Department of Energy
Office of Legacy Management

February 23, 2005

WM-43

Mr. Gary Janosko, Branch Chief
U.S. Nuclear Regulatory Commission
Fuel Cycle Facilities Branch, NMSS
11545 Rockville Pike #2, Mail stop T8A33
Rockville, MD 20852

Subject: Draft Long-Term Surveillance Plan (Revision 2) for the Lowman, Idaho, Disposal Site

Dear Mr. Janosko:

Enclosed for U.S. Nuclear Regulatory Commission (NRC) review and concurrence are four copies of the draft of Revision 2 of the Long-Term Surveillance Plan (LTSP) for the Lowman, Idaho, Disposal Site. Also enclosed are four copies of the supporting document *Leaching Characteristics of Radioactive Sands, Long-Term Surveillance and Maintenance Program, Lowman, Idaho, Site.*

The original LTSP (Revision 1, April 1994) required ground water monitoring and periodic performance evaluations to determine the effectiveness of the disposal cell ground water compliance strategy, the effectiveness of the ground water monitoring plan, and the need for continued ground water monitoring (Section 5.2 "Ground Water Monitoring Network"). As discussed in Section 2.4.3 "Ground Water Quality" and Section 3.7 "Environmental Monitoring" of Revision 2 of the LTSP, the contaminant of concern, antimony, is not leaching from the encapsulated materials and will not present a hazard to human health and the environment. Therefore, Revision 2 of the LTSP states that continued ground water monitoring is no longer required.

An assessment of vegetation encroachment and its effect on the disposal cell also was required in the original LTSP (Section 6.4.4 "Vegetation"). Native vegetation is establishing on the cell cover, including ponderosa pine trees. As discussed in Section 3.5 "Site Maintenance" of Revision 2 of the LTSP, it has been determined that the native vegetation can be left to grow and fully establish on the cell without risk to human health and the environment. Vegetation encroachment will continue to be monitored to verify that it is not adversely affecting the physical integrity of the cell cover (e.g., not causing exposure of the encapsulated materials as a result of blowdown).

Following acceptance of Revision 2 of the LTSP, the NRC concurrence letter will be inserted into Appendix A, and the LTSP will be finalized and distributed.

The next ground water sampling event at the Lowman site is scheduled for July 2005. NRC concurrence prior to July would permit the Department of Energy to eliminate that event. If you have any questions, please call me at (970) 248-6048.

Sincerely,

Thomas C Pauling

Thomas C. Pauling
Site Manager

Enclosures

cc w/enclosures:
D. Nygard, ID-DEQ
Records File LOW 505.15(A) (D. Roberts)

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DOE-LM/GJ771-2005

Office of Legacy Management

Long-Term Surveillance Plan for the U.S. Department of Energy Lowman, Idaho, (UMTRCA Title I) Disposal Site

January 2005

DRAFT

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE-AC01-02GJ79491 for the U.S. Department of Energy Office of Legacy Management.
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DOE-LM/GJ771-2004
Revision 2

Office of Legacy Management

Long-Term Surveillance Plan

for the

U.S. Department of Energy
Lowman, Idaho
(UMTRCA Title I) Disposal Site

January 2005

(Supercedes DOE/AL/62350-36, Revision 1, April 1994)

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

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Acronyms

AEC	U.S. Atomic Energy Commission
BM	boundary monument
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LM	[U.S. Department of Energy] Office of Legacy Management
LTSP	Long-Term Surveillance Plan
MCL	maximum concentration limit
mg/L	milligram(s) per liter
NRC	U.S. Nuclear Regulatory Commission
$pCi/m^2/sec$	picocuries per square meter per second
QA	quality assurance
SM/BM	combined survey monument and boundary monument
SMK	site marker
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978 (42 USC 7901, *et seq.*)
USFS	U.S. Forest Service

End of current text

1.0 Introduction

1.1 Purpose

This Long-Term Surveillance Plan (LTSP) explains how the U.S. Department of Energy (DOE) Office of Legacy Management (LM) will fulfill general license requirements of Title 10 *Code of Federal Regulations* Part 40.27 (10 CFR 40.27) as the long-term custodian of the radioactive sands disposal site at Lowman, Idaho. The LM Program at the DOE office in Grand Junction, Colorado, is responsible for the revision and implementation of this LTSP (Revision 2), which specifies procedures for inspecting the site; monitoring, maintenance, and annual and other reporting requirements; and maintaining records pertaining to the site.

1.2 Legal and Regulatory Requirements

The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, as amended, provides for the remediation and regulation of uranium mill tailings at uranium mill sites authorized under Title I of the Act. Title I sites are former uranium mill sites unlicensed and essentially abandoned as of January 1, 1978. Federal regulations at 10 CFR 40.27 provide for the licensing, custody, and long-term care of uranium mill tailings disposal sites remediated under Title I of UMTRCA. The Lowman processing site, included under Title I, did not process uranium, but the byproduct of operations contained residual uranium, radium, and thorium in sand.

A general license is issued by the U.S. Nuclear Regulatory Commission (NRC) for the long-term custody and care of UMTRCA Title I sites. Long-term care includes institutional controls, inspection, monitoring, maintenance, and other measures to ensure that the sites continue to protect human health, safety, and the environment after remediation is completed.

The general license becomes effective when a site-specific LTSP receives NRC concurrence. The original LTSP (Revision 1) for the Lowman disposal site (DOE 1994) received NRC concurrence on September 30, 1994 (Appendix A). The NRC acceptance letter for this revision of the LTSP (Revision 2) is included in Appendix A.

Requirements at 10 CFR 40.27 for the LTSP for the Lowman disposal site are listed in Table 1–1.

