the mean by a factor of 2, then additional samples would be analyzed at that location. [An alternative to the above action level is to use a factor of 0.1 of the maximum observed background concentration.]

An alternative to nitrate is to use a metal. The sampling plan specifies that metals are to be measured; metals are more chemically stable in the environment than nitrogen. Therefore, the need for an action level should not be one for nitrate but one for another more environmentally stable chemical such as a metal. Then rationale should be similar to the one for uranium. Compare the observed concentration of the metal (the sample below the pipeline) to the observed background concentration. If the pipeline value exceeds the mean background level by a factor of 3, take more samples. No background levels for metals were found in the *Oak Ridge Reservation Environmental Report for 1988, Volume 2: Data Presentation*. May 1989. ES/ESH-8/V2. Background measurements for these metals are being gathered now to permit quantitative comparisons resulting in action level. It is recommended that such metals as chromium and nickel be considered for the action level decisions. [An alternative is that if the pipeline value exceeds the maximum observed background concentration by a factor of 0.1, then analyze more samples.]



Source: Martin Marietta Energy Systems, Inc., *Oak Ridge Reservation Environmental Report for 1988*, Volume 2: Data Presentation. May 1989. ES/ESH-8/V2, pg. 157.

Figure 2.4.4. ORNL Perimeter and ORR Grass and Soil Monitoring Locations.

Attachment A. Calculation of Soil PRGs for Uranium

Equations for risk-based PRGs for soil given in Chapter 4 of RAGS Vol.I Part B are based on the assumption that the target incremental lifetime risk from exposure to the contaminant in question is 1×10^{-6}. The standard equation to calculate risk under the given scenario is then solved for soil contaminant concentration. The equation used herein was taken from RAGS Vol. I Part B, as modified per memo from Mark Stack, 9/2/92 (SAIC accession number 380.920908.004).

The governing equation is:

$$\text{Soil PRG (pCi/g soil)} = \frac{1 \times 10^{-6}}{(\text{ED} \times [\text{Ingestion term} + \text{Air term} + \text{External term}])}$$

Where:

ED = Exposure duration
Ingestion term = $SF_o \times 10^{-3}$ g/mg x EF x IR_{soil}
Air (inhalation) term = $SF_i \times 10^{3}$ g/kg x EF x IR_{air} x 1/PEF
External term = $SF_e \times (1-S_e) \times T_e$
SF_o = Slope factor for ingestion of soil (risk/yr per pCi/g)
EF = Exposure frequency (days)
IR_{soil} = Daily soil ingestion rate (mg/day)
SF_i = Slope factor for inhalation (risk/yr per pCi/g)
IR_{air} = Daily inhalation rate (m^3/day)
PEF = Particle emmmission factor (m^3/kg)
SF_e = Slope factor for external irradiation (risk/yr per pCi/g)
S_e = Gamma shielding factor (unitless)
T_e = Gamma exposure factor (unitless)

The values used for these parameters were default values given by U.S.EPA [RAGS Vol. I Part B and *Health Effects Assessment Summary Tables, Annual Update* (1992)]. They are as follows:

ED = 25 yr
EF = 250 days/yr
IR_{soil} = 50 mg/day
IR_{air} = 20 m^3/day
PEF = 4.6×10^{9} m^3/kg
S_e = 0.2
T_e = 1.0

The calculations of PRGs are shown below:

Ingestion term: $SF_o \times 10^{-3}$ g/mg x EF x IR_{soil} = $12.5 \times SF_o$
Inhalation term: $SF_i \times 10^{3}$ g/kg x EF x IR_{air} x 1/PEF = $1.087 \times 10^{-3} \times SF_i$
External term: $SF_e \times (1-S_e) \times T_e$ = $0.8 \times SF_e$

Slope factors (SFs) (HEAST, 1992 Annual Update) are shown in the following table:

Slope Factors for Uranium Isotope Exposure in Soil
(Risk/yr per pCi/g soil)

Isotope	SF_o	SF_i	SF_e
^{234}U	1.6×10^{-11}	2.6×10^{-8}	3.0×10^{-11}
^{235}U	1.6×10^{-11}	2.5×10^{-8}	2.4×10^{-7}
^{238}U	2.8×10^{-11}	5.2×10^{-8}	3.6×10^{-8}

The intermediate steps of the calculation are summarized in the following table:

Intermediate Calculations of PRG for Uranium in Soil
(Risk per pCi/g soil)

Isotope	Ingestion/yr	Air/yr	External/yr	Total/yr	Total lifetime
^{234}U	2.0×10^{-10}	2.8×10^{-11}	2.4×10^{-8}	2.4×10^{-8}	6.1×10^{-7}
^{235}U	2.0×10^{-10}	2.7×10^{-11}	1.9×10^{-7}	1.9×10^{-7}	4.8×10^{-6}
^{238}U	3.5×10^{-10}	5.6×10^{-11}	2.9×10^{-8}	2.9×10^{-8}	7.3×10^{-7}

The PRG is found by dividing the target lifetime risk increment, 1×10^{-6}, by the lifetime risk factor. The calculated soil PRG values are:

^{234}U $1 \times 10^{-6}/6.1 \times 10^{-7}$ = 1.6 pCi/g
^{235}U $1 \times 10^{-6}/4.8 \times 10^{-6}$ = 0.2 pCi/g
^{238}U $1 \times 10^{-6}/7.3 \times 10^{-7}$ = 1.4 pCi/g

APPENDIX B

TECHNICAL MEMORANDUM—RESULTS OF THE PHASE 1 RECONNAISSANCE SURFACE GEOPHYSICAL SURVEY TO DETECT AN ABANDONED NITRIC ACID PIPELINE

Technical Memorandum

Results of Phase 1 - Reconnaissance Surface Geophysical Surveying to Detect an Abandoned Nitric Acid Pipeline

Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

SAIC®
Science Applications International Corporation
An Employee-Owned Company

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Summary

Reconnaissance surface geophysical surveying (testing) was conducted at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee. The objective of the surveying was to evaluate the feasibility of using surface geophysical methods to detect an abandoned nitric acid pipeline. According to as-built diagrams, the geophysical target is a 1.5- to 3-inch (3.8- to 7.6-centimeter) diameter stainless steel pipe with a high concentration of nickel (brand name monel). The pipeline is approximately I mile in length, transacting the facility in an east-west direction. Maximum depth to the target is less than 15 feet (4.6 meters). Prior to geophysical surveying, the anticipated location of the pipeline was land surveyed and staked at 50-foot (15.2-meter) intervals based on the as-built diagrams.

A total of 4 representative sites were investigated. The geophysical surveying consisted of collecting data along transects oriented in a north-south direction, approximately perpendicular to and centered on staked locations, and sweeps or general walk-arounds in the near vicinity of the pipeline. Geophysical methods that were tested included electromagnetics (EM), ground-penetrating radar (GPR), and magnetics. Results of the surveying are summarized below.

- The pipeline can be considered geophysically non-magnetic and non-electrical. Sweeping within inches of an exposed section of the pipe with a metal locator indicated no magnetic response. Placing an inductive current source around the pipe and sweeping with the metal locator also resulted in no response. These observations are consistent with a stainless steel pipe that has a high concentration of nickel.

- The presence of numerous cultural features (e.g., power lines, buildings, other buried pipelines, etc.) has an adverse affect on the quality of EM and magnetic data. Such features are expected to have adverse affects on data quality for most geophysical methods and techniques except GPR.

- High-quality GPR data that indicated the presence of pipes were collected along some transects located on asphalt; poorer quality data were collected along adjacent transects located on grass. The difference in quality is probably related to different types of soil/fill and varying degrees of soil-moisture content. It is suspected that soil/fill beneath roads is more permeable and relatively dry as compared to adjacent areas. Beneath grassy areas, data quality degrades due to absorption of GPR energy by partially saturated silt and clay-rich soils. Using a longer wavelength antenna than was used in the reconnaissance surveying in order to achieve greater depths of penetration would not provide the needed resolution to detect the relatively small pipeline.

Based on results of testing, it is recommended that no additional geophysical surveying be conducted to help define the presence/location of the pipeline. Future efforts should concentrate on a strategy of selective subsurface sampling using as-built diagrams to guide the choice of sample locations.

Introduction

Reconnaissance surface geophysical surveying (testing) was conducted by personnel from Science Applications International Corporation (SAIC) between June 15 and 16, 1992, in the vicinity of Oak Ridge Y-12 Plant, Oak Ridge, Tennessee (Figure 1). The work was performed for the Environmental Restoration Division, Oak Ridge Y-12 Plant, in support of environmental study and remediation at the facility. The objective of the surveying was to evaluate the feasibility of using surface geophysical methods to detect an abandoned pipeline. Frequency-domain electromagnetic (EM), ground-penetrating radar (GPR, using a 300 megaHertz [MHz] antenna), and total-field/gradient/metal-locator magnetic techniques were evaluated. This report summarizes results of the reconnaissance surveying.

Based on as-built diagrams, the geophysical target is a 1.5- to 3-inch (3.8- to 7.6-centimeter) diameter stainless steel pipe that has a high concentration of nickel (brand name monel). Maximum depth to the target was assumed to be less than 15 feet (ft; 4.6 meters [m]). The strategy for using surface geophysical methods to delineate this target was divided into two phases because of anticipated uncertainties in detecting the target and collecting high-quality data. These uncertainties are associated with properties of the target (i.e., stainless steel with a high concentration of nickel is relatively non-magnetic and non-electrical); effects from near-surface cultural features (e.g., EM and magnetic interferences due to buildings, overhead and buried power lines, and other buried objects); and physical properties of near-surface soil/fill (i.e., material comprised mostly of silt and clay with a high soil-moisture content would result in attenuation of GPR signals).

Phase 1 consisted of reconnaissance surveying which included a walking tour of the Oak Ridge Y-12 Plant, a review of pertinent information including as-built diagrams of the pipeline, and tests of geophysical methods in the vicinity of exposed and buried portions of the pipeline. Based on an evaluation of the results from Phase 1, it is recommended that a second phase, consisting of extensive geophysical surveying over the entire length of the pipeline, not be performed.

Description of Target

The construction of the pipeline was completed in October, 1951 (SAIC, 1992). It

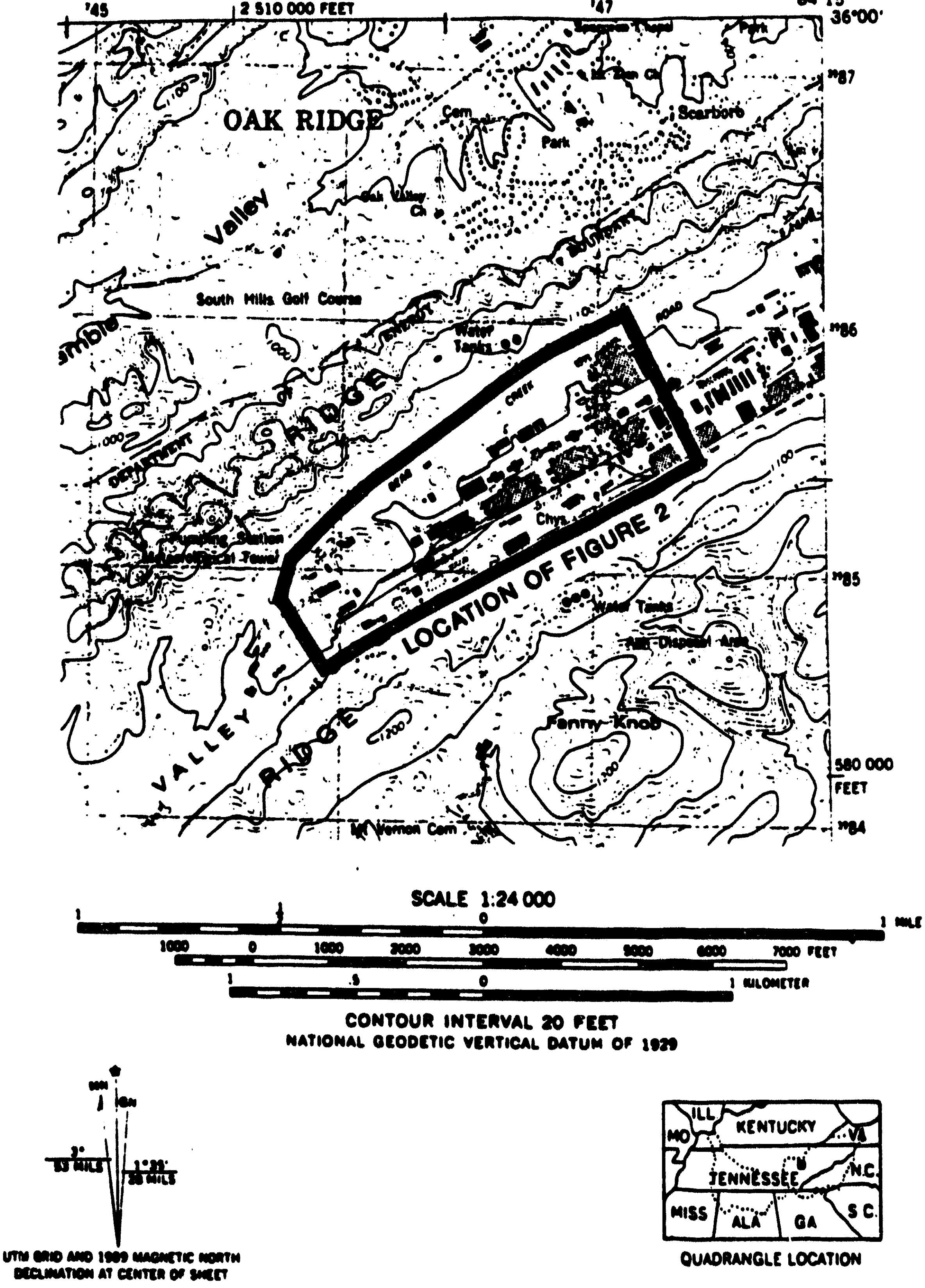


Fig. 1. Index map (base map: USGS, 1989).

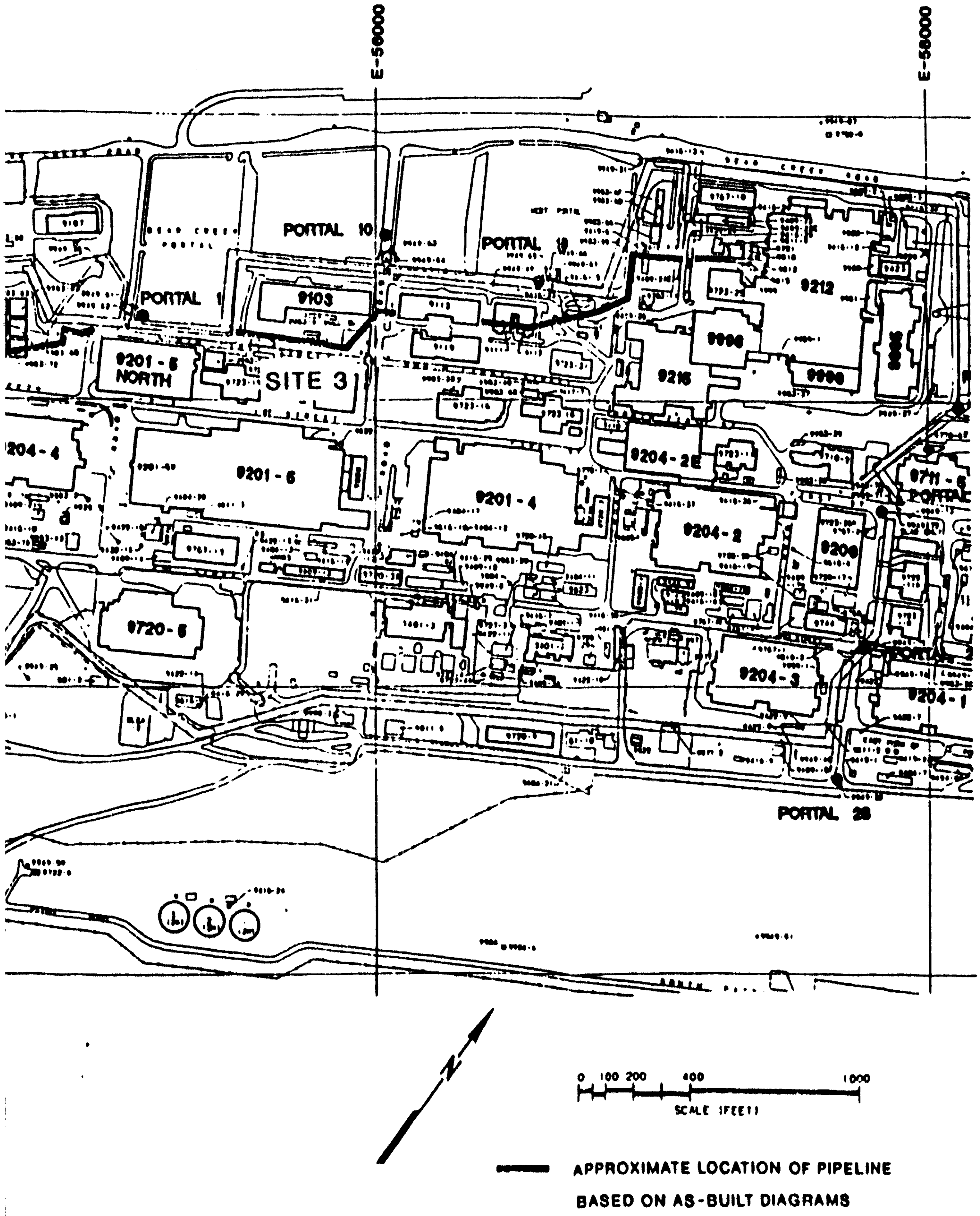
was used to transport effluent from Building 9999, located in the north-central portion of the facility, to the former S-3 Ponds that were located along the western boundary and is currently the site of an asphalt-covered parking lot (Figure 2). The effluent consisted of nitric acid with depleted uranium in solution that was produced during a uranium recovery process. The effluent was kept acidic to avoid a buildup of solid sludge in the S-3 Ponds. The total volume of wastes discharged to the ponds is estimated to have averaged about 5,000 gallons per day. The pipeline was abandoned in 1983 and was reportedly flushed and plugged with grout or concrete. Some records indicate that sections of the pipeline were not grouted.

The pipeline extends approximately 4800 ft (1460 m), the majority of which runs through the secured area of the Oak Ridge Y-12 Plant. Sections of the pipeline have been removed and/or renovated when in the path of new plant construction. Although as-built diagrams indicate that it was constructed of 1.5- to 3-inch (3.8- to 7.6-centimeter) diameter stainless steel pipe, some sources indicate that 6-inch (15.2-centimeter) diameter pipe may have been used in several sections (SAIC, 1992). In addition, available information indicates that it was buried at least 1 foot (0.3 m) throughout its length with average and maximum depths of about 6 ft (1.8 m) and 15 ft (4.6 m), respectively. The pipeline has many turns, bends, and welded joints along its course.

Geophysical Surveying

As part of the field sampling effort and prior to reconnaissance geophysical surveying, the anticipated location of the pipeline was land surveyed and staked using available as-built diagrams. The projected location was staked at 50-ft (15.2-m) intervals and at all turns and bends. Geophysical surveying consisted of collecting data in the vicinity of exposed and buried sections of the pipeline and qualitatively evaluating whether the pipeline was detectable and the effects of cultural interferences on data quality. Data were collected either along transects oriented perpendicular to and centered on the staked locations or by sweeping (i.e., general walk-around) in the near vicinity of stakes. A total of four sites were investigated and are considered representative of conditions that would be encountered in more detailed geophysical surveying.

The equipment used in surveying included a Geonics EM-31D ground-conductivity


E-56000
E-58000
PORTAL 10
PORTAL 18
PORTAL 1
PORTAL 28
9103
9201-5 NORTH
SITE 3
9204-4
9201-5
9201-4
9204-2E
9204-2
9206
9711-5
9720-5
9204-3
9204-1
9212
9215
9998
9995
9996
N
0
100
200
400
1000
SCALE (FEET)
APPROXIMATE LOCATION OF PIPELINE
BASED ON AS-BUILT DIAGRAMS

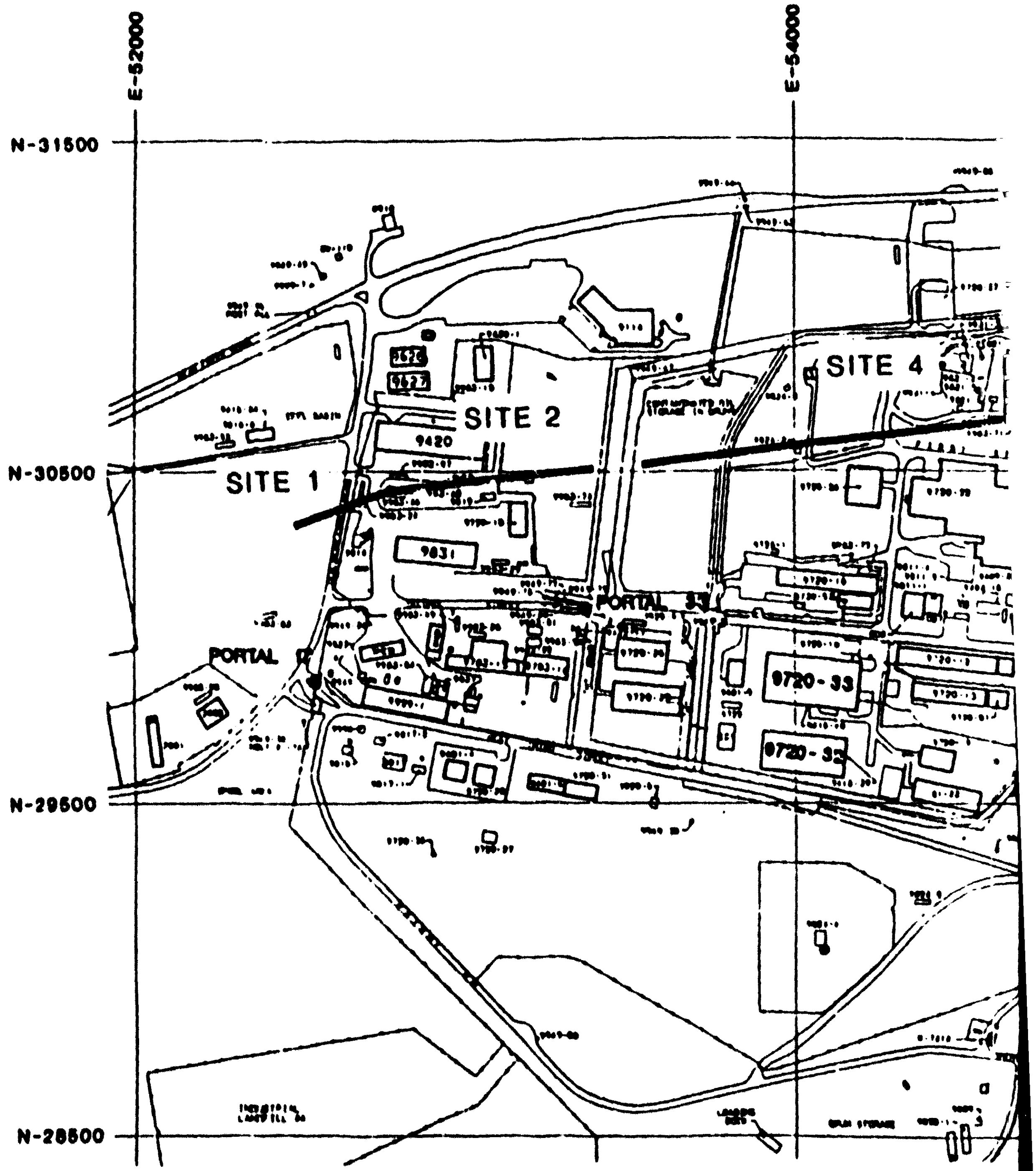


Figure 2. Location of Pipeline and Testing Sites (base map: Martin Marietta Energy Systems, Inc.

meter, a GSSI SIR-3 GPR system with 300 MHz antenna, a GSM GEM-19 proton-precession magnetometer/gradiometer, and a Schondstedt MAC-51B metal locator. Table 1 summarizes typical resolution and accuracy of the various equipment and expected magnitude or type of anomaly produced by a typical small-diameter steel pipe.