Table 1–1. General License Requirements for the Long-Term Surveillance and Maintenance of the Lowman, Idaho, Disposal Site

Requirements of LTSP		
No.	*Requirement*	*Location*
1	Description of final site conditions	Section 2.0
2	Legal description of the site	Appendix B
3	Description of the long-term surveillance program	Section 3.0
4	Criteria for follow-up inspections	Section 3.4.1
5	Criteria for maintenance and emergency actions	Sections 3.5 and 3.6
Requirements for the Long-Term Custodian (DOE)		
No.	*Requirement*	*Location*
1	Notification to NRC of changes to the LTSP	Section 3.1
2	NRC permanent right-of-entry	Section 3.1
3	Notification to NRC of significant construction, actions, or repairs at the site.	Sections 3.4.3 and 3.6.2

The plans, procedures, and specifications in this revised LTSP are based on the guidance document, *Guidance for Implementing the Long-Term Surveillance Program for UMTRCA Title I and Title II Disposal Sites* (DOE 2001). Rationale and procedures in the guidance document are considered part of this revised LTSP.

1.3 Role of the U.S. Department of Energy

In 1988, DOE designated the office at Grand Junction, Colorado, to be the program office for the long-term surveillance and maintenance of all DOE remedial action project disposal sites, as well as other sites as assigned, and to be the common office for the surveillance, monitoring, maintenance, and institutional control of these sites. At that time, DOE established the Long-Term Surveillance and Maintenance Program to carry out this responsibility. In December of 2003, all actions and responsibilities under this program were transferred and incorporated into DOE-LM. DOE-LM is responsible for the revision and implementation of this LTSP.

2.0 Final Site Conditions

2.1 Site History

Porter Brothers Corporation, Boise, Idaho, opened the mill at Lowman in 1955. Although the mill was subsequently owned by Michigan Chemical Corporation of Chicago and its successor, Versicol Chemical Corporation, Porter Brothers may have been the only operator of the mill (FBD 1977).

Porter Brothers operated the mill from 1955 until 1960 to recover heavy minerals from sands dredged from placer deposits at Bear Valley, 20 miles north of Lowman. At the Bear Valley dredge site, sands were fed through a jig concentrator to separate the heavier minerals from the lighter fractions. The heavy mineral concentrate was trucked from Bear Valley to the Lowman mill where the sands were further separated by density into several concentrates: columbite-euxenite, monazite, ilmenite, zircon, garnet, and quartz waste.

The radioactivity in these concentrates owed to the presence of uranium and thorium in several of the heavy minerals. For example, uranium is a common impurity in columbite. Uranium and thorium are common in euxenite. Thorium may replace cerium and lanthanum in monazite, and thorium and uranium commonly replace zirconium in zircon. Columbite, euxenite, and zircon are highly resistant oxide or silicate minerals that are very stable under surface weathering conditions. Contaminants do not leach easily from these minerals (DOE 1991a).

While the mill was in operation, approximately 200,000 tons of heavy mineral concentrates were processed at the mill. The final concentrates were shipped to Mallinckrodt Chemical Works in Hematite, Missouri, for recovery of columbium and tantalum pentoxides, uranium oxide, rare-earth elements, titanium, and thorium-iron residues. Some byproduct magnetite and ilmenite were shipped to the U.S. Atomic Energy Commission (AEC) at Las Vegas, Nevada, for stemming material at the Nevada Test Site; and some of the garnet sands were used for sand blasting grit.

Porter Brothers operated the mill under a contract with the General Services Administration for acquisition of columbium-tantalum pentoxides. Porter Brothers also operated under an AEC contract for uranium oxide, although no uranium oxide, or "yellow cake", was actually produced at the mill. As a result, uranium mill tailings typically associated with Title I sites were not generated. In this respect, the Lowman site is unique among Title I sites. Processing consisted only of mechanical separation of minerals according to their density—no chemical digestion of ores took place. Subsequently, the waste byproduct of the operation was radioactive sand rather than chemically processed mill tailings. This is an important point because it accounts for there being no extensive contamination of soils or ground water at the site. The stability and resulting low leachability characteristics of the uranium and thorium-bearing minerals remaining within the radioactive sand is a further contributing factor to the absence of water and soil contamination at the site.

The mill was closed in 1960 and the site abandoned. Prior to remedial action in 1991, all that remained at the site were concrete foundations, a few small sheds, scattered debris, and just over 90,000 tons of sand concentrates in several discrete piles. Composition of the piles could be determined by color: black (original jig concentrate, primarily magnetite); red (primarily garnet); gray (primarily columbite-euxenite), and white (primarily quartz) (DOE 1991b). All of the sand piles were radioactive to varying degrees.

Remedial action by DOE to encapsulate and isolate the radioactive sands began in 1991 and was completed in 1992. The site was included under the general license by NRC in 1994.

2.2 Area Description

The Lowman disposal site is in Boise County, Idaho, approximately 75 miles northeast of Boise and 0.5 mile east of the unincorporated town of Lowman (Figure 2–1).

The site is in Clear Creek valley on the western side of the Sawtooth Mountains at an elevation of 4,000 feet, and is located on a Pleistocene river terrace about 80 feet above Clear Creek. The area surrounding the site is steeply mountainous and forested by ponderosa pine. Mountains above the site rise to elevations of 6,000 feet. Clear Creek is a tributary to the South Fork of the Payette River, located approximately 0.5 mile south of the site.

Average annual precipitation ranges between 20 and 25 inches, and much of it is from snow that falls in late winter or early spring. Heavy summer rains are infrequent and reportedly occur only once every 10 years or so.

2.3 Site Description

2.3.1 Legal Description

The legal description of the site and a brief history of the acquisition of the site are provided in Appendix B. The site boundary is shown on Figure 2–2.

2.3.2 Location and Access

Directions to the site follow. See also see Figure 2–1.

Begin odometer reading on State Highway 21 at the bridge over the South Fork of the Payette River at Lowman.

Mileage	Route
0.0	From the bridge, proceed east toward Stanley, Idaho.
0.5	Cross a smaller bridge over Clear Creek and immediately turn left (north) onto a one-lane, hard-packed gravel road. The access gate is about 150 feet from the highway along this gravel road. The site boundary is approximately 500 feet further along the gravel road.

2.3.3 Disposal Site Description

Disposal Site—The Lowman disposal site comprises 18.07 acres and is irregular in shape. The site and site features described in this LTSP are shown on Figure 2–2.

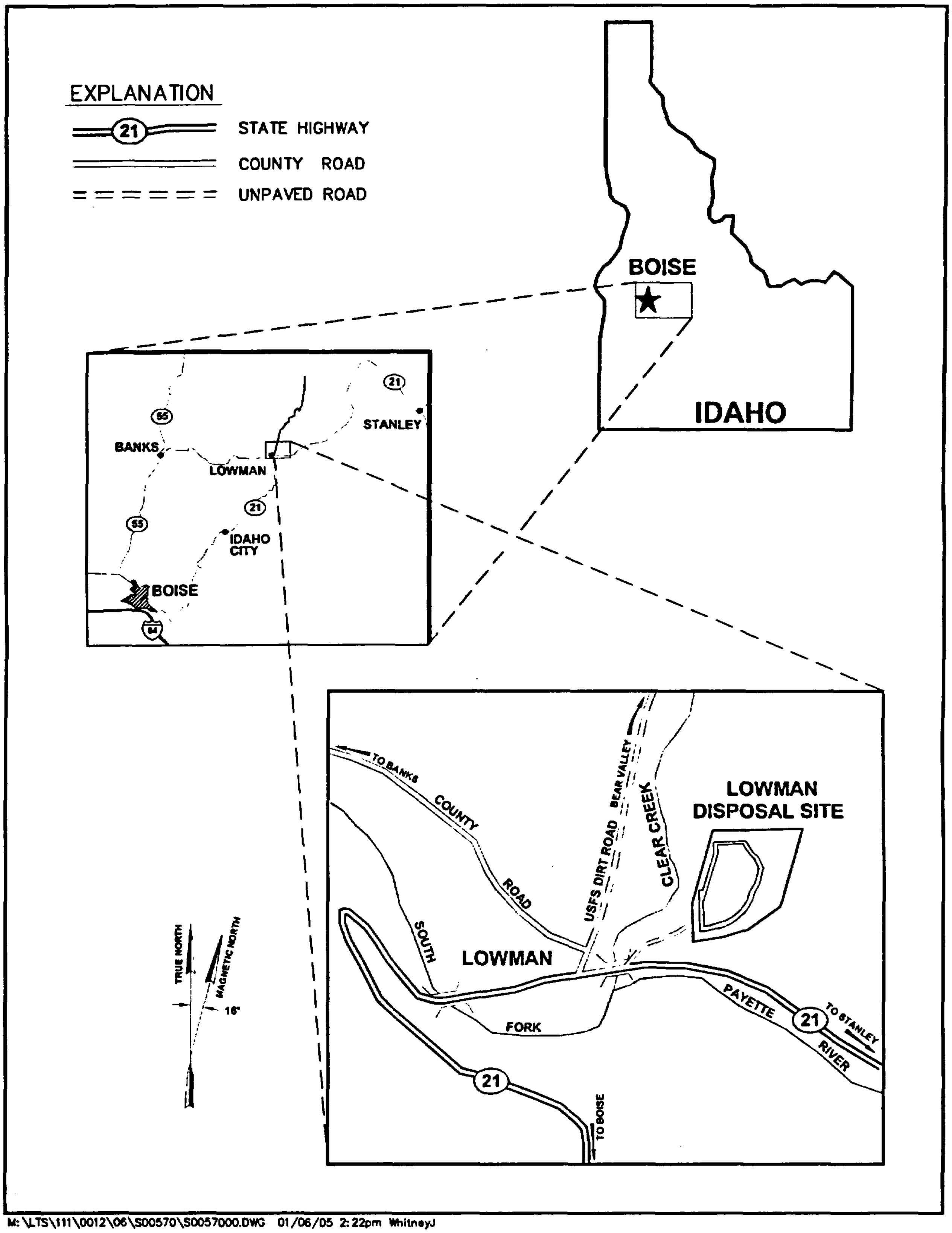


Figure 2–1. Location of Lowman, Idaho, Disposal Site

Disposal Cell—The disposal cell covers 8.29 acres and is irregular in shape. The cell contains 222,230 dry tons of encapsulated materials (radioactive sand residues, contaminated soil, and building debris). Radioactivity within the disposal cell is 12 curies of radium-226.

The disposal cell is a surface impoundment (Figure 2–3). The bottom or "footprint" of the disposal cell is essentially the original surface of the ground prior to remedial action. Radioactive sands and other contaminated materials, as placed, are about 20 feet thick in the center of the disposal cell. There is no liner between the ground and overlying radioactive materials because the sands are not leachable, as explained in Sections 2.4.3 and 3.5.

The radioactive materials are protected by an engineered cover that is 36 inches thick. The cover consists of three layers: a lowermost, relatively impermeable radon barrier constructed of compacted earthen materials (18 inches thick); a coarse-grained, free-draining, sandy bedding layer (6 inches thick); and a surface layer of riprap for erosion protection (12 inches thick). The riprap in the surface layer has a median diameter of 6 inches (DOE 1993).