Table 1. Typical Resolution and Overall Accuracy for Equipment Used

Equipment	Resolution of Equipment	Typical Survey Accuracy	Expected Magnitude or Type of Anomaly
Geonics EM-31D ground conductivity meter	± 2 percent scale (± 0.6 mmho/m)	± 2 mmho/m	high-low-high signature
GEM GSM-19 proton precession magnetometer/gradiometer	± 0.02 nT	± 0.1 nT	< 200 nT **; high-low signature
GSSI SIR-3 ground penetrating radar with 300 MHz antenna	inches	depends on site conditions *	not applicable
Schondstedt MAC 51B metal locator	qualitative, change in acoustic pitch	qualitative, detect objects 10-ft (3-m) deep	not applicable

* Presence of silt and clay results in significant attenuation of GPR signals.

** Order-of-magnitude estimate for a 2-inch diameter steel cylinder, extending east to west; based on the following (see Breiner, 1973, p. 27):

$$\text{maximum anomaly} = \frac{2\,k\,F\,\pi\,R^2}{r^2} = 188\ \text{nT}$$

where k = magnetic susceptibility (= 8 cgs),
F = total field (54,000 nT),
R = radius of cylinder (= 2.54 cm; i.e., 1 inch), and
r = distance between sensor and cylinder (= 305 cm; i.e., 10 ft).

Testing Site #1

Testing Site #1 was located near the former S-3 Ponds, in the vicinity of two exposed sections of pipe (Figure 3). Data were collected along a transect oriented perpendicular to the pipeline and centered about 20 ft (6.1 m) west of survey I.D. 3+50.00. The transect was positioned between the two exposed sections of pipe which are separated by 40 ft (12 m). Estimated depth to the pipe is 3 ft (1 m). The diameter of the pipe is 1.5 inches (3.8 centimeters); some brownish discoloration of the pipe was noted.

Figures 4 and 5 depict a GPR time section and total-field/gradient magnetic profiles, respectively, that were collected along the transect. The GPR time section clearly indicates the presence of two small-diameter pipes; one at the expected location of the pipeline (station 0) and another about 8 ft (2.4 m) to the south (station 8). Although evident on the GPR time section, the magnetic profiles do not clearly indicate the presence of pipes. Two distinct dipolar anomalies (i.e., high-low signature) are expected on the profiles but not observed. The anomalies which are observed (i.e., a relatively straight-line profile would be expected for normal conditions with no anomalies) are believed to be related to a culvert that is located about 15 ft (4.6 m) north of the transect and to overhead power lines which perpendicularly cross the transect between stations 8 and 16.

Supporting the observation that the pipeline is non-magnetic, sweeping within inches of exposed pipe with the metal locator indicated no magnetic response. Placing an inductive current source around the pipe and sweeping with the metal locator also resulted in no response. Lack of response indicates that the pipeline is both non-magnetic and non-electrical in terms of being detectable by surface geophysical methods. This interpretation is consistent with a stainless steel pipe that has a high concentration of nickel.

Testing Site #2

Testing Site #2 was located directly southeast of building 9420 (see Figure 3). The pipeline is at a depth of about 11 ft (3.4 m) in this area. GPR data were collected along a transect located on asphalt and centered on survey I.D. 8+50.00. The GPR time sections (data not presented) did not indicate the presence of a pipe. Poor depth of penetration is noted and attributed to absorption of GPR signals by the presence of silt and clay in the

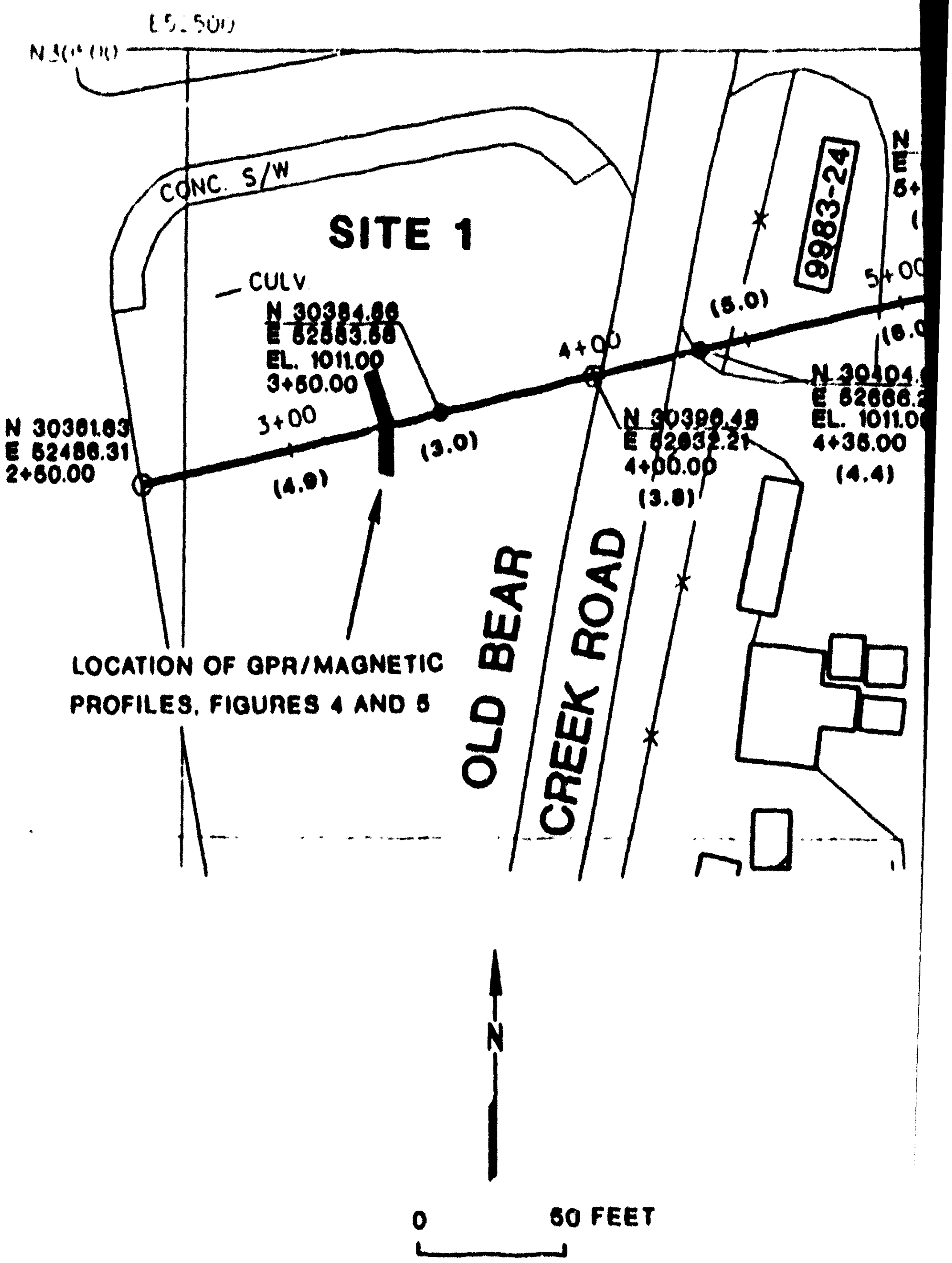
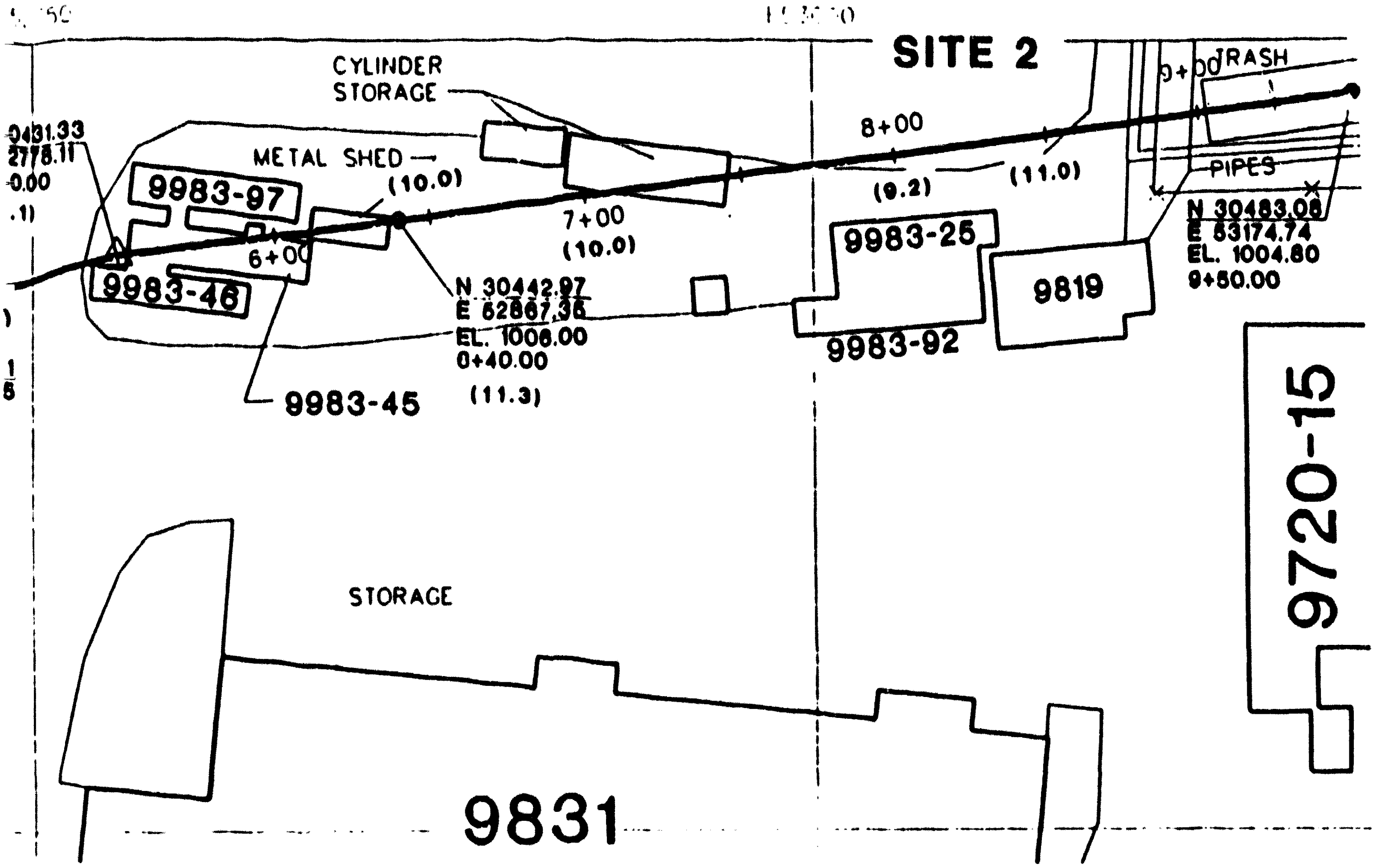


Fig. 3. Testing Sites #1 and #2 (base map: Martin Marietta Energy Systems, Inc., 1992a).



LEGEND

N XXXX	NORTHING
E XXXX	EASTING
EL XXXX	ELEVATION
X+XX.XX	SURVEY I.D.
(XX.X)	ESTIMATED DEPTH TO PIPE BASED ON AS-BUILT DRAWINGS

○	POINT ON TANGENT
△	POINT OF INTERSECTION
●	SOIL SAMPLING LOCATION
▨	AREA WHERE NITRIC ACID LINE HAS BEEN REMOVED
☐	INACCESSIBLE AREAS FOR SAMPLE LOCATIONS

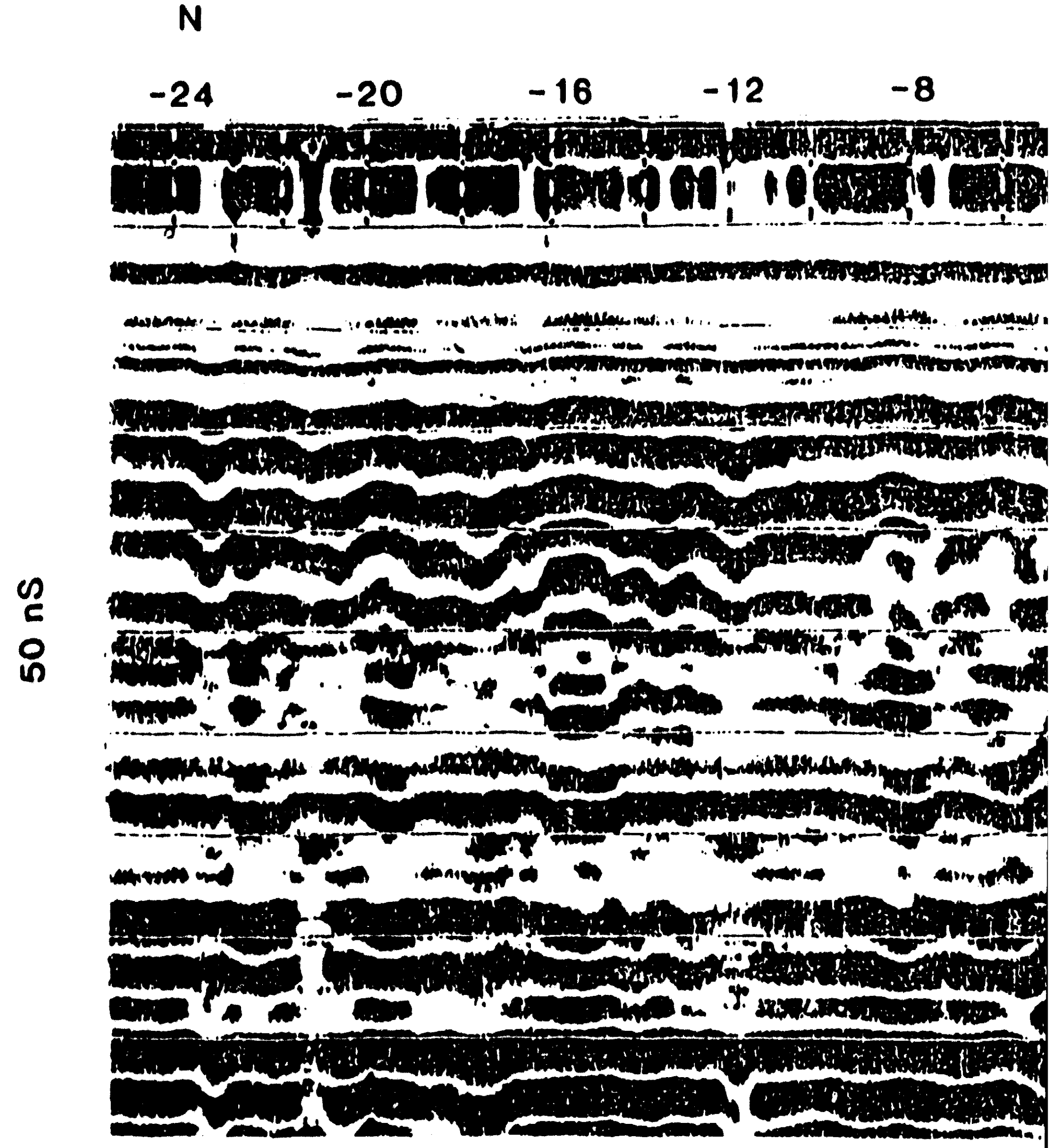
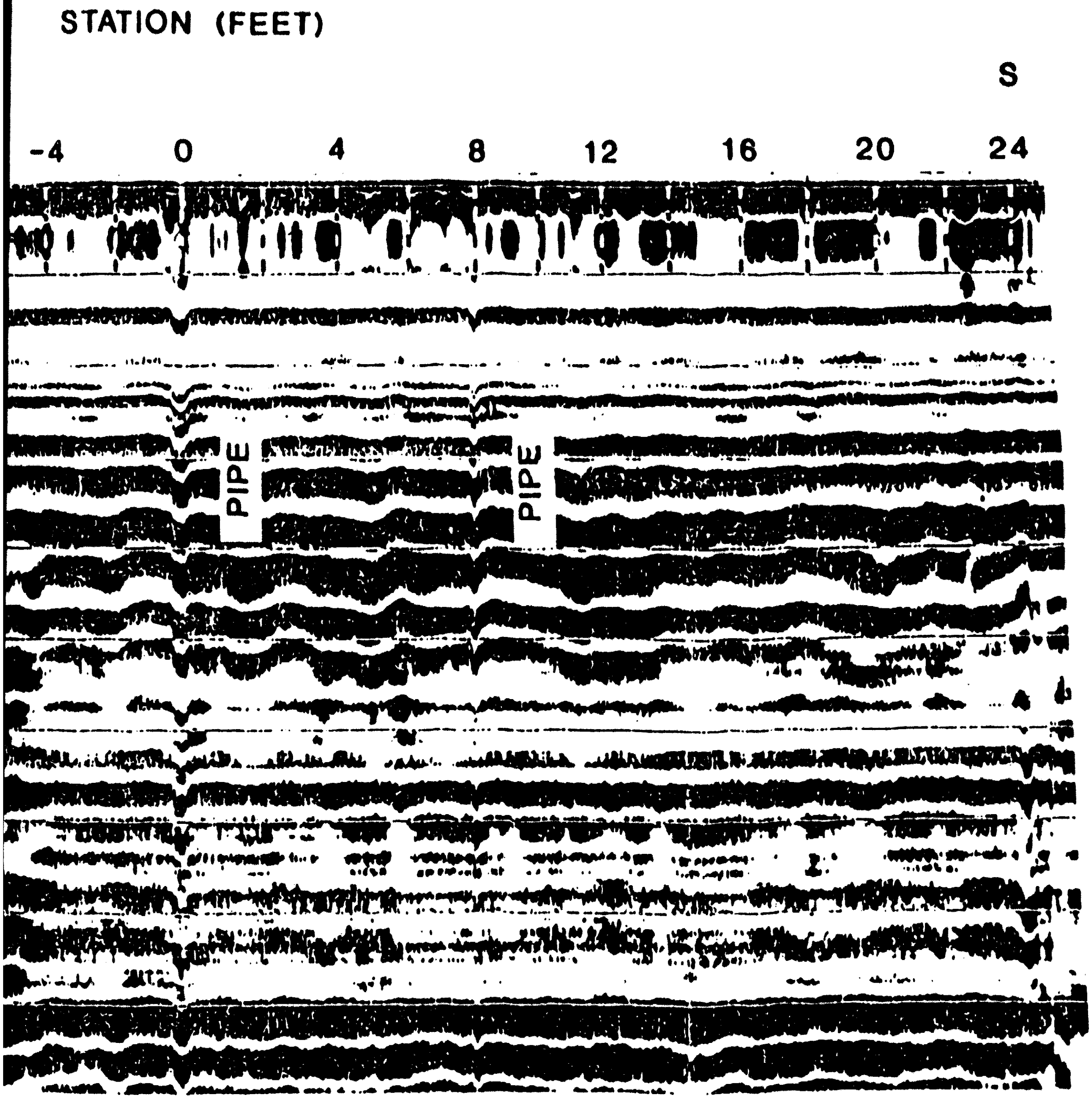


Figure 4. GPR Time Section, Testing Site #1.


STATION (FEET)
S
-4
0
4
8
12
16
20
24
PIPE
PIPE

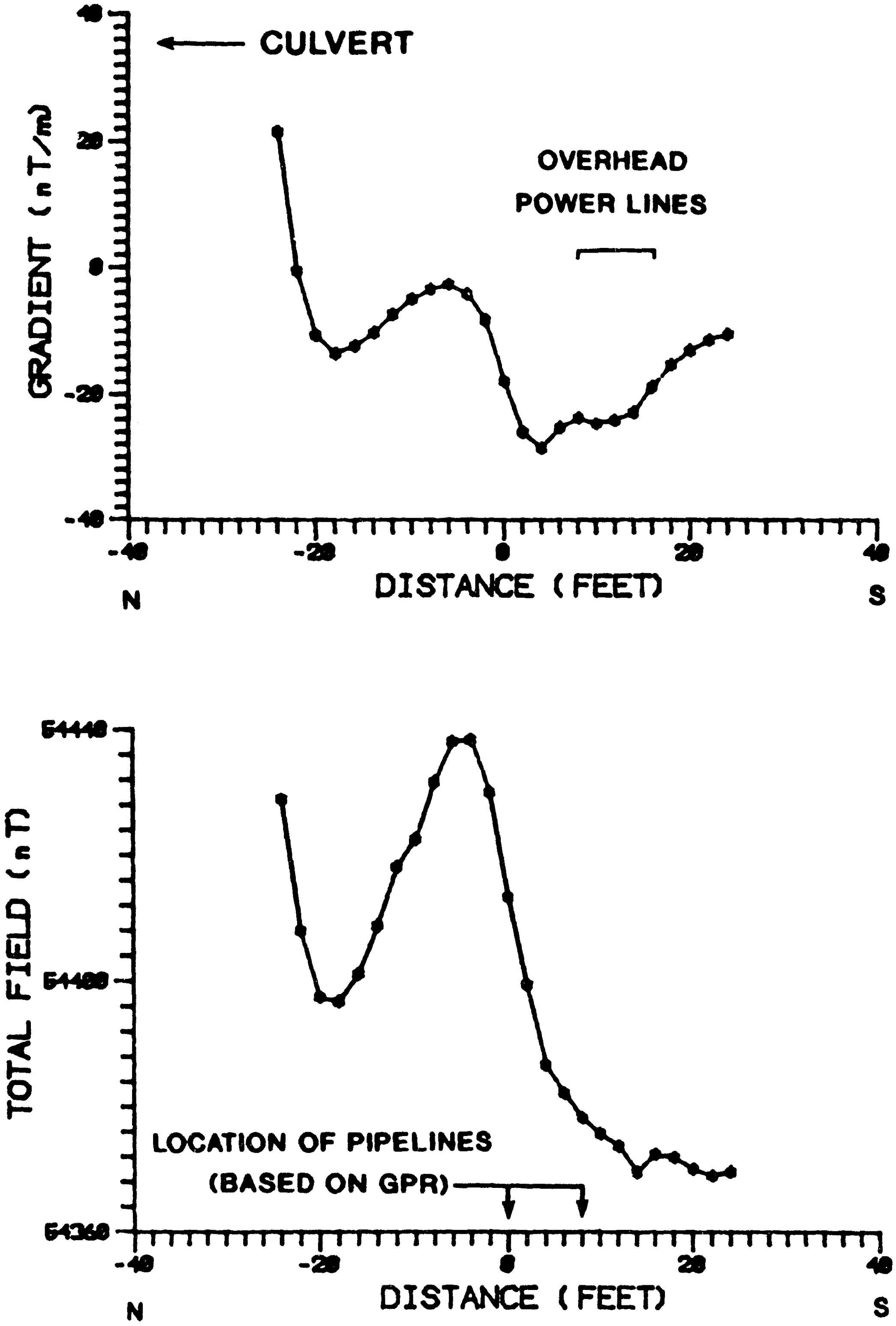


Fig. 5. Magnetic profile, Testing Site #1.

soil/fill at this site. Soils in the vicinity of the Oak Ridge Y-12 Plant are predominately silts and clays (Battelle, 1989). Other geophysical methods were not tried at this site because of the presence of vehicles, trucks, and a chain-link fence in the immediate vicinity of the transect.

Testing Site #3

Testing Site #3 was located directly south of buildings 9983-1 and 9103 (Figure 6). GPR data were collected along transects centered on survey I.D.s 35+00.00, 35+50.00, 36+25.00(one half the distance between 36+00.00and 36+50.00),37+00.00,and 37+16.00 (one half the distance between survey I.D. 37+00.00 and chain-link located to the east). The pipeline is at a depth of about 3 ft (1 m) in this area.

All GPR time sections (data not presented) indicated poor depth of penetration; no indications of a pipeline were evident. Of particular importance is the transect centered on survey I.D. 35+50.00. As noted by signs in the area, this transect crossed another buried pipeline which originates from building 9103. There was no indication of the pipeline on the GPR time section. Sweeping with the metal locator, however, did indicate the presence of this second pipeline. Lack of detection is attributed to poor depth of penetration related to the presence of silt and clay within the soil/fill at this site.

To further assess data quality, GPR transects were collected near another pipeline which feeds into an open storm drain in the area. The location of the pipeline was clearly visible; depth to the pipeline is about 3 ft (1 m). Again, no indication of a pipeline is noted on the GPR time section and is attributed to poor depth of penetration related to properties of the near-surface soil.

EM and magnetic sweeps conducted in the area did not detect the pipeline. Interferences from nearby cultural features which included buildings, power lines, and power transformers were noted. These interferences would have a significant affect on data quality for any detailed geophysical surveying in this area.

Testing Site #4

Testing Site #4 was located about 250 ft (76 m) west of building 9983-72 (Figure 7).

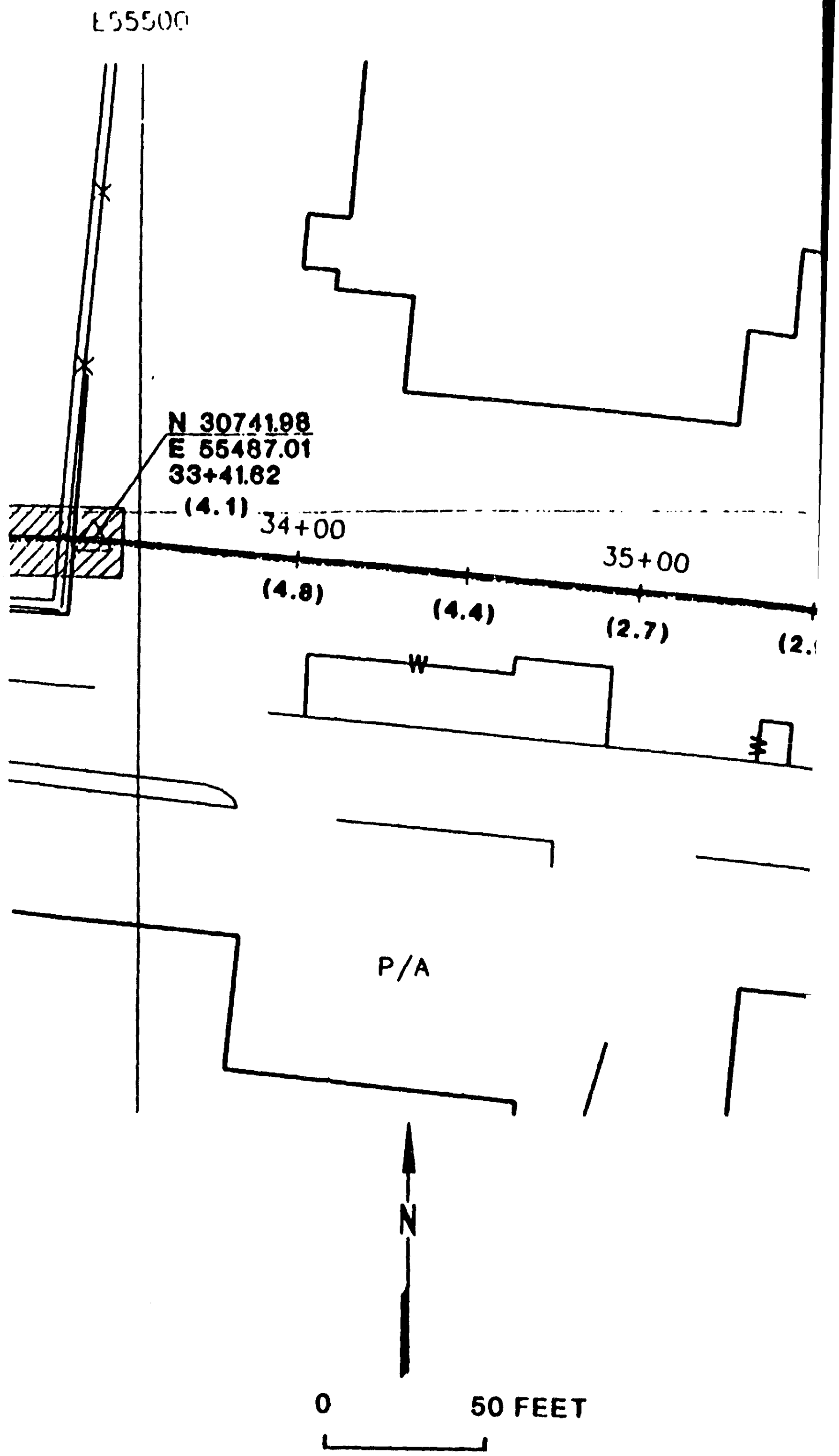
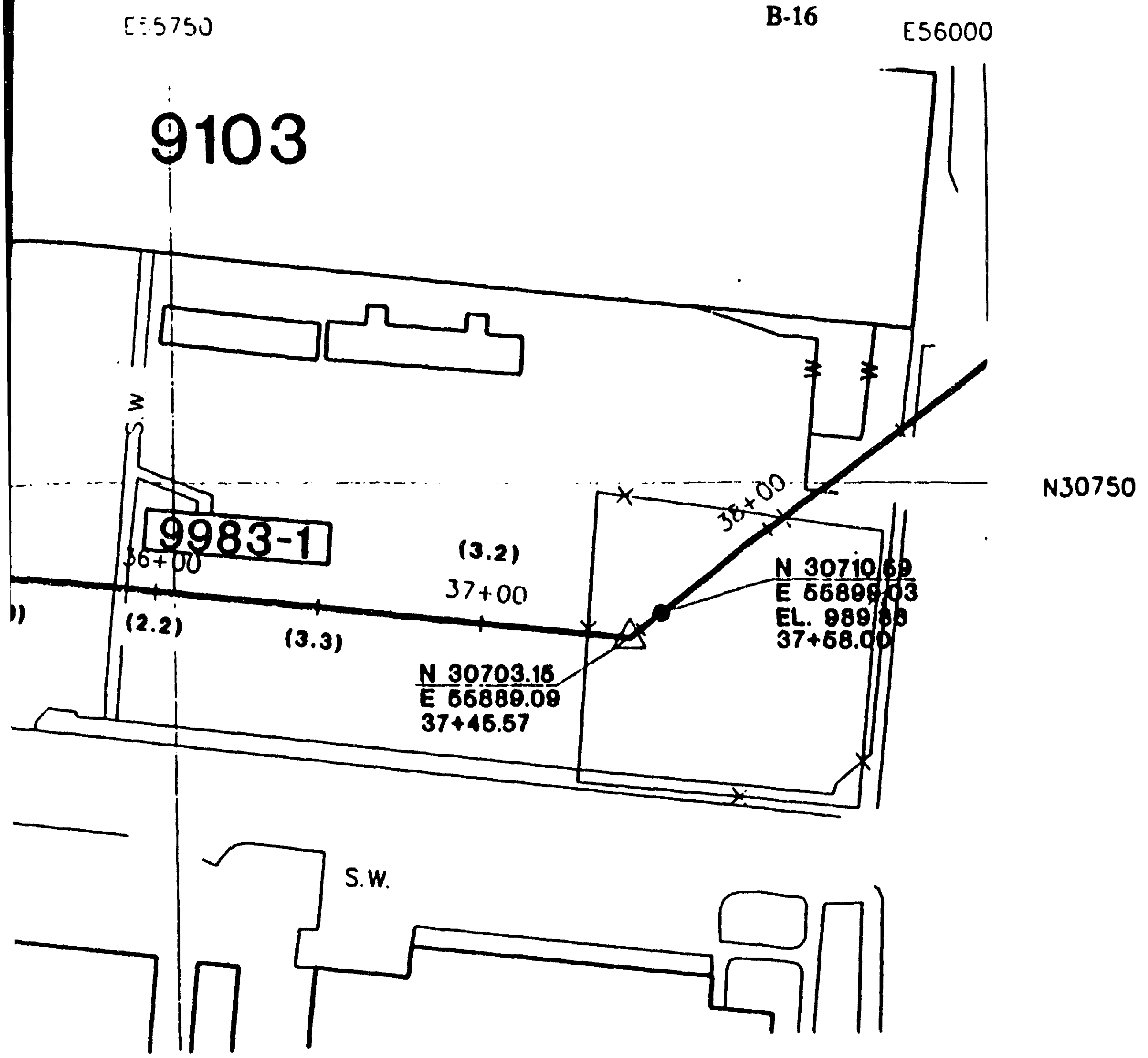


Figure 6. Testing Site #3 (base map: Martin Marietta Energy Systems, Inc.,



LEGEND

N XXXX NORTHING
E XXXX EASTING
EL XXXX ELEVATION
X+XX.XX SURVEY I.D.
(XX.X) ESTIMATED DEPTH TO PIPE BASED ON AS-BUILT DRAWINGS

○	POINT ON TANGENT
△	POINT OF INTERSECTION
●	SOIL SAMPLING LOCATION
▨	AREA WHERE NITRIC ACID LINE HAS BEEN REMOVED
☐	INACCESSIBLE AREAS FOR SAMPLE LOCATIONS

992h).

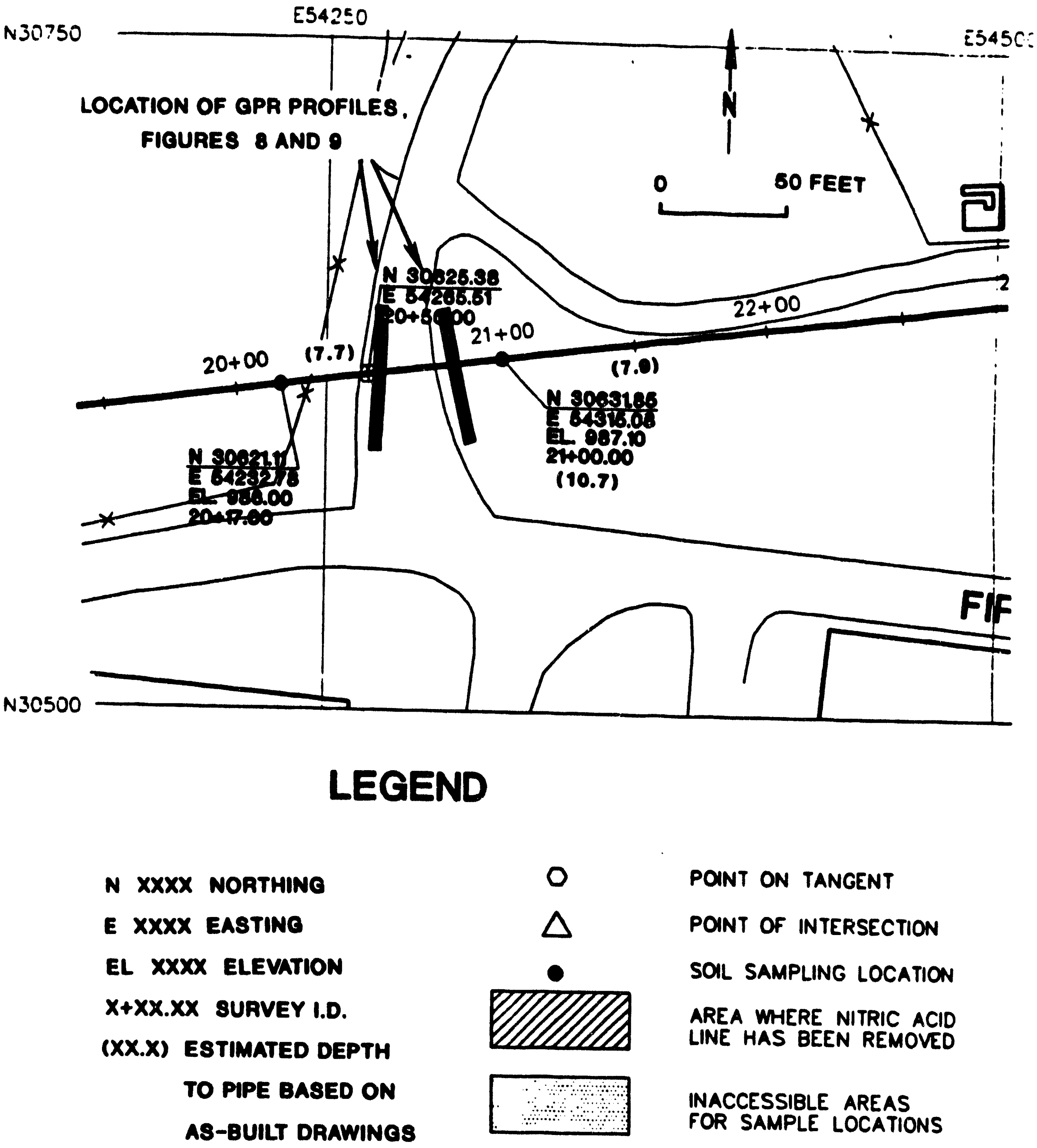


Fig. 7. Testing Site #4 (base map: Martin Marietta Energy Systems, Inc. 1992b).

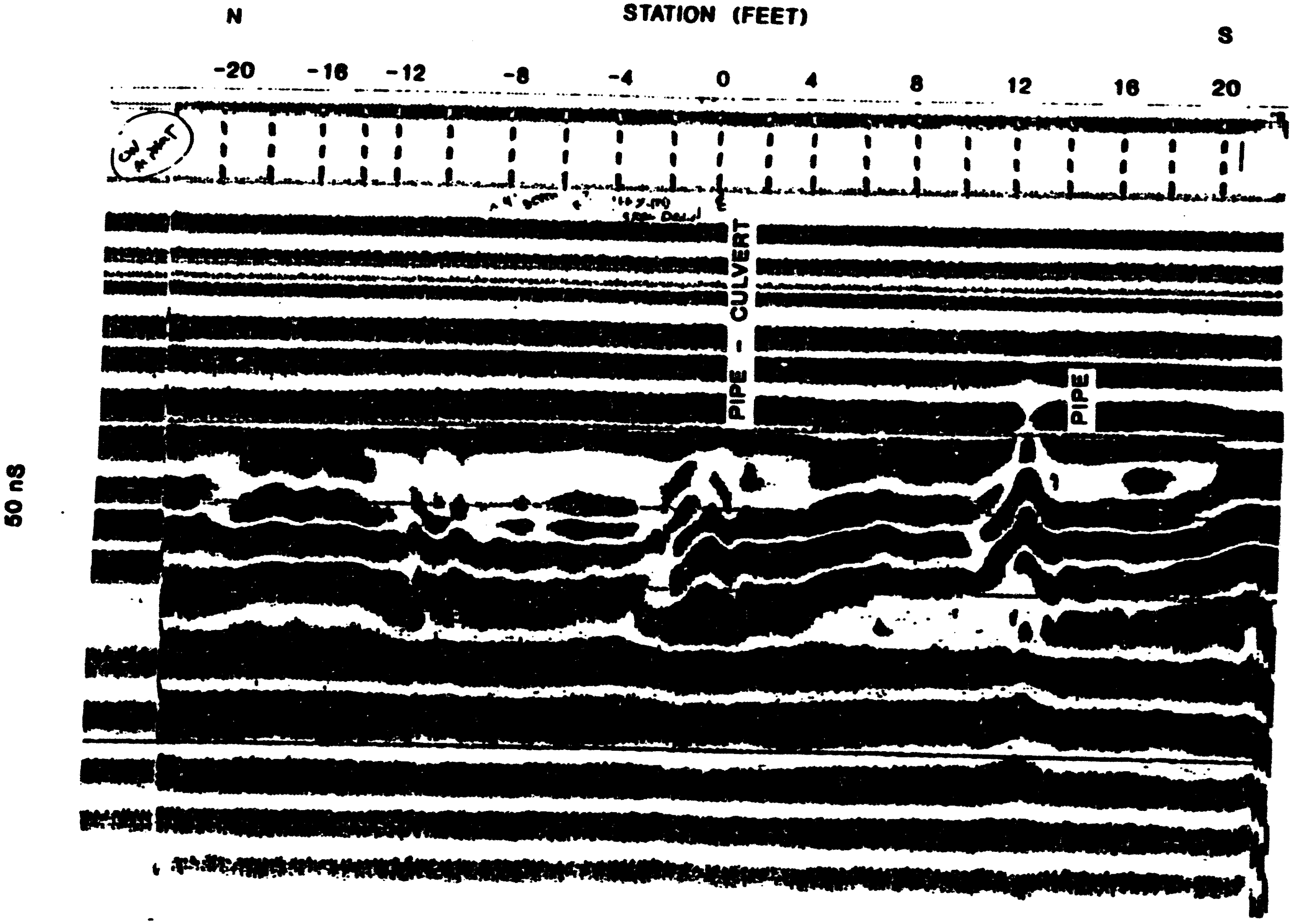


Fig. 8. GPR Time Section, Testing Site #4 (asphalt).