The cover is sloped to facilitate runoff. On the east, or up-slope side of the disposal cell, the cover is fairly flat with a 10:1 slope. On the west, or down-slope side, the cover is steeper with a 5:1 slope.

The cover is designed to (1) protect the disposal cell from erosion, (2) limit release of radon to the atmosphere (radon flux), and (3) facilitate runoff to minimize infiltration of precipitation.

An apron of coarse riprap surrounds the disposal cell for additional erosion protection. The apron is 3 to 6 feet deep and 30 to 35 feet wide. Riprap in the apron has a median diameter of 24 inches.

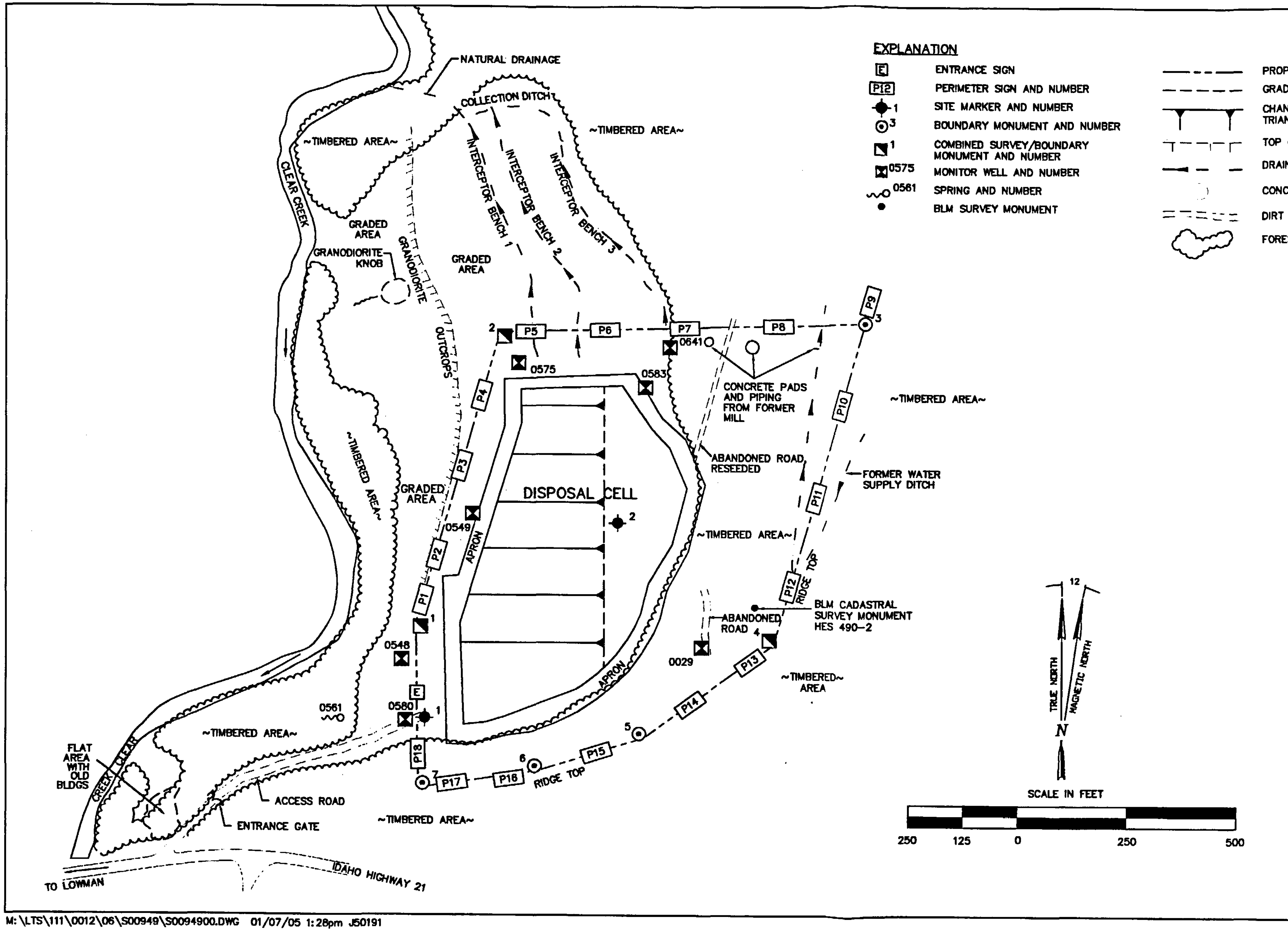
The apron is graded to prevent ponding around the edges of the disposal cell and to divert run-on from the hill slope above the site. In addition, the apron serves to protect the disposal cell from headward erosion that could potentially develop on the steep slope immediately west of the disposal site.

2.3.4 Area Adjacent to the Disposal Site

A steep, forested slope rises above the disposal cell on the east and south. Areas around the disposal cell on the north and west were disturbed during remedial action. These areas were graded and revegetated as part of remedial action. Initial seeding failed and natural vegetation did not establish sufficiently to prevent erosion. In 1997, DOE graded and planted the disturbed areas again. In the process, three large drainage terraces (Interceptor Benches 1, 2, and 3) and a collection ditch were constructed north of the disposal site (Figure 2–2). These benches and ditch intercept runoff and divert it north and away from the disposal site.

2.3.5 Institutional Controls

Institutional controls at the disposal site consists of (1) federal ownership (withdrawal) of the property; (2) warning signs; and (3) the gate across the access road that leads to the site from State Highway 21. There is no security fence at the site because of its remote location and open forest setting. As a result, human intrusion, vandalism, and livestock grazing are not expected to be problems. Inadvertent or casual intrusion by humans or animals is not of great concern.



LOCATIONS OF MONUMENTS, MARKERS, AND WELLS		
TYPE	COORDINATES	
	STATE PLANE EAST	STATE PLANE NORTH
BOUNDARY MONUMENT		
3	538222.0	881733.8
5	537696.9	880807.2
6	537455.7	880736.1
7	537200.1	880700.2
COMBINED BOUNDARY/ SURVEY MONUMENT		
1	537201.0	881060.2
2	537401.8	881727.0
4	538000.3	881017.4
SITE MARKER		
1	537207.6	880850.1
2	537654.8	881293.0
WELLS		
0029	537844.5	881002.6
0548	537157.1	880985.1
0549	537323.2	881318.7
0575	537433.5	881665.4
0580	537164.1	880845.1
0583	537723.6	881604.5
0641	537781.6	881696.7

U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION, COLORADO

Work Performed by
S.M. Stoller Corporation
Under DOE Contract
No. DE–AC01–02GJ79491

LOWMAN, IDAHO,
DISPOSAL SITE

DATE PREPARED: JANUARY 7, 2005
FILENAME: S0094900

Figure 2–2. Lowman, Idaho, Disposal Site

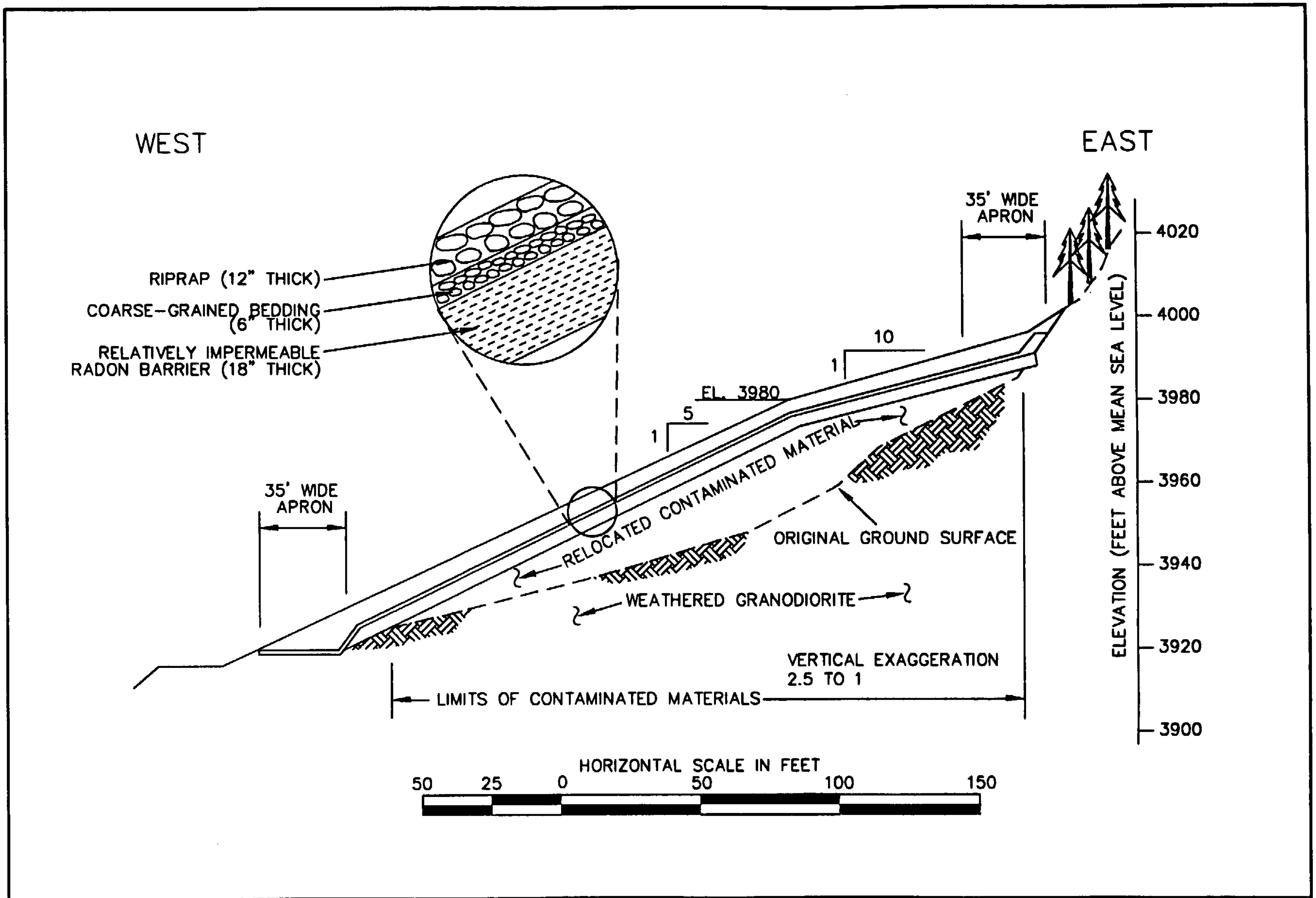


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Figure 2–3. Cross Section of the Lowman, Idaho, Disposal Cell

The site is within the Boise National Forest and therefore protected from development or changes in land use. The area immediately north of the site is state-owned, acquired from the U.S. Forest Service (USFS) under Section 104 of UMTRCA for the purpose of remedial action. DOE understands that the state may eventually convey this parcel back to the USFS. There are private inholdings within the national forest on the west side of Clear Creek opposite the disposal site. Some of this land is used for cabins and summer homes. There is no private land on the east side of the creek adjacent to the site.

2.3.6 Specific Site Surveillance Features

Features described in this section are shown on Figure 2–2. Specifications for construction of monuments, markers, and signs are in the *Guidance for Implementing the Long-Term Surveillance Program for UMTRCA Title I and Title II Disposal Sites* (DOE 2001). Coordinates in Figure 2–2 for boundary monuments, survey monuments, site markers, and monitor wells were established to second-order standards and confirmed by global positioning system survey in 1999.