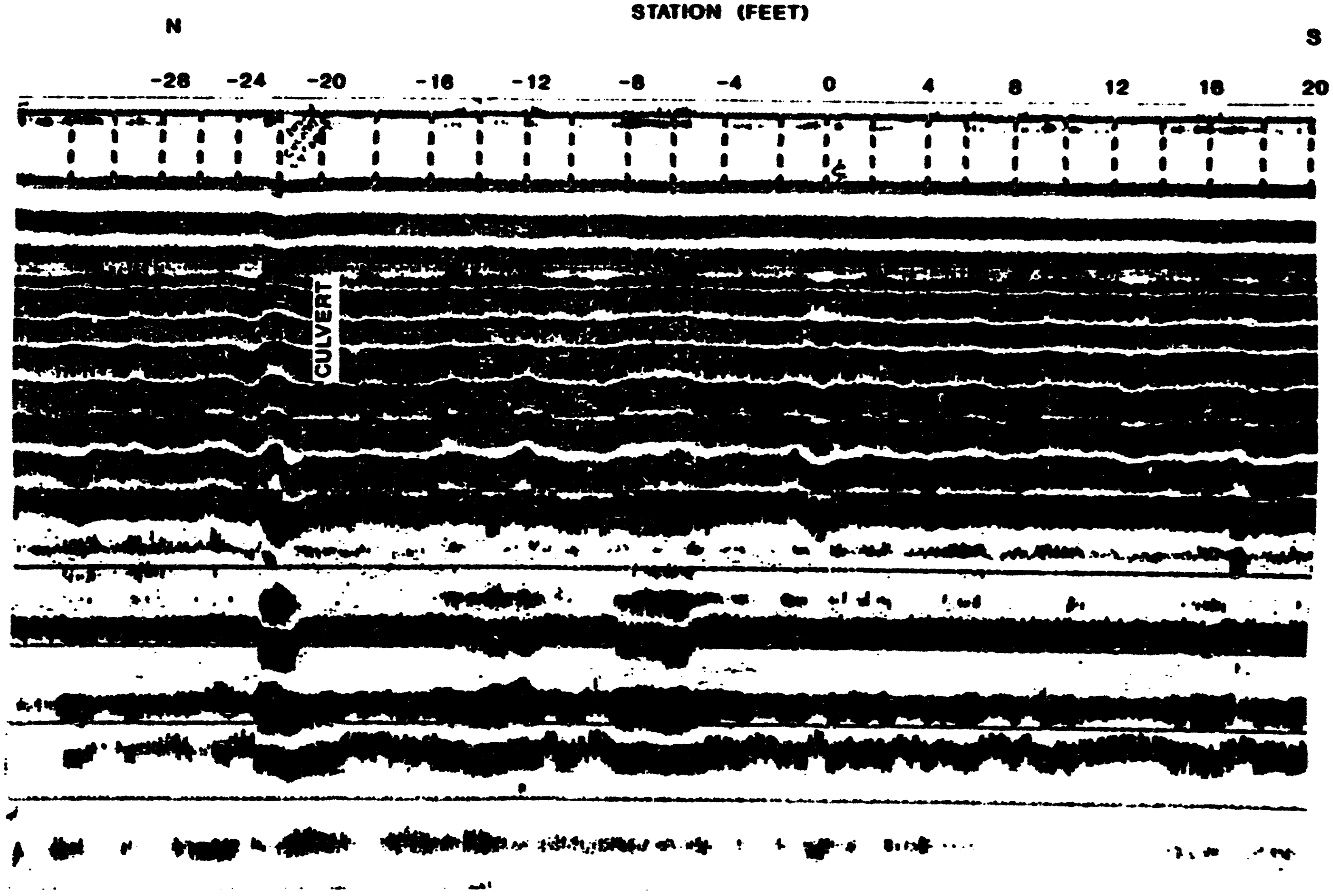


Fig. 9. GPR Time Section, Testing Site #4 (grass).

Transects were centered on survey I.D.s 20+50.00 (on asphalt), 20+80.00 (30 ft [9 m] east of survey I.D. 20+50.00;on grass), and 21+00.00. Figures 8 and 9 depict GPR time sections for data collected on asphalt and grass, respectively. The former time section clearly indicates the presence of two pipes; one pipe (station 0) is at the expected location of the pipeline but may actually be a culvert which was observed between two storm drains. A second pipe is observed 12 ft (3.7 m) to the south (station 12). The latter time section was collected about 30 ft (9 m) to the east of the first time section, on a grass surface. Poor depth of resolution is noted. The known location of the culvert is partially discernible on the section. The lack of resolution is due to poor depth of penetration and is attributed to absorption of GPR signals by the presence of silt and clay in the soil/fill.

Conclusions and Recommendations

Results of the reconnaissance surface geophysical surveying are summarized below.

- The pipeline can be considered geophysically non-magnetic and non-electrical. Sweeping within inches of exposed pipe with a metal locator indicated no magnetic response. Placing an inductive current source around the pipe and sweeping with the metal locator also resulted in no response. Sweeping with the ground-conductivity meter and magnetometer resulted in negligible responses. These observations are consistent with a stainless steel pipe that has a high concentration of nickel.

- The presence of numerous cultural features (e.g., power lines, buildings, other buried pipelines, etc.) has an adverse affect on the quality of EM and magnetic data. Such features are expected to have an adverse affect on data quality for most surface geophysical methods except GPR.

- High-quality GPR data that indicated the presence of pipes were collected along some transects located on asphalt; poorer quality data were collected along adjacent transects located on grass. The difference in quality is probably related to different types of soil/fill. It is suspected that soil/fill beneath roads is more permeable and relatively dry as compared to adjacent areas. Beneath grassy areas, data quality degrades due to absorption of GPR energy by partially saturated silt and clay-rich soils. Using a longer wavelength antenna than was used in the reconnaissance surveying in order to achieve greater depths of penetration would not provide needed resolution to detect the relatively small pipeline.

Based on results of testing, it is recommended that no additional geophysical surveying be conducted to help define the presence/location of the pipeline. Future efforts should concentrate on a strategy of selective subsurface sampling using as-built diagrams to guide the choice of sample locations.

References

Battelle, 1989. RCRA Facility Investigation Plan, General Document, Y-12 Plant, Oak Ridge, Tennessee: submitted to Martin Marietta Energy Systems, Inc., pp. 4-7 through 4-12.

Breiner, S., 1973. Applications Manual for Portable Magnetometers: GeoMetrics, Sunnyvale, CA, 58 pp.

Science Applications International Corporation, 1992. Draft-Sampling and Analysis Plan for the Abandoned Nitric Acid Pipeline: submitted to Environmental Restoration Division, Oak Ridge Y-12 Plant, 13 pp.

Martin Marietta Energy Systems, Inc., 1992a. Abandoned Nitric Acid Pipeline, Section E-2, 5/8/92, 1 sheet.

Martin Marietta Energy Systems, Inc., 1992b. Abandoned Nitric Acid Pipeline, Section F-3, 5/8/92, 1 sheet.

Martin Marietta Energy Systems, Inc., 1991. Oak Ridge Y-12 Plant Building Location & Directory, 1 sheet.

U.S.G.S., 1989. Bethel Valley, Tennessee Quadrangle Topographic Map, 1:24,000-scale, 1 sheet.

Signatory of Report

Field Work: June 15 and 16, 1992

Field Crew: Brian Damiata, SAIC - Boulder, CO
Greg Van, SAIC - Boulder, CO
Kurt Oschmann, SAIC - Oak Ridge, TN
Rocky Walker, DOE - Oak Ridge, TN

Equipment: 1 AST 386SX portable computer
1 Geonics EM-31D ground conductivity meter
1 GSSI SIR-3 ground-penetrating radar system with 300 MHz antenna
1 GSM GEM-19 proton-precession magnetometer/gradiometer
1 Schondstedt MAC-51B metal locator

Prepared by: Brian Damiata, SAIC - Boulder, CO
Greg Van, SAIC - Boulder, CO

Responsibility for Contents: Brian Damiata

Brian Damiata
Supervisory Geophysicist

Date: 7/21/92

APPENDIX C

ABANDONED NITRIC ACID PIPELINE PROJECT SAMPLING LOG

Boring No.:6 pg 1 of 1	Date:1-29-93
Coordinates: E 55889.05 N 30703.63	Elevation: 992-69

Depth (ft)	Description
25-4.5	Weathered shale with silts 30% and clay 30%. Weathering reddish colored stain on shale. Shale is lightly grey(5G 6/1)
5-7	Weathered shale with 40% clays, 10% silts. saprolitic material. Shale is light grey with greenish tint. Some small angular black pieces.
8-10	Weathered shale, silts, and clays. A few pieces of gravel road fill.
11-13	Broken shale bedrock. Distinctly different color than before. Dark grey (3N3). Some sand.

Boring No.:9	pg 1 of 1	Date:2-2-93
Coordinates: E 54811.05 N 30696.61		Elevation: 1014.52

Depth (ft)	Description
0-5	Small shale fragments mixed with clay and mud. Some small black pieces (not sure what this is). A few pieces of road gravel. Shale is light green/grey.
approx. 8	Small shale fragments mixed with clay and mud. High clay and moisture content. Shale is pale yellowish green when fresh 10 G 7/2
8-10	Highly weathered shale mixed with 60% clay.
11-13	High moisture content. Shale residual, clay and mud.
14-16	Saprolitic shale, silts and clay. Dark staining on the shale moisture content is less than before.
16-18	Weathered shale saprolitic fragments mixed with silts and some clays. Lower moisture content.
21-23	Weathered shale fragments, sand, silt with little clay. Powdery texture.

Boring No.:10A pg 1 of 1

Date:1-30-93

Coordinates: E 54620.04 N 30672.98

Elevation: 1014.41

Depth (ft)	Description
0-4	Fill derived gravels, poorly sorted, light grey to moderate yellowish brown 10YR 5/4. Some small black pieces.
4.5-6.5	Muddy clay, dark yellowish orange 10YR 6/6 possibly small pieces of greenish colored weathered shale
8-10	Highly weathered shale and clay, saprolite material, dark yellowish orange 10YR 6/6
11-13	Weathered shale and clay, some silts, dusky yellow 5Y 6/R
14-16	Weathered shale and clay, some silts, pale olive (fresh color) shale 10Y6/2
17-19	Weathered shale and clay, some sandy material.

Boring No.:11 pg 1 of 1	Date:1-27-93
Coordinates: E 30632.07 N 54315.03	Elevation: 998.04

Depth (ft)	Description
0-5	overburden, brown, crmbly, some red brick at 0.5 ft., silty
5	6.5 clay, moist, grayish green, dense
10	clay in top, dry silty clay in bottom Hit rock at approx. 14.5 ft. Took sample. Got 6in. recovery. Gray shale, wet, broken, crumbly.
15	Stopped hole at 14.5ft.

Boring No.:14	pg 1 of 1	Date:1-28-93
Coordinates: E 53810.25 N 30566.06		Elevation: 1014.32

Depth (ft)	Description
1-5	Brown , silty, loose, some moisture, clayey dirt.
7-9	Clay, reddish brown, gray blobs, few black spots like lignite, dense.
10-12	Clay, hard, dry, reddish brown, gray lenses, hard black lens about 3in. thick, not sure what this is.
13-15	Clay same as above, not as much black lens.
16-18	Clay same, hard, dense, black lenses could be lignite or weathered shale.
20-22	Clay, brown, silty, slight sand, weathered rock, wet, water.

Boring No.:15A	pg 1 of 1	Date:2-3-93
Coordinates: E 53321.46	N 30501.79	Elevation:1014.63

Depth (ft)	Description
4-6	Saprolitic shale with high clay and moisture content. Some small shale fragments light green to grey in color.
7-9	Same as above but with less moisture and more silts.
10-12	Weathered shale mixed with silts and sands. Moisture content is low.
13-15	Same as above. Black staining on some pieces of the shade.
17-17.5	Weathered shale with powdery texture. Completely different than last sample. Color is light grey. Little moisture.

Boring No.:16A pg 1 of 1	Date:2-5-93
Coordinates: E 53060.31 N 30468.03	Elevation: 1019.30

Depth (ft)	Description
8-10	Heavily weathered shale fragments mixed with moderate clay content. Shale fragments are light greyish/green 5GY 6/1. A few pieces of road gravel fill material.
11-13	Weathered shale mixed with sands, silts, and clay. Less moisture content than last sample. Some black staining on the shale pieces.
14-16	Same as above but with higher moisture content and more black staining of the shale pieces.
16-18	Weathered shale mixed with sands and silts. Little clay shale is a light greenish/grey 5 GY 6/1

Boring No.:17 pg 1 of 1

Date:2-3-93

Coordinates: E 52876.10 N 3044.17

Elevation: 1001.25

Depth (ft)	Description
0-5	Shale, clay-rich residual soil. Some small to medium sized road gravel fill material. High moisture content.
5-10	Shale clay-rich residual soil, some small shale fragments which are light green to grey in color. High moisture content.
10-12	Same as above. Soil has a reddish/orange color. Some small shale fragments and a few pieces of road gravel fill. High moisture content.
13-15	Pieces of weathered shale mixed with sands, silts, and clay. Less moisture content than last sample. Black staining on some of the shale pieces.
16-18	Pieces of weathered shale mixed with sands and silts, little clay content, little moisture.

Boring No.:18A pg 1 of 1	Date:2-3-93
Coordinates: E 52682.43 N 30407.09	Elevation: 1016-33

Depth (ft)	Description
4-6	Weathered shale mixed with sands and silts. Little clay.
8-10	Same as above. Some black staining on the shale fragments.
11-13	Same as above. Shale has more of a brownish color in this sample. Less moisture than last sample.
14-16	Same as above. More clay in this sample. Shale fragments are a light olive green to grey.

Boring No.:19 pg 1 of 1 **Date:2-5-93**

Coordinates: E 52589.11 N 30385.91 **Elevation: 1013.59**

Depth (ft)	Description
2-6	Small shale fragments mixed with some road gravel pieces, silts, sands, and clay. Shale has a weathered reddish stain. Some of the shale pieces are more weathered (saprolitic) than other pieces of shale.
7-9	Shale fragments mixed with muddy clay. Higher moisture content than last sample. Shale fragments are a light grey (7N7) Some black staining on the shale fragments.
10-12	Saprolitic shale fragments. Different than last sample due to lower moisture content. Sands and silts are prevalent. Shale is pale to moderate yellowish brown with somw black staining.
12-14	Saprolitic shale fragments mixed with sands and silts. Color is the same as last sample. Black staining is still evident.
15-17	Weathered shale and silts. Pale to moderate yellowish brown. Some orange and black stain is on the shale fragments.

APPENDIX D

ABANDONED NITRIC ACID PIPELINE PROJECT QUALITY ASSURANCE SURVEILLANCE REPORT

ENVIRONMENTAL TECHNICAL SUPPORT

QUALITY ASSURANCE SURVEILLANCE REPORT

321.930712.001

1. Surveillance Number ETS-93-002

2. Date(s) of Surveillance 1-28-93

3. Organization & Location SAIC ETS Task Y-03
ANAP

4. Surveillance Team Members:
Stephanie Mathis

5. Personnel Contacted:
Greg Schank - SAIC
Eric Corbin - SAIC
Mike Goldman - SAIC H&S
David Barbour - SAIC
Tim Coffey - SAIC Escort
Rocky Ross - Driller
Phil Getsi - Driller Helper
D J Lee - Escort
Mitch Guinn - ES

6. Scope: Describe document(s) evaluated, test(s) witnessed, and activities monitored.
The purpose of this surveillance was to observe the soil sampling process and ensure that all procedures and plans were being followed.

7. Requirements: Describe or list the requirements governing the activity or item surveilled.
ESPs 303-4 & 500, MMES ER/C-P2302 (IAD) & MMES ER/Y-P2103 (IAD), ANAP Quality Assurance Project Plan

8. Results: Describe results of testing, witnessing, and monitoring activities. A brief summary
A Health and Safety briefing was given upon arrival at the site. Drilling and sampling were being performed following ESP 303-4 with modifications made in the QAPjP. Samples were packaged, labeled, and shipped in accordance to ER/C-P2302 (IAD). All logbooks were complete and in order according to ESP 500. cont.

9. Attach Nonconformance Reports (if applicable) NCR-93-ETS-005

Prepared by: Surveillance Team Leader — Date 2-18-93

Approved by: James C Brannan QA/QC Officer — Date 7-12-93

cc: G Schank Prog/Proj Manager — Task Leader(s) — SAIC Surveilled Organization — above Team Members — S. Walker Other(s)

ETS-93-002 : Continued

Equipment was calibrated daily and recorded in the logbook.
Soil was put back in the hole after sampling was completed. Excess soil was durmmed per request of Mitch Guinn of Energy Systems.

The following problems were identified during this surveillance:
There was a problem with 2 chain-of-custody forms, 00797 and 00796. The pink copy of the 2 c-o-c forms was not signed in the "Received by" space. The original and the yellow copy were in the refrigerator at the Y-12 storage facility. The original was signed and the yellow copy had a faint impression of a signature.
The QAPjP was not in the field with the crew.
There was no plastic on the ground under the drill rig.

Attached is a 9 page checklist used in the field during the surveillance.

UNIVERSAL
FIELD OVERVIEW
CHECKLIST

Site Name ANAP

Location Hole # 14

Study Date(s) 1-28-93

Facility Contact Steve W-eker

Phone Number —

Contractor/State Personnel MMES

Address Y-12

Phone Number —

Project Leader Greg Schank

Other Contractor/~~State~~ ES Personnel Mitch Ginn

ESD Overview Personnel N/A

Other Personnel and Affiliation

Eric Corbin
David Becker
Michael [illegible] · MES
Rocky [illegible] - driller
Phil [illegible] " helper
Tim Coffey · escort
DT [illegible] "

Section No. 2
Exhibit No. 1
Date: 4/1/86
Page 2 of 9

PLANNING AND PREPARATION

Y or N

1) Was a study plan, work plan, site operations plan, etc. issued for this investigation? Y

Date Issued ?

If YES:

Was the study plan reviewed by ESD? ___

Was the ~~study~~ StA Y plan acceptable? SSP yes ___

H&S Y QAPP No

SAMPLING

General Procedures

1) Were sampling locations properly selected? Y

If No, explain Survey stakes

2) Were samples collected starting with the least likely contaminated and proceeding to the most likely contaminated? ___
Remarks

3) Were new disposable rubber gloves worn during collection of all samples? Y
Remarks

4) Was sampling equipment wrapped in aluminum foil and protected from possible contamination prior to sample collection? Y

If No, explain

5) If equipment was cleaned in the field, were proper procedures used? (This includes storage method for rinse water and solvents) Y

If No, explain

6) What field instruments were used during this investigation?
HNu, Gamma, Rad Victoreen 190, 450, LEL

Y or N

7) Were field instruments properly calibrated? Y

If No, explain

8) Were calibration procedures documented in the field notes? Y
Remarks

9) Were the samples chemically field preserved? NO
If No, explain Soil Samples - not required

10) Were the samples iced? Y

11) Were samples for selected parameters field filtered? N

If Yes, list parameters and describe procedures.

Well Sampling N/A

ST-12?? ST- reg?? ST-

1) Was depth of well determined? ~~20'~~ ~~22'~~ ~~Y~~

2) Was depth to water determined? ~~20' @ bedrock~~ ~~Y~~

3) Were the above depths to water converted to water level elevations common to all wells? N/A

Describe how the depths were determined

4) How was the volume of water originally present in each well determined? N/A

5) Was the volume determined correctly? N/A

6) How was completeness of purging determined? N/A
Volume
Measure_____
Time/Flow rate_____
Cond./pH/T_____

7) Was a sufficient volume purged? N/A

Was the well over-purged? N/A

Y or N

8) Was a dedicated (in-place) pump utilized? N/A

If no, describe the method of purging (bailer - include type and construction material, pump - include type)____________________

9) How were the samples collected?
Bailer______
Pump______
Combination______ N/A
Construction material of bailer:____________________

Design of bailer
Open Top______
Closed Top______ N/A
Other____________

10) If a pump was used, describe how it was cleaned before and/or between wells.____________________ N/A

11) Was the sample properly transferred from bailer to sample bottle (i.e., was the purgeable sample agitated, etc.)? N/A

12) Was the rope or line allowed to touch the ground? N/A

13) Was any wetted rope or line discarded after use at each well? N/A

14) How many wells were sampled? N/A

Surface Water Sampling N/A

1) What procedures and equipment were used to collect surface water samples? N/A
____

Who collected samples?____________________

2) Did the samplers wade in the stream during sample collection? N/A

If Yes:

Did the sampler face upstream while collecting sample? N/A

Did the sampler insure that roiled sediments were not collected along with water sample? N/A

Y or N

3) Note any deficiencies observed during the collection of the surface water samples N/A

Waste, Sludge, Soil/Sediment Sampling

1) What procedures including equipment were used to collect soil/sediment samples? 303 Y modified

2) Were the soil/sediment samples well mixed prior to placing the sample in the sample container? Y

3) Note any deficiencies observed during the collection of the soil/sediment samples N/A

Total number of samples collected Observed 3

Other Sampling

1) What other types of samples were collected during this investigation? N/A

2) What procedures were used for the collection of these samples? N/A

Who collected samples?

QUALITY ASSURANCE/QUALITY CONTROL

Y or N

(While all of these QA/QC procedures are not necessarily used, please identify the specific techniques which were employed by sampling personnel.)

1) Did the sampling personnel utilize any field trip blanks? No

no VOCs in water

Y or N

2) Did the sampling personnel utilize preservative blanks? NO

If Yes, to either of the above questions, list the types and handling of the blanks

3) Were any equipment blanks collected? yes

If Yes, list: 1-02-93

4) Were any duplicate samples collected? NO

If Yes, list the types (parameter coverage, etc.) and describe their handling. well take in holes # 10, 19

5) Were any spiked samples utilized? NO

If Yes, list the types (parameter coverage, etc.) and describe their handling.

FIELD DOCUMENTATION AND CHAIN-OF-CUSTODY

1) Were split samples offered to the site owner or facility representative? N/A

2) Was a receipt for samples given to the site owner or facility representative prior to leaving the site? Yes

3) Were chain-of-custody records completed for all samples? Yes

4) Were sample tag numbers and laboratory traffic report form numbers cross referenced to chain-of-custody forms? yes

5) Were chain-of-custody form numbers recorded in the field log book? yes

6) Were all samples properly sealed at the time of collection? yes

7) Were samples locked in vehicle or kept in a secure place after collection? yes

	Y or N
8) Were all sample tags and chain-of-custody forms signed by sample collector(s)? [illegible]	NO
9) Were sampling locations adequately documented?	yes
If No, explain	
10) Was sampling documented with photographs?	NO
If Yes, was a photolog maintained?	
11) Were the samples shipped to a contract laboratory?	NO
If Yes: Not ~~yet~~ yet Stored on site	
Were the traffic report forms filled out properly?	N/A
Were the samples properly packed for shipment?	yes

STATE REGULATORY AGENCY PERSONNEL	Y or N
Qualifications of investigative/sampling personnel (training and experience) by names	
Have investigative/sampling personnel received sampling technique and equipment training?	yes
Have personnel received safety training?	yes
If yes to either of the above questions, list where and when the training was received and who provided the instruction. SAME; H&S officer • PI	
Do the investigative/sampling personnel undergo periodic refresher training regarding safety?	yes
Did the investigative/sampling personnel have appropriate safety equipment in their possession during this inspection?	yes
If YES, describe the equipment which was available and/or used during this inspection. fire extinguishers, eye wash, hard hats, coveralls, safety shoes, first aid kit, safety glasses, hearing protection	
If NO, list the equipment which was needed.	