Boundary and Survey Monuments—Four boundary monuments (BMs) and three combined survey-boundary monuments (SM/BMs) mark corners along the site boundary (DOE 1994). These monuments are set back from each corner about 14 feet.

Survey monuments were initially established for location and elevation control during remedial action. Boundary monuments were set once the final site boundary was determined. Boundary monuments and combined survey-boundary monuments differ in their design and construction.

The four boundary monuments (BM–3, BM–5, BM–6, and BM–7) are Berntsen A–1 federal aluminum survey monuments. The bottom of each boundary monument is at a depth of 48 inches to prevent displacement by frost heaving.

Combined survey-boundary monuments (SM/BM–1, SM/BM–2, and SM/BM–4) are Berntsen RT–1 markers set in concrete. The concrete at the bottom of each SM/BM is at a depth of 38 inches.

Ceramic magnets are set in the top and bottom of each boundary monument to facilitate location by metal detector should the monument ever become buried. Magnets in the shaft and metal bars in the concrete along the side of the combined survey-boundary monuments serve a similar purpose.

Site Markers—Site markers (SMK) are unpolished granite monuments set in reinforced concrete. SMK–1 is just inside the site boundary at the southwest corner of the site. SMK–2 is on top of the disposal cell at the center and just east of the break in slope.

The markers are inscribed with a diagram to show the site boundary and location of the disposal cell within that boundary, the date of closure (September 14, 1991), the quantity of contaminated materials (222,230 dry tons), and the level of radioactivity (12 curies of radium-226).

Perimeter Signs—There are 18 perimeter signs and 1 entrance sign located along the site boundary. The signs are aluminum placards, similar to highway signs, and are mounted on steel posts set in concrete.

The perimeter signs identify the site as a uranium mill tailings repository on U.S. Government property with no trespassing allowed. In addition, the signs provide a 24-hour telephone number the public or outside agencies may use for emergency or inquiry (970-248-6070). The international symbol for radioactive materials (trefoil) on the signs warns of the potential hazard, although there is no hazard as long as the engineered cover over the tailings remains undisturbed.

The entrance sign is at the southwest corner of the site just inside the site boundary and a few feet north of site marker SMK–1. The entrance sign identifies the site as the Lowman site and provides the same information as the perimeter signs including the 24-hour telephone number.

Monitor Wells—There are 4 monitor wells (0549, 0575, 0583, and 0641) and 1 wellpoint (0029) onsite, and 2 monitor wells (0548 and 0580) just beyond the site boundary at the southwest corner of the site (Figure 2–2). All but the wellpoint are part of the monitoring network established for initial cell performance and ground water compliance monitoring. Because ground water monitoring is no longer required (see Section 3.7), all wells will eventually be decommissioned in accordance with state ground water protection requirements.

Spring—A small perennial spring (0561) is located southwest of the site (Figure 2–2). Ground water recharged from rain and snowmelt discharges to Clear Creek and this spring.

2.4 Ground Water

2.4.1 Geology

The Lowman disposal site is located in rugged mountainous terrain of the Idaho Batholith. The batholith comprises several Cretaceous granitic intrusions, with biotite granodiorite exposed at the disposal site. Rock exposed near the site is fractured and weathered to varying degrees, and unweathered bedrock crops out down slope from the northwest corner of the site and in adjacent Clear Creek.

Alluvial terraces of probable Pleistocene age occur along the sides of deeply incised V-shaped stream valleys and above the occasional flat, alluviated valley floor. The disposal site lies on such a terrace approximately 80 to 100 feet above Clear Creek. A second younger and narrower alluvial terrace is present below the site approximately 15 feet above Clear Creek. The alluvial terrace beneath the disposal site is mantled with stream deposits (poorly consolidated silty and gravely sands) overlain by thin colluvium derived from hill slopes above the terrace. The stream and colluvial deposits unconformably overlie weathered bedrock. Except on relatively flat, alluviated valleys floors, such as at the Lowman town site, soils in the area are typically thin mountain loams, which are young and poorly developed.

2.4.2 Hydrology

At the site, ground water occurs in the terrace deposits and underlying weathered bedrock, which together constitute the uppermost aquifer. Depth to ground water in the uppermost aquifer beneath the site has historically ranged between 27 and 78 feet (DOE 1994). Ground water is unconfined and generally flows toward the west and southwest (Figure 2–4). Ground water is recharged from rain and snowmelt, and discharges to Clear Creek and a small perennial spring (0561) southwest of the site (DOE 1991b).

Ground water also is present along fractures in the deeper, unweathered bedrock, but yields are insufficient for the unit to qualify as an aquifer as defined in 10 CFR 40, Appendix A.

2.4.3 Ground Water Quality

Ground water quality was extensively studied during remedial action. Studies included characterization of site hydrology and geology; analysis of radioactive sands pore water, soil pore water, and upgradient and downgradient ground water chemistry; and column leach tests on the radioactive sands. Site ground water is not contaminated from uranium milling operations or natural sources.

Contaminants in ground water at designated UMTRCA Title I sites must conform to maximum concentration limits (MCLs) established by the U.S. Environmental Protection Agency (EPA) at 40 CFR Section 192.02 and 192.04, or must not exceed background concentrations.