	Y or N
Have the investigative/sampling personnel been categorized as to the type of inspections they can conduct?	Yes
Have the investigative/sampling personnel had comprehensive physicals?	Yes
Do the sampling personnel participate in a medical monitoring program (i.e., periodic follow-up physicals)?	Yes
If yes, how often? yearly	

Do the investigative/sampling personnel perform the entire RCRA Interim Status Inspection or merely collect samples? N/A

If the personnel only collect samples, how are their sampling efforts coordinated with the rest of the inspection? N/A

If state personnel did not collect samples, did they thoroughly evaluate sampling procedures used by facility? N/A

If facility collected samples, did state representatives accept a split sample(s)? N/A

SOP (Applies only to state overviews)

Has the state developed an SOP for RCRA field sampling?	
Did the state personnel have a copy of the SOP with them during this inspection?	

What does the SOP Cover?

Field inspections in general (sampling techniques, etc.)
Sample handling ______
Sample I.D. and chain-of-custody ______
Uses and limitations of various types of bailers and pumps ______
Equipment cleaning ______
Field measurements (cond., pH, T, etc.) ______
Calibration of field instruments ______
Other ______

Did they follow their SOP during this inspection?	

MARTIN MARIETTA

Internal Correspondence

Ltr.#ER/L-Y-93/022

MARTIN MARIETTA ENERGY SYSTEMS, INC.

February 18, 1993

3[illegible]0.930302.008

W. R. Brown, Jr.

Environmental Restoration Program Surveillance of the Y-12 Plant Environmental Restoration Program's Field Sampling Activities Associated With the Abandoned Nitric Acid Pipeline Project

Please find enclosed a surveillance report which addresses the results of the completed surveillance of the Y-12 Plant Environmental Restoration (ER) Program for Field Sampling Activities Associated With the Abandoned Nitric Acid Pipeline (ANAP). The surveillance was conducted by Quality Assurance and the Technical and Field Coordination section of Y-12 Plant ER on February 3-5, 1993, and focused on the sampling team activities, interviews with responsible Y-12 Plant ER personnel, ANAP sampling contractor personnel, and a review of the existing documentation.

As a result of the surveillance, five findings and three negative observations were identified which warrant your attention. The findings and negative observations are documented on the Surveillance Finding/Observation Forms included with the enclosed surveillance report.

Please transmit your formal response to the findings and negative observations to me for review and acceptance within 30 calendar days of the date of this correspondence. Your responses are to be documented on the Surveillance Finding/Observation Response Forms and processed in accordance with ER/C-P1600, Rev. 0. Upon my acceptance of your response, the approved responses will be logged and tracked to closure.

If you have questions regarding the enclosed surveillance report, please contact me.

Hugh C. Newsom

Hugh C. Newsom, 9983-AH, MS-8247 (6-5810)

HCN:lsh

Enclosures:
1. Surveillance Report
2. Surveillance Plan
3. Surveillance Checklist

cc/enc: J. S. Colley
M. F. P. DeLozier, Enclosure 1
C. W. Kimbrough, Enclosure 1
C. G. Hudson
C. S. Walker
D. C. White
File—ER Document Management Center—RC
File—Y-12 ER Program—NoRC

Enclosure 1

SURVEILLANCE REPORT
ENVIRONMENTAL RESTORATION PROGRAM

Surveillance No. 93Y-01
Surveillance Topic: Sampling Activities Associated With the ANAP Project
Surveillance Schedule: February 1-5, 1993

I. Objective(s)

Determine if the ANAP Contractor and/or Subcontractor are conforming to the field Quality Assurance Project Plan (Y/ER-44, Rev 2), the Sampling and Analysis Plan (Y/ER-45, Rev 2) and the Environmental Restoration Quality Program Plan (ES/ER/TM-4/R2).

II. Scope and Approach

The surveillance focused on the fundamental requirements of the field sampling process, including personnel training, use of appropriate procedures, labeling of samples, utilization of field documentation, use of QC samples, the chain-of-custody process, field instruments calibration records, and the Field Change Request Process.

III. Activities Performed and Results

The surveillance was conducted to determine if the ANAP Contractor and/or Subcontractor are conforming to the field Quality Assurance Project Plan, the Sampling and Analysis Plan and the Environmental Restoration Quality Program Plan. The surveillance revealed five findings and three negative observations.

Finding 93Y-01-01

- No available documentation was furnished to indicate GeoTek personnel (SAIC drilling contractor) received training on applicable procedures governing cleaning and decontamination of sampling devices.

Finding 93Y-01-02

- There were no copies of the appropriate Environmental Surveillance Procedures on hand at the sampling/drilling site for field personnel to use.

Finding 93Y-01-03

- All samples being collected on 2/3/93 had seals with collector's initials and date, but did not contain the time when sampling took place.

Negative Observation 93Y-01-04

- Sample labels listed analytical method 6010 for both ICP and AA, when only applicable for ICP.

Negative Observation 93Y-01-05

- The designator code process for samples contained in SAP did not include coding for QC samples.

Negative Observation 93Y-01-06

- The O^2/LEL instrument, which was part of the instrument inventory at the field sampling site, was past due for annual calibration.

Enclosure 1

Finding 93Y-01-07
- The ANAP field and Laboratory Quality Assurance Project Plans were issued without required signatures.

Finding 93Y-01-08
- A VOA Sample was collected on 1/30/93 and sent to the Y-12 Lab for analysis without a required trip blank.

IV. Team Leader and Team Members

H. C. Newsom, Y-12 Plant ER QA Specialist, Team Leader
C. S. Walker, Y-12 Plant ER Assessment Specialist

SURVEILLANCE FINDING/OBSERVATION FORM
Environmental Restoration Program

[illegible] Hugh C. Newsom	Finding/Observation Number 93Y-01-01
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

<u>Y/ER-44, R2 - Section IIB (Readiness Review Form)</u> - Subcontractor assigned field personnel have been trained on the SOPs that govern their work assignments.

<u>Y/ER-44, R2 - Section IIIB (Readiness Review Checklist)</u> - Documented evidence that the assigned field personnel have been adequately trained in the specifics of this project to accomplish their tasks will be provided.

__X__ FINDING _____ NEGATIVE OBSERVATION _____ POSITIVE OBSERVATION

GeoTek (SAIC drilling contractor) personnel were observed on the date this surveillance was conducted, 2-3-93, decontaminating sampling collection equipment, the split-barrel samplers. One GeoTek employee, expressing some unfamiliarity, was at the decontamination pad performing decontamination while drilling operations continued. Available documentation does not indicate GeoTek personnel received training on the applicable procedure governing this activity, ESP-900 "Cleaning and Decontaminating Sample Containers and Sampling Devices."

RECOMMENDATION(S):

Ensure personnel are trained to all applicable procedures.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Surveillance Team Member Hugh C. Newsom	Finding/Observation Number 93Y-01-02
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

Y/ER-44, R2, Section II of the Readiness Review Form - Appropriate SOPs will be on-site and available to the field personnel.

X FINDING ____ NEGATIVE OBSERVATION ____ POSITIVE OBSERVATION

There were no copies of the appropriate Environmental Surveillance Procedures on hand for field personnel to use on the d[illegible] of this surveillance (2-3-93).

RECOMMENDATION(S):

Provide field personnel with controlled copies of the appropriate and applicable Environmental Surveillance Procedures.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Surveillance Team Member Hugh C. Newsom	[illegible] 93Y-01-03
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

ESP Procedure ESP-500, Section VIIC 2 and 3 - All samples will have a sample seal affixed which includes the collector's name, date and time of sampling.

__X__ FINDING ______ NEGATIVE OBSERVATION ______ POSITIVE OBSERVATION

All samples being collected on the date of this surveillance (2-3-93) had seals with collector's initials and date, but did not contain the time when sampling took place.

RECOMMENDATION(S):

Follow ESP-500 procedure in this area and make appropriate personnel aware of the procedure's requirement.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

C. Steve Walker	93Y-01-04
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

________ FINDING ___X___ NEGATIVE OBSERVATION ________ POSITIVE OBSERVATION

Sample labels for trace metals analysis on this project had the following printed on them: "AA/6010 or ICP/6010." The analytical method 6010 is an Inductively Coupled Plasma (ICP) method, whereas the method by Flame and Graphite Furnace Atomic Absorption Spectroscopy (AA) is the 7000 series.

RECOMMENDATION(S):

Ensure the participating lab(s) understand what analysis and methods are desired. Revise sample labels for any additional or future sampling.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Surveillance Team Member **Hugh Newsom**	Finding/Observation Number **93Y-01-05**
Organization **Y-12 Environmental Restoration**	Contact **Charles Hudson**

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

______ **FINDING** __X__ **NEGATIVE OBSERVATION** ______ **POSITIVE OBSERVATION**

The Sampling and Analysis Plan (Y/ER-45, R2), page 7, Section 7.6.2.1, is being followed to provide a coding process for samples being collected. However, the existing designator code does not provide for coding of the QC samples.

RECOMMENDATION(S):

Revise the SAP to provide for QC sample coding or issue a field change to clarify the QC sample coding process, so that a straightforward interpretation can be made from the codes being used on the chain-of-custody forms.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Hugh C. Newsom	93Y-01-06
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

______ FINDING __X__ NEGATIVE OBSERVATION ______ POSITIVE OBSERVATION

[illegible]e instrument O^2/LEL (Oxygen/Lower Explosion Level) Meter Model-MX251, SN1914, was last calibrated 1-6-92. An [illegible]umption is made that the instrument should be calibrated annually. This instrument is listed as instrument No. 7 on page two of the field log book. The instrument was not in use at the time, but was part of the instrument inventory at the field sampling site.

RECOMMENDATION(S):

Ensure referenced instrument is within calibration, and define instrument calibration frequency and requirements for each instrument that is to be used in the field sampling inventory for future projects.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Surveillance Team Member Hugh C. Newsom	Finding/Observation Number 93Y-01-07
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

Remedial Investigation Work Plan Outline, DOE/OR/01-1077 - The following personnel shall sign and date each Quality Assurance Project Plan (QAPjP), signifying review:
(1) Technical Support Contractor Program Mgr.;
(2) Technical Support Contractor QA/QC Officer;
(3) DOE-ER Site Program Manager;
(4) DOE-ER Division QA Program Manager;
(5) Energy Systems ER Site Program Manager;
(6) Energy Systems ER Site Project Manager;
(7) Energy Systems ER Site Quality Assurance Specialist.

__X__ FINDING ________ NEGATIVE OBSERVATION ________ POSITIVE OBSERVATION

The Field and Laboratory Quality Assurance Project Plans for the Abandoned Nitric Acid Pipeline were issued without obtaining the required signatures referenced above.

RECOMMENDATION(S):

Obtain the required approvals and follow the stated requirements in the future.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE FINDING/OBSERVATION FORM

Environmental Restoration Program

Surveillance Team Member Hugh C. Newsom	Finding/Observation Number 93Y-01-08
Organization Y-12 Environmental Restoration	Contact Charles Hudson

SUBJECT:
Field Sampling Activities Associated With the ANAP Project

REQUIREMENT(S):

Y/ER-44, Revision 2, Page 24, Section 8.8 - One Trip Blank is to accompany each cooler containing VOA samples. Each Trip Blank is to be stored at the laboratory with associated samples and analyzed with those samples.

__X__ FINDING ______ NEGATIVE OBSERVATION ______ POSITIVE OBSERVATION

According to chain-of-custody record S00808, sample N01003 with custody seal number 48 was collected on 1-30-93 and sent to the Y-12 Lab for analysis of VOCs (VOA), Lot Number 2083013. However, a trip blank did not accompany this batch of samples.

RECOMMENDATION(S):

Validation of Lab data must incorporate the deficient condition as stated above concerning VOA sample N01003. Enhance involved personnel's awareness of this important requirement.

Surveillance Team Leader Hugh C. Newsom	Validator (for findings and negative observations) Charles Hudson

SURVEILLANCE PLAN
ENVIRONMENTAL RESTORATION PROGRAM

Surveillance No. 93Y-01
Surveillance Topic: Sampling Activities Associated With the ANAP Project
Surveillance Schedule: February 1-5, 1993

Objective(s)

Determine if the ANAP Contractor and/or Subcontractor are conforming to the Field Quality Assurance Project Plan (Y/ER-44, Rev 2), the Sampling and Analysis Plan (Y/ER-45, Rev 2) and the Environmental Restoration Quality Program Plan (ES/ER/TM-4/R2).

Scope and Approach

An evaluation will be made of the field sampling process including personnel training, use of appropriate procedures, labeling of samples, utilization of field documentation, use of QC samples, the chain of custody process, field instruments calibration records, and the Field Change Request Process.

Activities To Be Evaluated

(1) Training records of sampling personnel.
(2) Use of appropriate procedures on site.
(3) Correct use and marking of sample containers, seals, labels.
(4) Proper utilization of required field documentation.
(5) Correct use of QC samples.
(6) The chain of custody process.
(7) Calibration of field instruments.
(8) Field Change Request Process.

Requirements Documents

(1) Field and Laboratory Quality Assurance Project Plans for The Abandoned Nitric Acid Pipeline (Y/ER-44, Rev 2).
(2) Sampling and Analysis Plan for The Abandoned Nitric Acid Pipeline (Y/ER-45, Rev 2).
(3) Environmental Restoration Quality Program Plan (ES/ER/TM-4/R2).

Team Leader and Team Members

H. C. Newsom, Y-12 ER QA Specialist, Team Leader
C. S. Walker, Y-12 ER Assessment Specialist

Surveillance Checklist Attached

PREPARED BY Hugh C. Newsom **DATE** 2-1-93

SURVEILLANCE CHECKLIST

Environmental Restoration Program

Surveillance Number 93Y-01	**Date** February 17, 1993
[illegible] Field Sampling Activities Associated With the ANAP Project	**Prepared By** Hugh C. Newsom
Organization Y-12 Environmental Restoration	**Approved By** Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	Description	Sat	Unsat	Remarks
1.	Contractor personnel actively involved in the ANAP field sampling effort are trained to the ESP procedures being used. (Reference the Readiness Review Checklist, Sections II.B and III.B in Y/ER-44, R2.) Procedures are: ESP-303-1 - Soil Sampling With Spade & Scoop (MOD Sh. 1-9) ESP-303-2 - Soil Sampling With an Auger (MOD Sh. 1-6) ESP-303-4 - Penetration Test and Split Barrel Sampling (MOD Sh. 1-10) ESP-307-6 - Field Measurements Procedures-OV Detection (MOD Sh. 1-4) ESP-307-7 - Field Measurements Procedures-Operation of Radiation Survey Insts. (MOD Sh. 1-3) ESP-500 - Manual Chain of Custody Procedures (MOD Sh. 1-10) ESP-701 - Sample Preservation and Container Materials ESP-900 - Cleaning & Decontaminating Sample Containers and Sampling Devices (MOD Sh. 1-16) ESP-901 - Equipment Decontamination (MOD Sh, 1-3)		X	No Training Records furnished by the Subcontractor. Request was made on 2/3/93; no receipt of any as of 2/18/93 (Finding 93Y-01-01). This applies to GeoTek personnel only. Records exist for SAIC personnel.
2.	An up-to-date copy of the procedures listed in No. 1 is at the drilling site. (Reference RR Checklist Section II.B.)		X	None of the ESP procedures listed in No. 1 were located at the Drilling Site (Finding 93Y-01-02).

SURVEILLANCE CHECKLIST
Environmental Restoration Program

Surveillance Number 93Y-01	**Date** February 17, 1993
Surveillance Topic Field Sampling Activities Associated With the ANAP Project	**Prepared By** Hugh C. Newsom
Organization Y-12 Environmental Restoration	**Approved By** Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	**Description**	**Sat**	**Unsat**	**Remarks**
3.	Sample container are marked in accordance with the following requirements.			
	(A) Sample seals are used and marked in accordance with ESP-500 Section VII.C. The seal includes the collector's initials, date, and time.		X	Sample seals are being marked with collector's initials and date, but does not include the time. The APO organization (Joe Pardeu) advised that the time should be on the seal as well as on the label (Finding 93Y-01-03).
	(B) Sample labels contain the following as a minimum: 1) activity or study ID; 2) unique sample no.; 3) sample location; 4) sampling date and time; 5) sample preservation used; 6) media sample or sample type; 7) analyses required; 8) comments or special precautions.		X	Sample labels are being marked with the items listed under "B" with the exception of No. 5 which is not applicable. One problem was noted and is as follows: sample labels for Metals Analysis on this project had the following - "AA/6010 or ICP/6010." According to the "Guide to Environmental Analytical Methods" by Robert E. Wagner, Method 6010 is an ICP method only (Negative Observation 93Y-01-04).
	(C) Samples collected are identified by using the following designator N00101: N = ANAP 001 = bore hole location (1) 0 = designates a soil sample 1 = first sample collected from the bore hole (Reference the SAP, page 7, Section 7.6.2.1.)		X	Samples are being collected and identified by using the SAP designators. However, the SAP does not allow for coding of the QC samples. A field manual was used to provide this code. SAP should be revised via a field change to reflect the code being used (Negative Observation 93Y-01-05).
4.	Field documentation is properly utilized and consists of the following.			

SURVEILLANCE CHECKLIST

Environmental Restoration Program

illance Number 93Y-01	Date February 17, 1993
Surveillance Topic Field Sampling Activities Associated With the ANAP Project	Prepared By Hugh C. Newsom
Organization Y-12 Environmental Restoration	Approved By Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	Description	Sat	Unsat	Remarks
	(A) Field Log Book with hard cover, stitched bindings, and water-resistant pages, containing entries as listed in ESP-500 Section VII.D with QAPjP modifications listed in Section 8.2.2.	X		Requirements for the field log book are being met.
	(B) Instrument calibration log sheets.	X		Requirements for B-D are being met.
	(C) Sample log sheets.	X		
	(D) Site log book, which documents each day's activities. (Reference for B-D is the SAP Section 7.7.1.)	X		
5	QC samples are being properly used in the following manner. (Reference Y/ER-44, Section 8.8.)			
	(A) Trip Blanks are being used when volatile organic samples are collected.			
	(1) Trip blanks are 40 ML of ASTM Type II water.	N/A		No Trip Blanks were being prepared while the surveillance was in progress. However, on 2/4/93, 2 Trip Blanks, TB0002, were collected per chain-of-custody sheet S00697. On 1/27/93, a Trip Blank was collected, TB0001, per chain-of-custody sheet S00797. A VOA sample was collected on 1/30/93 per chain-of-custody sheet S00808, sample no. N01003, but no Trip Blank was documented as being collected on this date (Finding No. 93Y-01-08).
	(2) Each Trip Blank is contained in a vial that is identical to the VOA sample container.	N/A		
	(3) One Trip Blank accompanies each cooler containing VOA samples as it leaves the drilling site.		X	

SURVEILLANCE CHECKLIST
Environmental Restoration Program

Surveillance Number 93Y-01	**Date** February 17, 1993
Surveillance Topic Field Sampling Activities Associated with the ANAP Project	**Prepared By** Hugh C. Newsom
Organization Y-12 Environmental Restoration	**Approved By** Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	Description	Sat	Unsat	Remarks
	(B) <u>Equipment Rinsate Samples</u>:			
	(1) Are samples of ASTM Type II water;	X		Rinsates are documented as being collected. 5 on 2/4/93, 3 on 1/27/93.
	(2) Collected each time the decon process takes place or as a minimum 10% of samples:	X		
	(3) Are analyzed for the same analyses as samples collected that day.	X		
	(C) <u>Field Blanks</u>: (1) Are begin taken of each source of water used for decontamination; (2) Field blanks are being sent to the Lab for analysis; (3) Field blank samples are ASTM Type II water.	N/A		No field blanks had been documented as of 2/4/93.
	(D) <u>Field Duplicate/Splits</u>: Samples submitted for VOA analyses are not being homogenized or split.	X		VOA samples were viewed being collected on 2/4/93 and were not being homogenized or split.
6.	The chain-of-custody record is being utilized in accordance with ESP-500 and Section 7.7.3 of the SA plan. based on the following items of evaluation.			
	(A) The client ID part of the form is in accordance with the SAP Section 7.6.2.1, with the following designator concept (N00101): N - project 000 - three-digit number identifies sample location 0 - designates a soil sample 1 - first sample collected from the bore hole		X	See Response for 3(c). The code does not include a code for QC samples in the SAP illustration. However, field personnel use an additional manual for the source of this applicable code (Negative Observation 93Y-01-05).

SURVEILLANCE CHECKLIST

Environmental Restoration Program

Surveillance Number [illegible]Y-01	**Date** February 17, 1993
Surveillance Topic Field Sampling Activities Associated With the ANAP Project	**Prepared By** Hugh C. Newsom
Organization Y-12 Environmental Restoration	**Approved By** Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	Description	Sat	Unsat	Remarks
	(B) The chain-of-custody form has the following items listed: (1) Unique Sample Number; (2) Field Study or Sampling Activity; (3) Date and time of sample collection: (4) Name of sampler(s); (5) Signature of the collector or field sample custodian: (6) Lab destination; (7) Waste type, if known; (8) Chain-of-custody control number; (9) The first person signing as relinquishing custody must be one of the sample collectors; (10) Signature and date blocks for personnel relinquishing or receiving sample custody are being completed and are legible.	X		The person signing in the "Samplers" block may not be the actual person collecting the sample, but they work as a team.
7.	Field instruments used are calibrated and cared for properly, based on the following elements.			
	(A) A list of all field measuring and test equipment to be used is available.		X	This list was in the field Site Log Book. One instrument appeared to be out of calibration listed as instrument no. 7 on page 2 of the field Log Book - O^2/LEL (Oxygen/Lower Explosion Level), Meter Model-MX251 SN 1914 last calibrated 1/6/92, assuming annual calibration required (Negative Observation 93Y-01-06).
	(B) A schedule for calibration for all M&TE is available at the drilling site.	X		This schedule is contained in Y/ER-44.
	(C) Instrument log books for each piece of M&TE are being maintained (reference Y/ER-44, Section 8.4.1).	X		Instrument log books for each piece of M&TE are not being maintained; however, equivalent information is available via the site Log Book and the field Log Book.

SURVEILLANCE CHECKLIST
Environmental Restoration Program

Surveillance Number 93Y-01	**Date** February 17, 1993
Surveillance Topic Field Sampling Activities Associated With the ANAP Project	**Prepared By** Hugh C. Newsom
Organization Y-12 Environmental Restoration	**Approved By** Hugh C. Newsom

ATTRIBUTES		RESULTS		
Item	Description	Sat	Unsat	Remarks
8.	Field change requests are used when variances are necessary and the process includes the following. (Reference Y/ER-44, Section 8.2.8.) (A) Variances from approved operating procedures and requirements documents are documented. (B) Variances are documented on: (1) Field change request forms; and (2) Nonconformance report forms. (C) Approval by the Project Manager and the QAS of a variance takes place before work proceeds. (D) The field coordinator chronologically maintains a variance log. (E) Y-12 ER Project Manager and QAS are notified and forwarded a copy of all nonconformances documented. (Reference ES/ER/TM-4/R2, Section 3.2.)	N/A		According to the field personnel on site, dates of 2/3/93 and 2/4/93, they were not aware of any field change requests being filed or being processed.
9.	The field and Laboratory Quality Assurance Project Plans for ANAP were issued with the required signatures indicating appropriate review and approval. (Reference the Remedial Investigation Work Plan Outline, DOE/OR/01-1077.)		X	The QAPjPs were issued without all of the required signatures (Finding 93-01-07).

ACTION PLAN
for the DOE surveillance
of the
Abandoned Nitric Acid Pipeline
Remedial Investigation Project

- List of Findings and tracking numbers
- Y-12 ER Response and root cause
- Summary description of corrective measures
- Itemized list of corrective measures and scheduled completion dates

Steve Walker

Y-12 Environmental Restoration Program

March 9, 1993

Summary

The Phase I field effort of the Remedial Investigation for the Abandoned Nitric Acid Pipeline was conducted from January 26, 1993 to February 9, 1993 and consisted of subsurface sampling at 19 locations along the location of the buried pipeline. Between one and three soil samples were obtained from each borehole depending upon subsurface conditions at that particular borehole. The samples were analyzed for total metals (ICP and selected AA), and leachable nitrate at the Y-12 Environmental Laboratory, and for isotopic uranium at Pace, Inc. of Golden, Colorado. The laboratory deliverables will be EPA level III, CLP-type data packages. The analysis results are pending.

On February 3, 1993.The Department of Energy, Oak Ridge conducted a surveillance of the field effort then in progress. The proficiencies, deficiencies and observations noted during the surveillance were transmitted to the Martin Marietta Energy Systems, Inc. Environmental Restoration Program on February 19, 1993. The findings and deficiencies were screened and it was determined that they did not constitute either an environmental non-compliance or a level I, II, or level III occurrence

Finding EQA-930203-A: **Sample storage coolers are not being maintained at or near the required EPA preservation temperature. (Priority II)(EPA SW-846)**

Response: The cooler used to temporarily store samples in the field contained ice every day during field operations in order to keep samples as cool as possible (the requirement is to cool the samples to 4°C, + or - 2°C) before transporting the samples to the lab each afternoon. Field personnel in charge of sample handling were maintaining a log of temperatures within the sample cooler throughout the project. On the afternoon of the surveillance, the field log book indicates that the two bags of ice in the cooler had partially melted and the temperature within the cooler was above 4°C . The individual from DOE conducting the surveillance observed the temperature in the cooler where the thermometer was located to be 15°C.

The coolers in question contained soil samples that had been obtained within the hour. The samples were at the temperature of the ground (or close to ambient air temperature) when taken (the high temp. in Oak Ridge that day was 57°F or 17°C according to the NOAA Atmospheric Turbulence and Diffusion Laboratory). The samples must also undergo processing before being placed in the cooler. Therefore, the samples were in the early stages of cooling to 4°C when observed by surveillance personnel. Their very presence in a cooler would tend to raise the temperature temporarily within the cooler until a temperature equilibrium od 4°C could again be achieved.

While a temperature of 15°C is a definite excursion from 4°C, this was a very temporary arrangement in the field that day. Samples were staged in the cooler until sampling activities ceased at that location, and the cooler could be taken to the Y-12 laboratory. Some samples were taken to the Y-12 ER sample refrigerator for overnight storage if sampling ceased too late in the day. This temperature excursion will not effect the validity of the samples.

Root Cause: The root cause was the fact that the samples had been obtained from the ground and were processed very recently before the surveillance (within an hour). The samples were at approximately 17°C when obtained from the ground and were either being processed or had just been processed and placed in the cooler. The placing of samples in the cooler and repeatedly removing and the placing them back (to process/label) temporarily increases the temperature of the cooler until equilibrium can be achieved. A contributing cause was an inability to obtain additional ice for the cooler due to excessive workload requirements for sample handling personnel involved in a fast-paced sampling effort. A single person was in charge of all sample labeling, all sample paperwork (this represents an inordinate amount of the sample handling workload) and maintaining most of the logbooks. The reason for the contributing cause was a slightly uneven distribution in the sample handling workload.

A second contributing cause was the fact that Y-12 ER agreed to begin field work on this project with a field team that was one person short of being complete. An additional trained field team member on site would have alleviated much of the problem; however, a better use of resources (personnel) could have reduced the demands on the field team leader and enabled him to train/orient the newer employee when he arrived on site.

Corrective Measures: The DOE personnel conducting the surveillance communicated this finding to the field team while on site. As soon as possible thereafter (when field operations ceased at that borehole location), more ice was added to the cooler and the samples were transported in the cooler to a secure, locked and refrigerated sample storage area.

The most effective corrective measure would be to handle the samples in such a way as to reduce the amount of opening and closing of the cooler. Additionally, have a more even distribution of the workload among field team members. The field sampling portion of this project has ended. To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.

Finding EQA-930203-B: Sampling equipment decontamination is not in strict accordance with required protocol and no approved variance exists. (Priority III)

Response: The MMES Environmental Surveillance procedure ESP-900 states that stainless steel sampling equipment to be utilized for trace organic analysis must be rinsed twice with pesticide grade isopropanol and allowed to air dry before usage. During the surveillance, the technician performing the decontamination procedure only rinsed the sampling equipment once with isopropanol. The technician observed performing the decontamination procedure during the surveillance had arrived on site approximately 2 hours before the surveillance (this was the field team member that was not present at the start of the project). The field team leader was heavily involved in the drilling/sampling effort and could afford only limited time to train or instruct the new field team member (who he knew to be experienced in operations at contaminated sites at Y-12). The new field team member was basically familiar with decontamination procedures in general, but he did skip one of the required rinses. This fact was brought to his attention during the surveillance and the situation was corrected immediately.

Root Cause: A lack of adequate site specific training was a factor in the finding. The primary root cause was an uneven distribution of work among field team members. An additional trained field team member on site would have alleviated much of the problem; however, a better use of resources (personnel) could have reduced the demands on the field team leader and enabled him to orient the newer employee when he arrived on site. A contributing cause was the decision to work with an incomplete field team (minus one person) rather than delay the project.

Corrective Measures: As stated above, better resource utilization could have prevented the occurrence of the problem.To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.

Finding EQA-930203-C: A formal system is not in place for the ANAP project to assure that field equipment blanks are traceable to the field samples that are collected using cleaned equipment. (Priority III)

Response: Rinsate samples were intended to be collected at the decontamination area without recording which specific piece of sampling equipment the rinsate was taken from and where that piece of sampling equipment was subsequently used. This potential problem was brought to the attention of the field team at the site and the rinsate collected after the surveillance was obtained from equipment identified with a discreet sample.

Root Cause: The root cause was the fact that neither the ANAP Sampling and Analysis Plan nor the MMES ESP Procedures specify that rinsates should be correlated with samples taken from the same equipment latter.

Corrective Measures: As with all findings made during the surveillance, this one was communicated to the field team while in the field and the deficiency was corrected. The field sampling portion of this project has ended.To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.

Due to the fact that there is a general lack of knowledge regarding this requirement, the probability exists that this deficiency could reoccur. This finding has therefore been communicated to the MMES Analytical Project Office which is in charge of the ESP Procedures. This information will be incorporated into the appropriate environmental surveillance procedure, tentatively scheduled for revision in July, 1993

Itemized list of corrective measures and Completion Dates

Finding	Corrective Measure	Completion Date
EQA-930203-A	Ice was added to the cooler as soon as field sampling activity subsided at that location.	February 3, 1993
EQA-930203-B	The technician conducting equipment decontamination initiated a second isopropanol rinse upon notification of its omission.	February 3, 1993
EQA-930203-C	During the decontamination process, team personnel were notified to collect rinsate samples from specific pieces of equipment that could latter be traced to specific samples. Field team members complied.	February 3, 1993

Negative Observations

Negative Observation #1: (summary)The lot number of the HNU calibration gas was not being recorded in the calibration check logbook.

Response: This fact was communicated to the field team during the surveillance and the situation was corrected immediately.

Root Cause: The deficiency resulted from a lack of knowledge regarding the need to record the subject information in the calibration check logbook. The root cause was omission of this requirement during personnel training due to a lack of detailed procedures governing the calibration process.

Corrective Measures: This negative observation was communicated to the field team while in the field and the deficiency was corrected immediately.

The field sampling portion of this project has ended To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.Prior to the start of the next Y-12 ER field effort, the calibration log sheet will be revised to have a space for this information.

Negative Observation #2: (summary)Decontamination of equipment at the decontamination area allowed fugitive spray to land outside the control area.

Response: The field team had constructed splash boards (4'x8' plywood covered with plastic which drained spray/splatter back into the decon pad) along two sides of the decontamination area; however, spray (consisting mostly of potable water from the steam jenny) was able to blow over the splash boards on occasion. Also, no splash boards were present on two sides of the decon area. This allowed the drill rig to back into the decon area from one side, and field team members to enter/exit the decon area from the other direction. The fact that splash boards were present at the decon area indicates that the field team leader had considered the potential for fugitive spray, even though splash boards have not been routinely used around decon areas in the past (at Y-12 or nationally).The addition of splash boards to two sides was commendable, although they were not quite as efficient at preventing fugitive spray/splatter as was intended.

Root Cause: While there is no procedure which covers this deficiency, it is indeed a best management practice to prevent spray from exiting a decontamination area. The root cause was inattention to detail during the decontamination procedure.

Corrective Measures: This deficiency was brought to the attention of field team members during the surveillance. Greater care was taken during all subsequent decontamination events. It should be mentioned that the addition of splash boards to all four sides of the decon area could constitute a confined space.

The field sampling portion of this project has ended. To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.During the next Y-12 ER field effort, alternate splash board arrangements will be utilized to minimize overspray. Any splash board arrangement will be approved by the Y-12 ER assessment specialist before use.

Negative Observation #3: (summary)The field team member conducting equipment decontamination during the surveillance had not been adequately trained.

<u>Response:</u> This Individual had arrived on site two hours before the surveillance, without previous notification of pending arrival. He arrived at a critical time while drilling and subsurface sampling was underway. As a result, the field team leader was unable to conduct additional training for this employee (all of the field team members received 4 hours of site-specific training prior to the start of this project). This experienced employee was sent over to the decontamination area to clean equipment while the rest of the field team completed sampling at the borehole location remote from the decontamination area. The subject employee was basically familiar with the decontamination process but inadvertently skipped a second isopropanol rinse. This was brought to the employee's attention at that time and he immediately conducted a second isopropanol rinse.

<u>Root Cause:</u> The individual had been improperly trained in the execution of the decontamination procedure. This occurred because the field team leader was heavily involved in drilling/sampling activities at a location along the pipeline remote from the decontamination area. A better workload distribution would have reduced the involvement of the field team leader and allowed the new arrival on site to be briefed on site conditions and procedures. A contributing factor was the fact that the sampling effort was undertaken with one person unavailable due to other, previous commitments.

<u>Corrective Measures:</u> An effective measure to correct this problem would be to have a more equitable distribution of work among field team members. This could have reduced the involvement of the field team leader. An additional field team member present would have also rectified the situation, but at an increase in cost. Work loads can be scheduled before the start of a project and coordination problems can be rectified early in the field effort.

The field sampling portion of this project has ended.The field sampling portion of this project has ended. To prevent a reoccurrence in future field efforts, Y-12 ER will initiate a meeting with the subcontractor (SAIC) management to review MMES expectations regarding verbatim compliance with procedures/requirements. In addition, at the beginning of each project, the project manager or field team leader shall conduct a pre-job briefing to emphasize procedures and requirements.

Future readiness reviews will require written proof of training for all field team members, whether MMES, subcontractor or second-tier subcontractor. Field team personnel arriving late at a site where field work is in progress will not be allowed to participate in work unless that individual has been trained and his or her attendance has been documented on an attendance roster.

APPENDIX E

BACKGROUND SAMPLING LOCATIONS FOR THE ABANDONED NITRIC ACID PIPELINE PROJECT

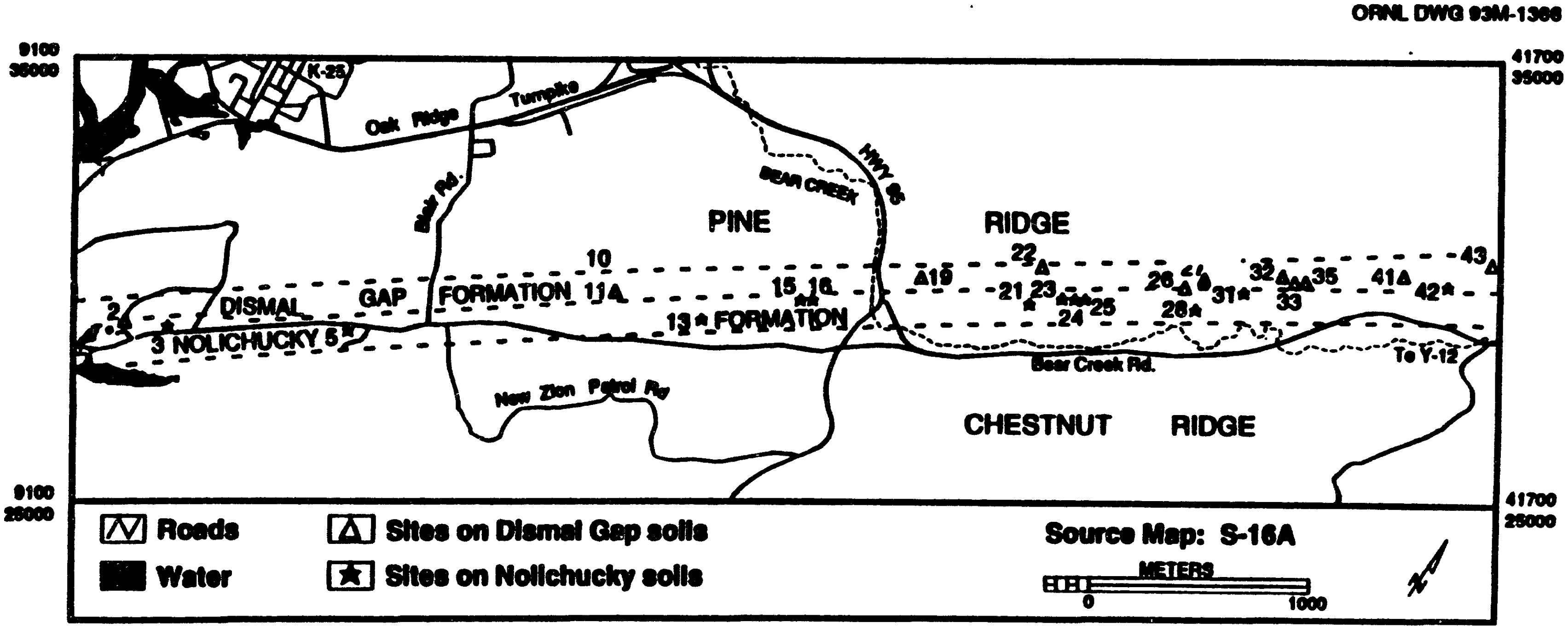


Fig. E.1. Background sampling site locations for the ORR.

Source: U.S. Department of Energy. 1993. *Annual Report on the Background Soil Characterization Project on the Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/OR/01-1136, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May.

Table E.1. Background sampling results in the Nolichucky Formation on the ORR.

Analysis	Units	A horizon	Q*	B horizon	Q	C horizon	Q	A horizon field dup	Q	B horizon field dup	Q	C horizon field dup	Q
Location = ORR; Formation = NOLICHUCKY; Site = 5, 21, 31													
Aluminum	mg/kg	20800.00		29300.00		33700.00							
Antimony	mg/kg	0.47	U	0.59	B	0.62	B						
Arsenic	mg/kg	5.80		5.90		11.00							
Barium	mg/kg	75.40		86.20		81.30							
Beryllium	mg/kg	0.76	B	0.84	B	1.10	B						
Boron	mg/kg	9.90	UJ	10.00	UJ	9.70	UJ						
Cadmium	mg/kg	0.23	U	0.24	U	0.24	U						
Calcium	mg/kg	498.00	B	370.00	B	339.00	U						
Chromium	mg/kg	27.70		30.70		80.10							
Cobalt	mg/kg	15.90		8.70	B	27.30							
Copper	mg/kg	11.00		14.90		29.70							
Cyanide	mg/kg	0.12	UJ	0.12	UJ	0.12	UJ						
Iron	mg/kg	23000.00		33400.00		39200.00							
Lead	mg/kg	15.30		9.80		49.60							
Lithium	mg/kg	10.90	B	21.80		23.30							
Magnesium	mg/kg	1940.00		2870.00		3740.00							
Manganese	mg/kg	733.00		173.00		689.00							
Mercury	mg/kg	0.18		0.11	U	0.10	U						
Molybdenum	mg/kg	1.60	U	1.70	U	1.60	U						
Nickel	mg/kg	17.80		22.30		30.90							
Potassium	mg/kg	2640.00		3330.00		4600.00							
Selenium	mg/kg	0.56	B	0.62	B	1.10	B						
Silicon	mg/kg	328.00	J	294.00	J	246.00	J						
Silver	mg/kg	1.20	UJ	1.20	UJ	1.20	UJ						
Strontium	mg/kg	4.40		5.00		3.40							
Sulfate	mg/kg	25.40		58.90		34.90							
Thallium	mg/kg	0.47	U	0.48	U	0.72	B						
Vanadium	mg/kg	29.40		41.30		38.70							
Zinc	mg/kg	40.60		49.50		50.70							

Table E.1 (continued)

Analysis	Units	A horizon	Q[a]	B horizon	Q	C horizon	Q	A horizon field dup	Q	B horizon field dup	Q	C horizon field dup	Q
Location = ORR; Formation = NOLICHUCKY; Site = 15, 23, 25													
Aluminum	mg/kg	25100.00		38800.00		38200.00							
Antimony	mg/kg	0.49	B	0.80	B	0.60	B						
Arsenic	mg/kg	6.30		6.80		5.20							
Barium	mg/kg	59.70		76.00		71.20							
Beryllium	mg/kg	0.73	B	0.91	B	1.10	B						
Boron	mg/kg	9.30	UJ	10.20	UJ	10.00	UJ						
Cadmium	mg/kg	0.22	U	0.24	U	0.24	U						
Calcium	mg/kg	422.00	U	550.00	U	451.00	U						
Chromium	mg/kg	29.90		45.30		38.10							
Cobalt	mg/kg	11.10		7.30	B	6.90	B						
Copper	mg/kg	12.20		19.30		20.40							
Cyanide	mg/kg	0.11	UJ	0.12	UJ	0.12	UJ						
Iron	mg/kg	28800.00		45900.00		45700.00							
Lead	mg/kg	20.40		9.30		11.70							
Lithium	mg/kg	15.50		26.90		19.90							
Magnesium	mg/kg	2010.00		2460.00		2900.00							
Manganese	mg/kg	405.00		128.00		133.00							
Mercury	mg/kg	0.18		0.12	U	0.11	U						
Molybdenum	mg/kg	1.50	U	2.00	B	1.70	U						
Nickel	mg/kg	16.50		17.50		18.70							
Potassium	mg/kg	2950.00		3660.00		5070.00							
Selenium	mg/kg	0.74	B	1.00	B	0.88	B						
Silicon	mg/kg	203.00	J	218.00	J	217.00	J						
Silver	mg/kg	1.10	UJ	1.20	UJ	1.20	UJ						
Strontium	mg/kg	3.20		3.80		3.70							
Sulfate	mg/kg	18.90		44.50		47.40							
Thallium	mg/kg	0.45	U	0.59	B	0.48	B						
Vanadium	mg/kg	35.20		54.10		42.80							
Zinc	mg/kg	36.80		44.10		39.40							

Table E.1 (continued)