Background ground water quality was determined at wells upgradient from the site in an area unaffected by processing operations. Ground water at the Lowman site is oxidizing with a neutral pH. No hazardous constituent in background ground water exceeded its respective MCL. In tests performed during remedial action, no potentially hazardous constituent in the radioactive sands pore fluid had a mean concentration in excess of its MCL, and only a few (barium, molybdenum, gross alpha, nitrate, and uranium) exceeded laboratory-method detection limits. Only the sand pore fluid concentration of antimony exceeded the statistical maximum for background ground water (background soil pore fluids had higher concentrations of antimony than the tailings pore fluids). Chromium, lead, and radium-226 plus radium-228 exceeded laboratory detection limits only in neutral pH leach tests conducted on the various radioactive sand products left at the site. Pore fluids in upgradient native soils contain higher concentrations of soluble metals, including antimony, than pore fluids in the radioactive sands (DOE 1991b).

Antimony was designated as the target analyte and the sole hazardous constituent with the potential to affect ground water quality downgradient from the disposal cell. Antimony does not have an MCL under 40 CFR 192, but EPA established a standard of 0.006 milligrams per liter (mg/L) under the Safe Drinking Water Act (40 CFR 141.51). The maximum background ground water concentration for antimony exceeded 0.007 mg/L only two times since 1987. The maximum background concentration prior to completion of the disposal cell was 0.007 mg/L. Therefore, this value (0.007 mg/L) for antimony was adopted as the standard for ground water compliance at the site. Although antimony was the target analyte during monitoring, other constituents in downgradient ground water also had the same median or mean concentrations as background water quality. This suggests that all ground water that was sampled was of the same population with no detectable contribution from the uncontrolled sands or, later, the disposal cell.

Granites typically contain 0.1 to 0.9 parts per million antimony, where it may occur in sulfide minerals or with niobium and tantalum in oxide minerals (Wedepohl 1978). Abundance of antimony in mineralized metamorphic rocks may be an order of magnitude higher. Several minerals in the heavy sand concentrates processed at the Lowman site (monazite, euxenite, samarskite, fergusonite, thorite, xenotime, zircon, and others) may contain antimony together with niobium and tantalum (Fairbridge 1972).

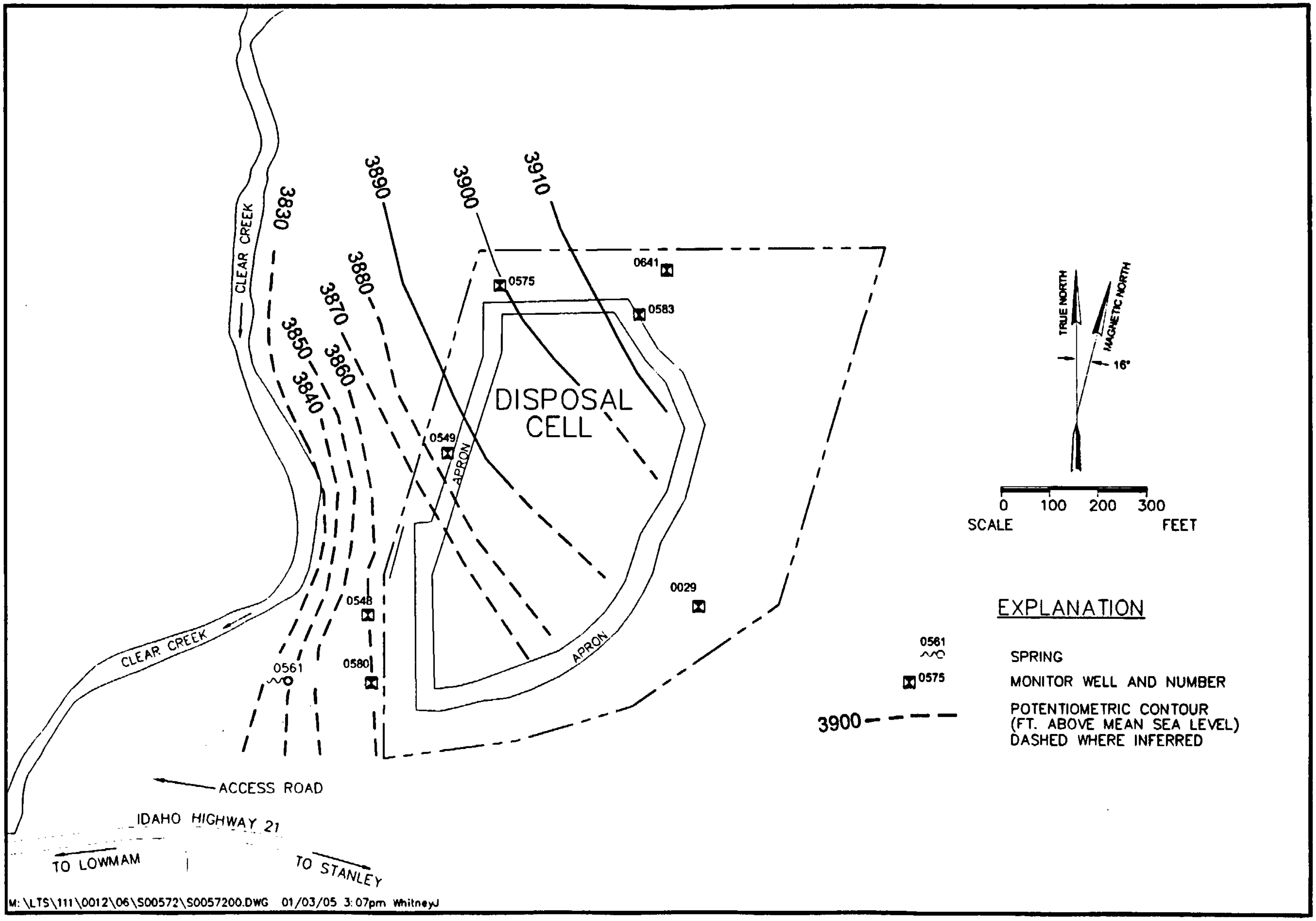

Figure 2–4. Potentiometric Surface at the Lowman, Idaho, Disposal Site

Processing-related contamination is not expected because activities at the Lowman site consisted solely of mechanical separation of minerals according to their respective densities. No chemical digestion of ores took place and no acids or other potentially contaminating chemicals were used.