Location = ORR; Formation = NOLICHUCKY; Site = 16, 28, 42

Analysis	Units	A horizon	Q[a]	B horizon	Q	C horizon	Q	A horizon field dup	Q	B horizon field dup	Q	C horizon field dup	Q
Aluminum	mg/kg	21300.00		30500.00		34300.00							
Antimony	mg/kg	0.47	U	0.70	B	0.55	B						
Arsenic	mg/kg	0.46	U	0.48	U	5.20	UJ						
Barium	mg/kg	67.60		78.80		85.20							
Beryllium	mg/kg	0.85	B	1.10	B	1.10	B						
Boron	mg/kg	9.90	UJ	10.10	UJ	10.10	UJ						
Cadmium	mg/kg	0.23	U	0.24	U	0.24	U						
Calcium	mg/kg	594.00	U	901.00	B	1160.00	B						
Chromium	mg/kg	0.46	U	0.48	U	39.30							
Cobalt	mg/kg	14.10		12.70		18.60							
Copper	mg/kg	11.00		18.90		21.00							
Cyanide	mg/kg	0.12	UJ	0.12	UJ	0.12	UJ						
Iron	mg/kg	32100.00		51800.00		44700.00							
Lead	mg/kg	0.23	U	0.24	U	11.50							
Lithium	mg/kg	7.60	B	19.70		20.20							
Magnesium	mg/kg	1730.00		2360.00		3140.00							
Manganese	mg/kg	657.00		291.00		364.00							
Mercury	mg/kg	0.19		0.11	U	0.11	U						
Molybdenum	mg/kg	1.60	U	1.70	U	1.70	U						
Nickel	mg/kg	15.20		20.20		22.30							
Potassium	mg/kg	3010.00		3520.00		4800.00							
Selenium	mg/kg	0.46	U	0.48	U	0.47	U						
Silicon	mg/kg	291.00	J	215.00	J	487.00	J						
Silver	mg/kg	1.20	UJ	1.20	UJ	1.20	UJ						
Strontium	mg/kg	5.00		5.60		7.60							
Sulfate	mg/kg	17.90		43.10		37.00							
Thallium	mg/kg	0.46	U	0.48	U	0.47	B						
Vanadium	mg/kg	33.20		42.80		40.80							
Zinc	mg/kg	33.90		38.30		38.50							

Table E.1 (continued)

Analysis	Units	A horizon	Q[a]	B horizon	Q	C horizon	Q	A horizon field dup	Q	B horizon field dup	Q	C horizon field dup	Q
Location = ORR; Formation = NOLICHUCKY; Site = 3, 13, 24													
Aluminum	mg/kg	21800.00		42100.00		46700.00							
Antimony	mg/kg	0.47	U	0.80	B	1.00	B						
Arsenic	mg/kg	6.40		6.70		8.80							
Barium	mg/kg	106.00		107.00		86.80							
Beryllium	mg/kg	0.81	B	1.20	B	1.40							
Boron	mg/kg	9.80	UJ	10.20	UJ	10.20	UJ						
Cadmium	mg/kg	0.23	U	0.24	U	0.23	U						
Calcium	mg/kg	952.00	B	1360.00		1320.00							
Chromium	mg/kg	26.40		36.80		72.80							
Cobalt	mg/kg	17.50		40.10		12.70							
Copper	mg/kg	12.70		25.50		30.20							
Cyanide	mg/kg	0.12	UJ	0.12	UJ	0.12	UJ						
Iron	mg/kg	28500.00		40600.00		37700.00							
Lead	mg/kg	17.20		18.20		47.60							
Lithium	mg/kg	11.10	B	27.80		32.10							
Magnesium	mg/kg	2410.00		3300.00		3830.00							
Manganese	mg/kg	935.00		761.00		320.00							
Mercury	mg/kg	0.19		0.12	U	0.12	U						
Molybdenum	mg/kg	1.60	U	1.70	U	1.70	U						
Nickel	mg/kg	20.00		23.90		27.00							
Potassium	mg/kg	3230.00		4340.00		5560.00							
Selenium	mg/kg	0.63	B	0.66	B	1.10	B						
Silicon	mg/kg	185.00	J	274.00	J	238.00	J						
Silver	mg/kg	1.20	UJ	1.20	UJ	1.20	UJ						
Strontium	mg/kg	6.10		8.70		7.60							
Sulfate	mg/kg	14.10		344.00		35.10							
Thallium	mg/kg	0.47	U	0.49	U	0.68	B						
Vanadium	mg/kg	32.10		46.30		43.50							
Zinc	mg/kg	40.70		46.80		51.60							

Source: U.S. Department of Energy. 1993. *Annual Report on the Background Soil Characterization Project on the Oak Ridge Reservation, Oak Ridge, Tennessee.* DOE/OR/01-1136, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May.

APPENDIX F

SUPPLEMENTARY RISK ASSESSMENT TABLES

Table F.1. Outliers detected in the Abandoned Nitric Acid Pipeline data set[a]

Borehole Number	Sample ID	Analyte	Frequency of Detection	Percentage Detected	Analytical Result	Lower Outlier Limit	Upper Outlier Limit
			Radionuclides (pCi/g)				
SB001	N00101	U-234	19/19	100.0	1.30E+01	-6.90E+00	1.13E+01
		U-235	19/19	100.0	7.50E-01	-3.70E-01	5.75E-01
			Nitrate/Nitrite (mg/kg)				
SB010	N01001	Nitrate	14/19	73.7	1.00E+01	-1.30E+00	2.90E+00
		Nitrite	14/19	73.7	1.00E+01	-1.30E+00	2.90E+00
SB017	N01701	Nitrate	14/19	73.7	3.20E+01	-1.30E+00	2.90E+00
		Nitrite	14/19	73.7	3.20E+01	-1.30E+00	2.90E+00
SB019	N01901	Nitrate	14/19	73.7	2.00E+01	-1.30E+00	2.90E+00
		Nitrite	14/19	73.7	2.00E+01	-1.30E+00	2.90E+00
			Metals (mg/kg)				
SB018	N01801	Molybdenum	1/19	5.3	1.40E+01	8.00E-01	2.20E+00

[a] Data values beyond the "outer fences" (smaller than the Lower Outlier Limit or larger than the Upper Outlier Limit) are declared to be outliers (Tukey 1977).

Table F.2. Comparison of ANAP sample results with associated detected field blank results[a]

Borehole Number	Field Blank ID	Analyte	Field Blank Qualifier	Field Blank Result	Sample Qualifier	Sample Result	New Qualifier[a]	New Result[a]
				Radionuclides (pCi/g)				
SB012	N01971	U-234	J	2.10E-01	J	9.90E-01	U	2.10E-01
		U-235	J	1.40E-02	J	1.50E-02	U	1.40E-02
		U-238	J	1.40E-02	J	1.10E+00	–	–
SB016	N01071	U-234	J,DL	2.70E-02	J	3.50E+00	–	–
		U-235	J	1.80E-02	J	1.70E-01	–	–
		U-238	J,DL	3.20E-02	J	3.20E+00	–	–
				Metals (mg/kg)				
SB012	N01971	Manganese	–	7.20E-04	–	1.44E+02	–	–
		Silicon	–	1.34E+00	–	7.25E+02	–	–
		Strontium	–	9.90E-04	J	6.50E+00	–	–

[a] The result (concentration) and qualifier are changed if the ANAP sample concentration is less than five times the detected field blank concentration (EPA 1989a).

Table F.3. Comparison of ANAP sample results with associated duplicate sample results (using a statistical t-test)

Analyte	Number of Duplicates	Mean Difference	Standard Deviation of Difference	Minimum Difference	Maximum Difference	Calculated T-statistic	Confidence Level[a]
			Radionuclides (pCi/g)				
U-234	2	-5.00E-03	2.90E-01	-2.10E-01	2.00E-01	-0.024	1.6
U-235	2	-1.53E-01	6.72E-02	-2.00E-01	-1.05E-01	-3.211	80.8
U-238	2	-2.50E-01	7.07E-02	-3.00E-01	-2.00E-01	-5.000	87.4
			Nitrate/Nitrite (mg/kg)				
Nitrate	2	-1.60E+01	2.26E+01	-3.20E+01	0.00E+00	-1.000	50.0
Nitrite	2	-1.60E+01	2.26E+01	-3.20E+01	0.00E+00	-1.000	50.0
			Metals (mg/kg)				
Aluminum	2	-1.15E+03	3.61E+03	-3.70E+03	1.40E+03	-0.451	27.0
Antimony	1	-1.00E-01	—	-1.00E-01	-1.00E-01	—	—
Arsenic	2	6.45E-01	2.05E-01	5.00E-01	7.90E-01	4.448	85.9
Barium	2	1.80E+00	4.24E-01	1.50E+00	2.10E+00	6.000	89.5
Beryllium	2	5.00E-02	2.83E-02	3.00E-02	7.00E-02	2.500	75.8
Cadmium	2	-3.00E-02	0.00E+00	-3.00E-02	-3.00E-02	—	—
Calcium	2	3.13E+03	4.28E+03	1.07E+02	6.15E+03	1.035	51.1
Chromium	2	-1.03E+01	1.93E+01	-2.39E+01	3.40E+00	-0.751	41.0
Cobalt	2	-9.50E-01	2.62E+00	-2.80E+00	9.00E-01	-0.514	30.2
Copper	2	-5.30E+00	7.78E+00	-1.08E+01	2.00E-01	-0.964	48.8
Iron	2	-8.50E+02	1.12E+04	-8.80E+03	7.10E+03	-0.107	6.8

Table F.3. (continued)

Analyte	Number of Duplicates	Mean Difference	Standard Deviation of Difference	Minimum Difference	Maximum Difference	Calculated T-statistic	Confidence Level[a]
Lead	2	3.87E+01	3.63E+01	1.30E+01	6.44E+01	1.506	62.7
Lithium	2	-1.00E+01	1.50E+01	-2.06E+01	6.00E-01	-0.943	48.1
Magnesium	2	1.34E+03	1.85E+03	3.00E+01	2.64E+03	1.023	50.7
Manganese	2	5.95E+01	7.28E+01	8.00E+00	1.11E+02	1.155	54.6
Molybdenum	2	-5.00E-02	7.07E-02	-1.00E-01	0.00E+00	-1.000	50.0
Nickel	2	-2.10E+00	3.39E+00	-4.50E+00	3.00E-01	-0.875	45.8
Phosphorus	2	5.60E+01	5.94E+01	1.40E+01	9.80E+01	1.333	59.0
Potassium	2	9.00E+01	2.55E+02	-9.00E+01	2.70E+02	0.500	29.5
Selenium	2	-8.50E-01	7.07E-02	-9.00E-01	-8.00E-01	-17.000	96.3
Silicon	2	1.40E+01	4.67E+01	-1.90E+01	4.70E+01	0.424	25.5
Silver	1	-4.00E-02	—	-4.00E-02	-4.00E-02	—	—
Sodium	2	3.05E+00	1.48E+00	2.00E+00	4.10E+00	2.905	78.9
Strontium	2	2.75E+00	3.46E+00	3.00E-01	5.20E+00	1.122	53.7
Thallium	2	-1.50E-01	7.07E-02	-2.00E-01	-1.00E-01	-3.000	79.5
Vanadium	2	-2.95E+00	7.14E+00	-8.00E+00	2.10E+00	-0.584	33.7
Zinc	2	-4.65E+00	5.59E+00	-8.60E+00	-7.00E-01	-1.177	55.2

[a] The confidence level (% CL) at which the mean difference (sample minus duplicate) is not different from zero, i.e., the confidence at which the mean sample concentration is the same as the mean duplicate concentraion. A value of 95.0 in this column would be interpreted as a 95% confidence that there is a statistical difference between the mean sample concentration and the mean duplicate concentration.

Table F.4. Tentatively identified compounds found in the ANAP data set

Tentatively Identified Compound	Number of Samples where TICs[a] were found	Total Number of VOC Samples	Percentage of Samples where TICs were found	Number of TIC Results	Mean TIC Conc. (mg/kg)	Minimum TIC Conc. (mg/kg)	Maximum TIC Conc. (mg/kg)
2-propanol	2	10	20.0	2	1.81E-01	9.10E-02	2.70E-01
decane	1	10	10.0	1	4.80E-02	4.80E-02	4.80E-02
diethyl benzene	1	10	10.0	1	1.70E-01	1.70E-01	1.70E-01
ethyl cyclohexane	1	10	10.0	1	3.10E-01	3.10E-01	3.10E-01
propanol	1	10	10.0	1	7.30E-03	7.30E-03	7.30E-03
tri methyl silanol	1	10	10.0	1	7.00E-03	7.00E-03	7.00E-03
unknown dimethylheptanol	1	10	10.0	1	3.30E-01	3.30E-01	3.30E-01
unknown ethyl dimethylbenzene	1	10	10.0	2	1.60E-01	1.40E-01	1.80E-01
unknown ethyl methylbenzene	1	10	10.0	1	1.80E-01	1.80E-01	1.80E-01
unknown methyl nonene	1	10	10.0	1	9.00E-02	9.00E-02	9.00E-02
unknown methyl propylbenzene	1	10	10.0	1	1.80E-01	1.80E-01	1.80E-01
unknown methyl-(methylethyl)benzene	1	10	10.0	1	1.70E-01	1.70E-01	1.70E-01
unknown methyl-(methylethyl)cyclop	1	10	10.0	1	1.10E-01	1.10E-01	1.10E-01
unknown trimethylheptane	1	10	10.0	1	1.40E-01	1.40E-01	1.40E-01

[a] TICs = Tentatively Identified Compounds

Table F.5a. Comparison of ANAP data with BSCP data[a]

Analyte	Frequency of Detection	Median for ANAP Data	LCB95 for BSCP Nolichucky Data[b]	Median for BSCP Nolichucky Data	UCB95 for BSCP Nolichucky Data[c]	LCB95 for BSCP Dismal Gap Data[b]	Median for BSCP Dismal Gap Data	UCB95 for BSCP Dismal Gap Data[c]	Is ANAP Median Within Confidence Bounds or Below Lower Bound?[d]
				Radionuclides (pCi/g)					
U-234	18/19	1.10E+00	1.06E+00	1.28E+00	1.55E+00	7.76E-01	9.37E-01	1.13E+00	Within Bounds
U-235	18/19	1.10E-01	5.94E-02	7.13E-02	8.55E-02	6.60E-02	7.92E-02	9.50E-02	—
U-238	19/19	1.10E+00	1.15E+00	1.28E+00	1.43E+00	9.16E-01	1.02E+00	1.15E+00	Below Lower Bound
				Nitrate/Nitrite (mg/kg)					
Nitrate	14/19	7.80E-01	—	—	—	—	—	—	—
Nitrite	14/19	7.80E-01	—	—	—	—	—	—	—
				Metals (mg/kg)					
Aluminum	19/19	3.08E+04	1.97E+04	2.22E+04	2.50E+04	1.84E+04	2.07E+04	2.32E+04	—
Antimony	0/7	2.70E+00	4.43E-01	4.63E-01	4.85E-01	—	—	—	—
Arsenic	15/19	1.80E+00	4.64E+00	6.16E+00	8.18E+00	4.88E+00	6.24E+00	7.97E+00	Below Lower Bound
Barium	19/19	9.99E+01	5.81E+01	7.54E+01	9.78E+01	7.63E+01	9.91E+01	1.29E+02	Within Bounds
Beryllium	19/19	1.10E+00	6.41E-01	7.86E-01	9.64E-01	6.37E-01	7.81E-01	9.57E-01	—
Cadmium	0/19	6.80E-01	—	—	—	—	—	—	—
Calcium	19/19	3.88E+03	4.37E+02	6.89E+02	1.08E+03	8.60E+02	1.25E+03	1.81E+03	—
Chromium VI	19/19	3.94E+01	2.30E+01	2.80E+01	3.40E+01	2.08E+01	2.47E+01	2.92E+01	—

Table F.5a. (continued)

Analyte	Frequency of Detection	Median for ANAP Data	LCB95 for BSCP Nolichucky Data[b]	Median for BSCP Nolichucky Data	UCB95 for BSCP Nolichucky Data[c]	LCB95 for BSCP Dismal Gap Data[b]	Median for BSCP Dismal Gap Data	UCB95 for BSCP Dismal Gap Data[c]	Is ANAP Median Within Confidence Bounds or Below Lower Bound?[d]
Cobalt	19/19	1.62E+01	1.09E+01	1.44E+01	1.92E+01	1.09E+01	1.45E+01	1.93E+01	Within Bounds
Copper	19/19	1.90E+01	9.21E+00	1.17E+01	1.49E+01	1.27E+01	1.61E+01	2.05E+01	Within Bounds
Iron	19/19	3.32E+04	2.40E+04	2.79E+04	3.24E+04	2.53E+04	2.94E+04	3.42E+04	Within Bounds
Lead	16/16	1.16E+01	1.22E+01	1.75E+01	2.51E+01	1.49E+01	2.03E+01	2.77E+01	Below Lower Bound
Lithium	19/19	2.20E+01	8.55E+00	1.09E+01	1.40E+01	1.22E+01	1.62E+01	2.14E+01	—
Magnesium	19/19	4.92E+03	1.67E+03	2.01E+03	2.41E+03	2.37E+03	2.85E+03	3.42E+03	—
Manganese	19/19	5.36E+02	4.77E+02	6.53E+02	8.95E+02	7.28E+02	9.97E+02	1.37E+03	Below Lower Bound
Molybdenum	1/19	1.50E+00	—	—	—	—	—	—	—
Nickel	19/19	3.13E+01	1.39E+01	1.73E+01	2.14E+01	1.89E+01	2.35E+01	2.91E+01	—
Nickel (salts)	19/19	3.13E+01	1.39E+01	1.73E+01	2.14E+01	1.89E+01	2.35E+01	2.91E+01	—
Phosphorus	19/19	3.47E+02	—	—	—	—	—	—	—
Potassium	19/19	4.35E+03	2.42E+03	2.95E+03	3.59E+03	1.89E+03	2.30E+03	2.80E+03	—
Selenium	0/19	2.04E+01	4.45E-01	5.65E-01	7.18E-01	—	—	—	—
Silicon	19/19	6.13E+02	2.23E+02	2.45E+02	2.69E+02	4.60E+02	5.06E+02	5.56E+02	—
Silver	0/7	8.20E-01	—	—	—	—	—	—	—

Table F.5a. (continued)

Analyte	Frequency of Detection	Median for ANAP Data	LCB95 for BSCP Nolichucky Data^b	Median for BSCP Nolichucky Data	UCB95 for BSCP Nolichucky Data^c	LCB95 for BSCP Dismal Gap Data^b	Median for BSCP Dismal Gap Data	UCB95 for BSCP Dismal Gap Data^c	Is ANAP Median Within Confidence Bounds or Below Lower Bound?^{d}
Sodium	5/19	7.03E+01	—	—	—	—	—	—	—
Strontium	19/19	1.78E+01	3.32E+00	4.55E+00	6.25E+00	5.51E+00	7.93E+00	1.14E+01	—
Thallium	0/19	4.30E+00	—	—	—	4.90E-02	1.65E-01	5.56E-01	—
Vanadium	19/19	3.23E+01	2.83E+01	3.24E+01	3.71E+01	2.98E+01	3.42E+01	3.91E+01	Within Bounds
Zinc	19/19	6.29E+01	3.07E+01	3.79E+01	4.68E+01	4.10E+01	5.06E+01	6.26E+01	—
				Organics (mg/kg)					
1,1,1-Trichloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
1,1,2,2-Tetrachloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
1,1,2-Trichloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
1,1-Dichloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
1,1-Dichloroethene	0/3	1.30E-02	—	—	—	—	—	—	—
1,2-Dichloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
1,2-Dichloropropane	0/3	1.30E-02	—	—	—	—	—	—	—
2-Butanone	0/3	7.00E-03	—	—	—	—	—	—	—

Table F.5a. (continued)

Analyte	Frequency of Detection	Median for ANAP Data	LCB95 for BSCP Nolichucky Data[b]	Median for BSCP Nolichucky Data	UCB95 for BSCP Nolichucky Data[c]	LCB95 for BSCP Dismal Gap Data[b]	Median for BSCP Dismal Gap Data	UCB95 for BSCP Dismal Gap Data[c]	Is ANAP Median Within Confidence Bounds or Below Lower Bound?[d]
2-Hexanone	0/3	1.30E-02	—	—	—	—	—	—	—
4-Methyl-2-pentanone	0/3	1.30E-02	—	—	—	—	—	—	—
Acetone	1/3	1.20E-02	—	—	—	—	—	—	—
Benzene	0/3	1.30E-02	—	—	—	—	—	—	—
Bromodichloromethane	0/3	1.30E-02	—	—	—	—	—	—	—
Bromoform	0/3	1.30E-02	—	—	—	—	—	—	—
Bromomethane	0/3	1.30E-02	—	—	—	—	—	—	—
Carbon Disulfide	0/3	1.30E-02	—	—	—	—	—	—	—
Carbon Tetrachloride	0/3	1.30E-02	—	—	—	—	—	—	—
Chlorobenzene	0/3	1.30E-02	—	—	—	—	—	—	—
Chloroethane	0/3	1.30E-02	—	—	—	—	—	—	—
Chloroform	0/3	1.30E-02	—	—	—	—	—	—	—
Chloromethane	0/3	1.30E-02	—	—	—	—	—	—	—
Dibromochloromethane	0/3	1.30E-02	—	—	—	—	—	—	—
Ethylbenzene	0/3	1.30E-02	—	—	—	—	—	—	—
Methylene Chloride	0/3	1.30E-02	—	—	—	—	—	—	—

Table F.5a. (continued)

Analyte	Frequency of Detection	Median for ANAP Data	LCB95 for BSCP Nolichucky Data[b]	Median for BSCP Nolichucky Data	UCB95 for BSCP Nolichucky Data[c]	LCB95 for BSCP Dismal Gap Data[b]	Median for BSCP Dismal Gap Data	UCB95 for BSCP Dismal Gap Data[c]	Is ANAP Median Within Confidence Bounds or Below Lower Bound?[d]
Styrene	0/3	1.30E-02	–	–	–	–	–	–	–
Tetrachloroethene	0/3	1.30E-02	–	–	–	–	–	–	–
Toluene	0/3	1.30E-02	–	–	–	–	–	–	–
Trichloroethene	0/3	1.30E-02	–	–	–	–	–	–	–
Vinyl Chloride	0/3	1.30E-02	–	–	–	–	–	–	–
Xylene, (meta-, para-)	0/3	1.30E-02	–	–	–	–	–	–	–
Xylene, (ortho-)	0/3	1.30E-02	–	–	–	–	–	–	–
cis-1,2-Dichloroethene	0/3	1.30E-02	–	–	–	–	–	–	–
cis-1,3-Dichloropropene	0/3	1.30E-02	–	–	–	–	–	–	–
trans-1,2-Dichloroethene	0/3	1.30E-02	–	–	–	–	–	–	–
trans-1,3-Dichloropropene	0/3	1.30E-02	–	–	–	–	–	–	–

[a] BSCP = Background Soil Characterization Project (Energy Systems 1993c).

[b] LCB95 = Lower 95% Confidence Bound on Median

[c] UCB95 = Upper 95% Confidence Bound on Median

[d] If an ANAP analyte median concentration falls within the UCB95 and the LCB95 bounds (or below the LCB95) of the BSCP data (for either the Dismal Gap or the Nolichucky formation), that analyte is considered to be background.

Table F.5b. Comparison of ANAP data with ANAP nitrate/nitrite background data[a]

Analyte	Bckgrnd. Frequency of Detection	ANAP Frequency of Detection	Bckgrnd. Lower 95% C.L. on Mean	Bckgrnd. Mean Conc.	Bckgrnd. Upper 95% C.L. on Mean	Sample Lower 95% C.L. on Mean	Sample Mean Conc.	Sample Upper 95% C.L. on Mean
				Nitrate/Nitrite (mg/kg)				
Nitrate	0/3	14/19	5.00E-01	5.00E-01	5.00E-01	1.34E+00	3.88E+00	6.42E+00
Nitrite	0/3	14/19	5.00E-01	5.00E-01	5.00E-01	1.34E+00	3.88E+00	6.42E+00

[a] The 95% confidence intervals on means (ANAP data means versus background data means) do not overlap; therefore, the ANAP nitrate/nitrite concentrations are greater than those concentrations found in background.

Table F.6. ANAP toxicity screening for detected analytes (carcinogenic and noncarcinogenic; ingestion and inhalation)

Analyte	Maximum Detected Concentration (pCi/g; mg/kg)	Oral RfD (mg/kg-d)	Oral Slope Factor [(mg/kg-d)$^{-1}$]	Inhalation Slope Factor [(mg/kg-d)$^{-1}$]	Noncarcinogenic Oral Toxicity Score	% of Total Noncarcinogenic Oral Scores	Carcinogenic Oral Toxicity Score	% of Total Carcinogenic Oral Scores	Carcinogenic Inhalation Toxicity Score	% of Total Carcinogenic Inhalation Scores	Final Decision[a]
Radionuclides											
U-234[b]	1.30E+01	—	—	—	—	—	—	—	—	—	—
U-235[b]	7.50E-01	—	—	—	—	—	—	—	—	—	—
U-238[b]	5.00E+00	—	—	—	—	—	—	—	—	—	—
Nitrate/Nitrite											
Nitrate[c]	3.20E+01	1.6E+00	—	—	2.00E+01	0.11	—	—	—	—	—
Nitrite[c]	3.20E+01	1.0E-01	—	—	3.20E+02	1.79	—	—	—	—	—
Metals											
Beryllium[d]	1.70E+00	5.0E-03	4.3E+00	8.4E+00	3.40E+02	1.90	7.31E+00	100.00	1.43E+01	0.61	—
Chromium VI	5.63E+01	5.0E-03	—	4.1E+01	1.13E+04	62.90	—	—	2.31E+03	99.39	—
Molybdenum	1.40E+01	5.0E-03	—	—	2.80E+03	15.64	—	—	—	—	—
Nickel	5.30E+01	2.0E-02	—	—	2.65E+03	14.80	—	—	—	—	—
Nickel (salts)[e]	5.30E+01	2.0E-02	—	—	2.65E+03[e]	14.80[e]	—	—	—	—	—
Strontium	7.06E+01	6.0E-01	—	—	1.18E+02	0.66	—	—	—	—	Eliminate
Zinc	1.18E+02	3.0E-01	—	—	3.93E+02	2.20	—	—	—	—	Eliminate

Table F.6. (continued)

Analyte	Maximum Detected Concentration (pCi/g; mg/kg)	Oral RfD (mg/kg-d)	Oral Slope Factor [(mg/kg-d)$^{-1}$]	Inhalation Slope Factor [(mg/kg-d)$^{-1}$]	Noncarcinogenic Oral Toxicity Score	% of Total Noncarcinogenic Oral Scores	Carcinogenic Oral Toxicity Score	% of Total Carcinogenic Oral Scores	Carcinogenic Inhalation Toxicity Score	% of Total Carcinogenic Inhalation Scores	Final Decision[a]
					Organics						
Acetone	6.40E-02	1.0E-01	—	—	6.40E-01	0.00	—	—	—	—	Eliminate
Total Score					1.79E+04[f]	—	7.31E+00	—	2.32E+03	—	

[a] A decision to eliminate analytes based on toxicity screening can be made, when all existing pathway scores are less than 5% of the total score (for all existing pathways). For example, if an analyte toxicity score is less than 5% for two pathways, but greater than 5% for a third pathway, then that analyte would not be eliminated from the COPC list based on this toxicity screening test (EPA 1989a).

[b] Because the uranium isotopes are related to the ANAP site operations, no toxicity screening was performed; they will remain on the quantitative COPC list for this BRA.

[c] Based on the toxicity screening criteria (EPA 1989a), nitrate and nitrite can be eliminated from the quantitative ANAP COPC list; however, since these analytes are known COPC for the ANAP process, they will not be eliminated from the quantitative COPC list for this BRA.

[d] Because beryllium is the only non-radionuclide COPC in this ANAP data set with an oral slope factor, no valid toxicity screening comparisons could be made for carcinogenic-risk from exposure via ingestion or dermal contact; therefore, beryllium will not be eliminated from the quantitate COPC list for this BRA.

[e] The noncarcinogenic oral toxicity score for nickel salts was assigned the same value as that shown for nickel (i.e., no oral RfD for nickel salts was available; therefore, the oral RfD for nickel was used for nickel salts). The % of total noncarcinogenic oral scores for nickel salts was also assigned the same value as that for nickel; i.e., the values add to 100% when nickel salts are not included in the summation.

[f] The total score does not include the toxicity score from nickel salts.

Table F.7. Comparison of ANAP nondetected analyte concentrations with residential PRGs[a]

Analyte	Frequency of Detection	Representative Concentration[b] (mg/kg)	Noncarcinogenic Residential Ingestion PRG for HI = 1	Carcinogenic Residential Ingestion PRG for Risk = 10^{-4}	Carcinogenic Residential Ingestion PRG for Risk = 10^{-6}
Metals					
Antimony	0/7	3.00E+00	1.1E+02		
Cadmium	0/19	7.40E-01	1.4E+02		
Selenium	0/19	2.32E+01	1.4E+03		
Silver	0/7	9.20E-01	1.4E+03		
Organics					
1,1,2,2-Tetrachloroethane	0/3	6.20E-02		3.2E+02	3.2E+00
1,1,2-Trichloroethane	0/3	6.20E-02	1.1E+03	1.1E+03	1.1E+01
1,1-Dichloroethane	0/3	6.20E-02	2.7E+04		
1,1-Dichloroethene	0/3	6.20E-02	2.5E+03	1.1E+02	1.1E+00
1,2-Dichloroethane	0/3	6.20E-02		7.0E+02	7.0E+00
1,2-Dichloropropane	0/3	6.20E-02		9.4E+02	9.4E+00
2-Butanone	0/3	6.20E-02	1.6E+05		
4-Methyl-2-pentanone	0/3	6.20E-02	1.4E+04		
Benzene	0/3	6.20E-02		2.2E+03	2.2E+01
Bromodichloromethane	0/3	6.20E-02	5.5E+03	1.0E+03	1.0E+01
Bromoform	0/3	6.20E-02	5.5E+03	8.1E+03	8.1E+01
Bromomethane	0/3	6.20E-02	3.8E+02		
Carbon Disulfide	0/3	6.20E-02	2.7E+04		
Carbon Tetrachloride	0/3	6.20E-02	1.9E+02	4.9E+02	4.9E+00
Chlorobenzene	0/3	6.20E-02	5.5E+03		
Chloroethane	0/3	6.20E-02			
Chloroform	0/3	6.20E-02	2.7E+03	1.0E+04	1.0E+02
Chloromethane	0/3	6.20E-02		4.9E+03	4.9E+01
Dibromochloromethane	0/3	6.20E-02	5.5E+03	7.6E+02	7.6E+00
Ethylbenzene	0/3	6.20E-02	2.7E+04		
Methylene Chloride	0/3	6.20E-02	1.6E+04	8.5E+03	8.5E+01
Styrene	0/3	6.20E-02	5.5E+04		
Tetrachloroethene	0/3	6.20E-02	2.7E+03		
Toluene	0/3	6.20E-02	5.5E+04		
Vinyl Chloride	0/3	6.20E-02		3.4E+01	3.4E-01
Xylene, (ortho-)	0/3	6.20E-02	5.5E+05		
cis-1,2-Dichloroethene	0/3	6.20E-02	2.7E+03		
trans-1,2-Dichloroethene	0/3	6.20E-02	5.5E+03		

[a] Preliminary Remediation Goals (PRGs), for the residential land use scenario (ingestion of soil pathway), calculated for a target risk of 10^{-4} and 10^{-6} for carcinogens and a target hazard index of 1 for noncarcinogens.

[b] The representative concentration is assigned as the maximum nondetected analyte concentration. All analyte concentrations are below PRG concentrations.

Table F.8. ANAP nondetected analytes that can be evaluated qualitatively[a]

Analyte	Frequency of Detection	Representative Concentration[b] (mg/kg)
	Metals	
Thallium	0/19	4.90E+00
	Organics	
1,1,1-Trichloroethane	0/3	6.20E-02
2-Hexanone	0/3	6.20E-02
Trichloroethene	0/3	6.20E-02
Xylene, (meta-, para-)	0/3	6.20E-02
cis-1,3-Dichloropropene	0/3	6.20E-02
trans-1,3-Dichloropropene	0/3	6.20E-02

[a] These analyte concentrations cannot be compared with preliminary remediation goals (PRGs) because neither toxicity values are known (i.e., slope factors nor reference doses). These analytes are not believed to be associated with the ANAP process and will not be evaluated further in this BRA.

[b] The representative concentration is assigned as the maximum nondetected concentration.

APPENDIX G

INTERNAL CORRESPONDENCE ON ANAP REMOVAL FOR PIDAS

Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

October 7, 1987

W. D. Walker

Soil and Water Analyses - Abandoned 3-Inch Acid Line

As part of the Utilities Relocation III package, Rust is removing several sections of abandoned acid line to the north and northwest (NW) of Building 9201-5N. With the exposure of the NW section of line, the line was checked to determine if it contained any residual liquid. The line was full of water at its lowest elevation and overflowed upon penetration. A sample of the water was taken on September 16, 1987. The analytical results are listed below.

Parameter	Value
Uranium, % 235	.27
Uranium, Total (mg/L)	.185
Nitrate (mg/L)	20
* pH	6.7
* Conductivity (ms/cm)	550

* Field measurements

The nitrate level of the water trapped in the acid line at this location prevented the outright emptying of the line. A saddle valve was installed, and on September 25, 1987, this section of line was drained and pumped by Environmental Management personnel. The water was containerized and removed for treatment.

Three composite soil samples were taken from around this section of acid line and submitted to the Y-12 Lab on September 30, 1987. These analytical results are listed below.

	Sample Numbers		
Parameters	001	002	003
Uranium, % 235	.82	1.25	.60
Uranium, Total (ug/g)	1.20	1.80	2.80
Nitrate (ug/g)	3.74	2.30	<1.0
pH	6.6	7.8	7.1

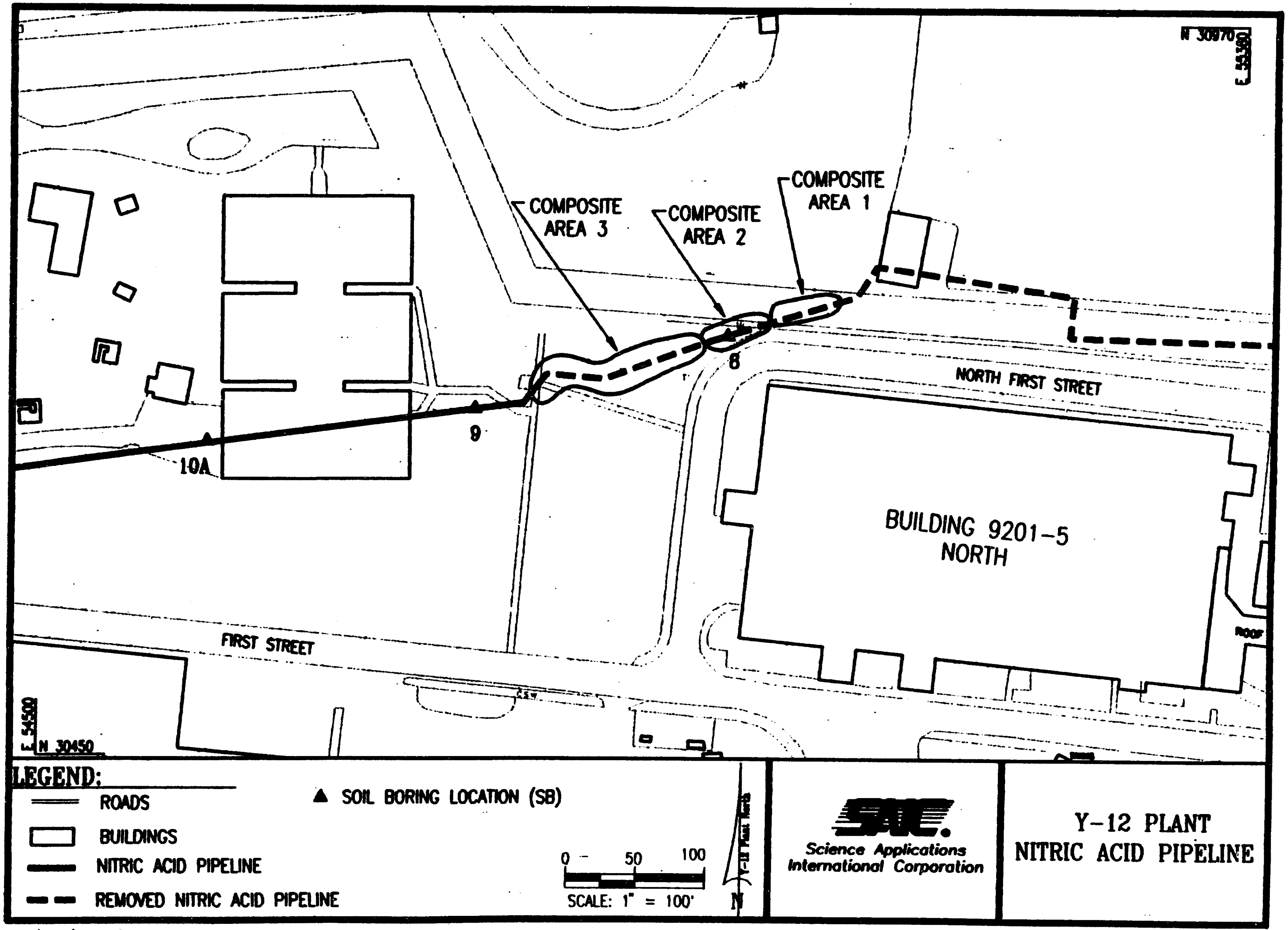
The soil results indicate no apparent problem with leakage in this section of acid line. The physical condition of the line would support this, as there is no visual sign of corrosion or a breakage.

D. E. Bohrman

D. E. Bohrman, 9704-1, MS-1, Y-12 (4-7536) - NoRC

DEB:ssh

cc: C. W. Kimbrough
F. E. Kirkpatrick
L. L. McCauley
File - DEB



93034\DWGS\614ANAP

Fig. G.1. Locations of composite soil samples.

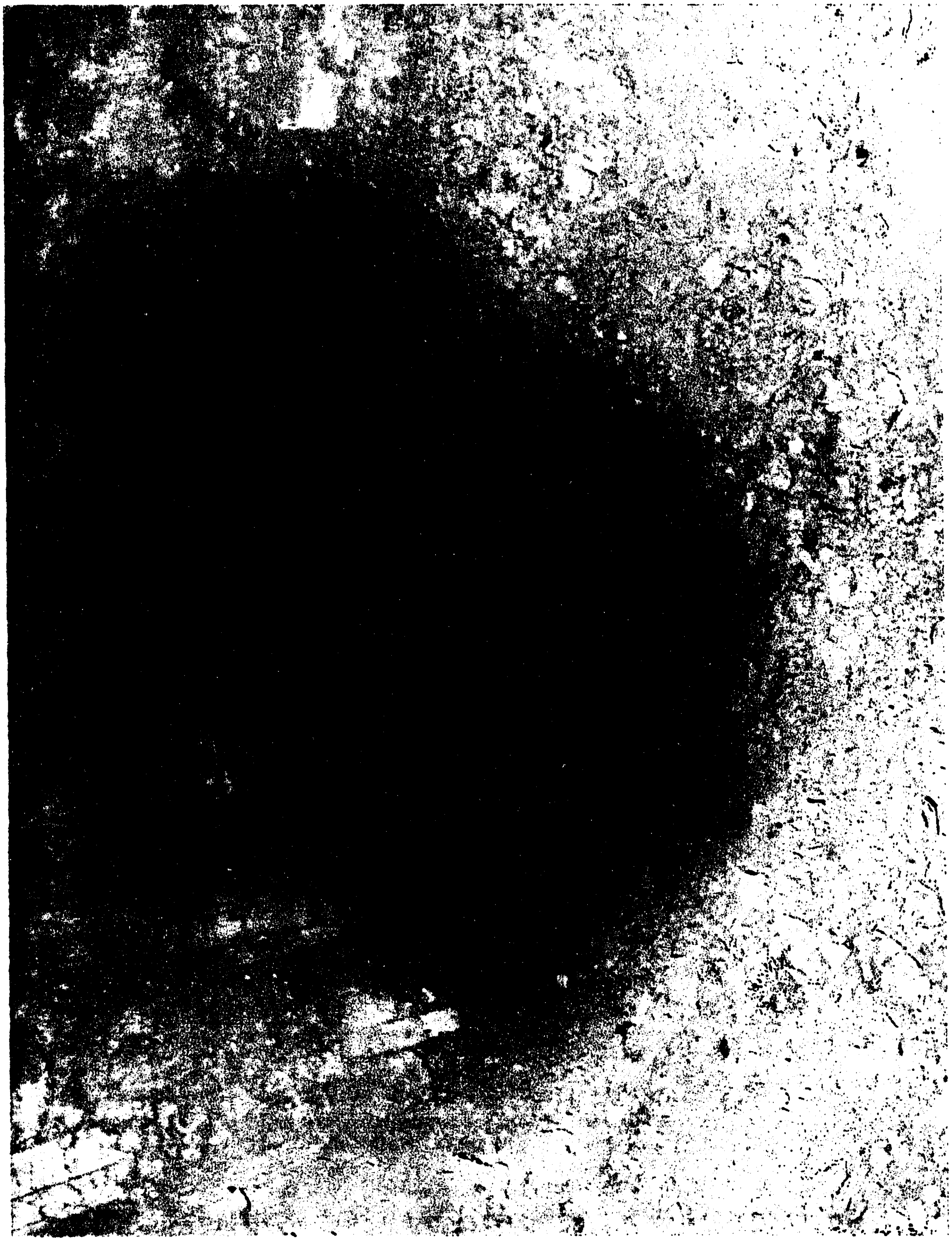


Fig. G.2. Exposed pipeline.

Fig. G.3. Exposed pipeline.

Fig. G.4. Exposed pipeline.

DISTRIBUTION

1. D. T. Bell
2. V. J. Brumback
3. M. F. P. DeLozier
4. S. D. Easterling
5. C. D. Goins
6. J. T. Grumski
7. P. J. Halsey
8. R. M. Hill
9. C. G. Hudson

10–11. A. K. Lee

12–16. D. M. Matteo

17. L. W. McMahon
18. K. M. Nelson
19. H. C. Newsom

20–22. M. J. Norris

23. B. D. Nourse

24–25. P. T. Owen

26. G. E. Rymer
27. C. M. Smith
28. R. J. Spence
29. T. S. Tison
30. B. Vann
31. C. S. Walker
32. D. R. Watkins
33. R. W. Weigel
34. L. E. White
35. R. K. White
36. C. H. Wilkinson
37. Central Research Library

38–42. ER Document Management Center

43. Y-12 ER Document Management Center
44. Y-12 Central Files

45–54. S. L. Lankford, DOE Oak Ridge Operations Office, P.O. Box 2001, Oak Ridge, TN 37831-8541

55–56. R. L. Nace, Branch Chief, Nonenrichment Facilities, Oak Ridge Program Division, Office of Eastern Area Programs, Office of Environmental Restoration, EM-423, Trevion 2, U.S. Department of Energy, Washington, DC 20585

57. R. C. Sleeman, DOE Oak Ridge Operations Office, P.O. Box 2001, Oak Ridge, TN 37831-8541

58–59. H. M. Thron, Chief, Enrichment Facilities, Oak Ridge Program Division, Office of Eastern Area Programs, Office of Environmental Restoration, EM-423, Trevion 2, U.S. Department of Energy, Washington, DC 20585

60–61. J. Archer, Jacobs Engineering, 800 Oak Ridge Turnpike, Suite C102, Oak Ridge, TN 37830

62. Sheldon Meyers, Jacobs Engineering, 800 Oak Ridge Turnpike, Suite C102, Oak Ridge, TN 37830
63. S. Belding, Radian Corporation, 120 South Jefferson Circle, Oak Ridge, TN 37830
64. D. W. Swindle, Radian Corporation, 120 South Jefferson Circle, Oak Ridge, TN 37830
65. Greg Schank, Science Applications International Corporation, 800 Oak Ridge Turnpike, P.O. Box 2502, Oak Ridge, TN 37830

DATE
FILMED

5/16/94

END