Leaching and transport of hazardous constituents has not occurred. The radioactive minerals stockpiled on site, chiefly columbite, euxenite, and zircon in the form of dredged placer sands, are highly resistant to further physical and chemical weathering under surface conditions. Contaminants do not easily leach from these minerals. More specifically,

- Sand derived from the weathering of granitic source rocks and transported and deposited by streams does not contain significant amounts of easily soluble minerals. All of the soluble minerals in the stream deposits were likely removed by physical and chemical weathering before the sands were dredged.
- The small quantities of soluble minerals that may have been present in sands stored at the site would not contain significant amounts of radioactive or other contaminants.
- The heavy minerals dredged from Bear Creek and later concentrated at the mill are "resistates" or end-state weathering products, highly resistant to physical and chemical weathering that might contribute to leaching of contaminants.
- Sand piles with very high porosity were exposed at the site for 30 years (before remedial action). Infiltration through the piles did not contaminate site ground water.

DOE proposed to demonstrate ground water compliance by meeting MCLs or the background concentration for antimony, the designated hazardous constituent for the uppermost aquifer, at the downgradient wells and spring. The Remedial Action Plan (DOE 1991b) concluded that the MCLs would be met at downgradient locations because none of the constituents that exceeded laboratory-method detection limits in the tailings pore fluid were above their respective MCL. Antimony, with an adopted compliance standard of 0.007 mg/L, was left as the target analyte for demonstrating initial cell performance and ground water compliance at downgradient locations.

3.0 Long-Term Surveillance Program

3.1 General License for Long-Term Custody

With NRC concurrence in the original LTSP (Appendix A), the site was included under the general license for long-term custody [10 CFR 40.27(b)].

Although sites remediated under UMTRCA are designed and constructed to last "for up to 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years" (40 CFR 192, Subpart A, 192.02), there is no provision for termination of the general license for DOE's long-term custody of these sites (10 CFR 40.27(b)).

When DOE determines that revision of the LTSP is necessary, DOE will notify NRC. Changes to the LTSP may not conflict with the requirements of the general license.

Additionally, DOE must guarantee NRC permanent right-of-entry to the site so that NRC may conduct site inspections. Access to the Lowman site is described in Section 2.3.2.

3.2 Requirements of the General License

Requirements of the general license are at 10 CFR 40.27 and 10 CFR 40, Appendix A, Criterion 12. The requirements of the general license and the sections in this LTSP where each is addressed are listed in Table 3–1.

Table 3–1. Requirements of the General License and DOE Response

Requirement	LTSP Section
Annual site inspection	Section 3.3
Annual inspection report	Section 3.3.5
Follow-up inspections and reports of follow-up inspections	Section 3.4
Site maintenance	Section 3.5
Emergency response	Section 3.6
Environmental monitoring	Section 3.7

3.3 Annual Site Inspections

3.3.1 Frequency of Inspection

At a minimum, sites must be inspected annually to confirm the integrity of visible features at the site and to determine the need, if any, for maintenance, additional inspections, or monitoring (10 CFR 40, Appendix A, Criterion 12).

To meet the inspection requirement, DOE will inspect the Lowman site once each calendar year. DOE will notify NRC of the annual inspection at least 30 days in advance.

3.3.2 Inspection Procedure

To ensure a thorough and uniform inspection, the site is divided into three areas referred to as transects. Transects for the inspection of the Lowman site are listed in Table 3–2 and shown on Figure 3–1.

Table 3–2. Transects Used During Inspection of the Lowman, Idaho, Disposal Site

Inspection Transect	Description
Top and Side Slope of the Disposal cell	Rock-covered top surface of the disposal cell and surrounding side slope apron of riprap.
Area between the disposal cell and site boundary	Graded and revegetated areas immediately north and west of the disposal cell. Natural, undisturbed forest on steep hillsides east and south of the disposal cell.
Outlying Area	The area immediately surrounding the site in all directions up to a distance of a quarter mile.

Each transect is visually inspected during a walk-over. Within each transect, inspectors examine any specific site surveillance features that are present. Specific site surveillance features at the Lowman site include; survey and boundary monuments, entrance and perimeter signs, site markers, monitor wells, a wellpoint, and a spring (Section 2.3.6 and Appendix D). Inspectors also examine each transect for maintenance requirements, success of any previous maintenance performed, and for erosion, settling, slumping, plant or animal encroachment, human intrusion or vandalism, and other activity or phenomenon that might affect the safety, integrity, long-term performance, or institutional control of the site.

Inspectors will note changes within 0.25 mile of the site. Changes that might be significant include signs of human activity such as new development or changes in the current land use, along with any environmental changes such as changes in and along the banks of Clear Creek or the stability of slopes around the site.

Inspectors will use photographs, as necessary, to support or supplement written observations. When photographs are taken, a photograph log will be generated and will include: site name, purpose of visit (i.e., annual inspection), date taken, inspector name, photograph number, electronic photograph file name, orientation (azimuth), and caption.

3.3.3 Inspection Checklist

A pre-inspection briefing is held involving the site inspectors and other DOE and contractor personnel associated with site activities. An inspection checklist and site drawings, addressing all required site surveillance features and other pertinent site issues, are prepared and discussed. The checklist and drawings, updated each year, serve as a guide for conducting a thorough inspection and a means of documenting observations, issues, and recommendations. Minimum information contained in the checklist is provided in Appendix D.

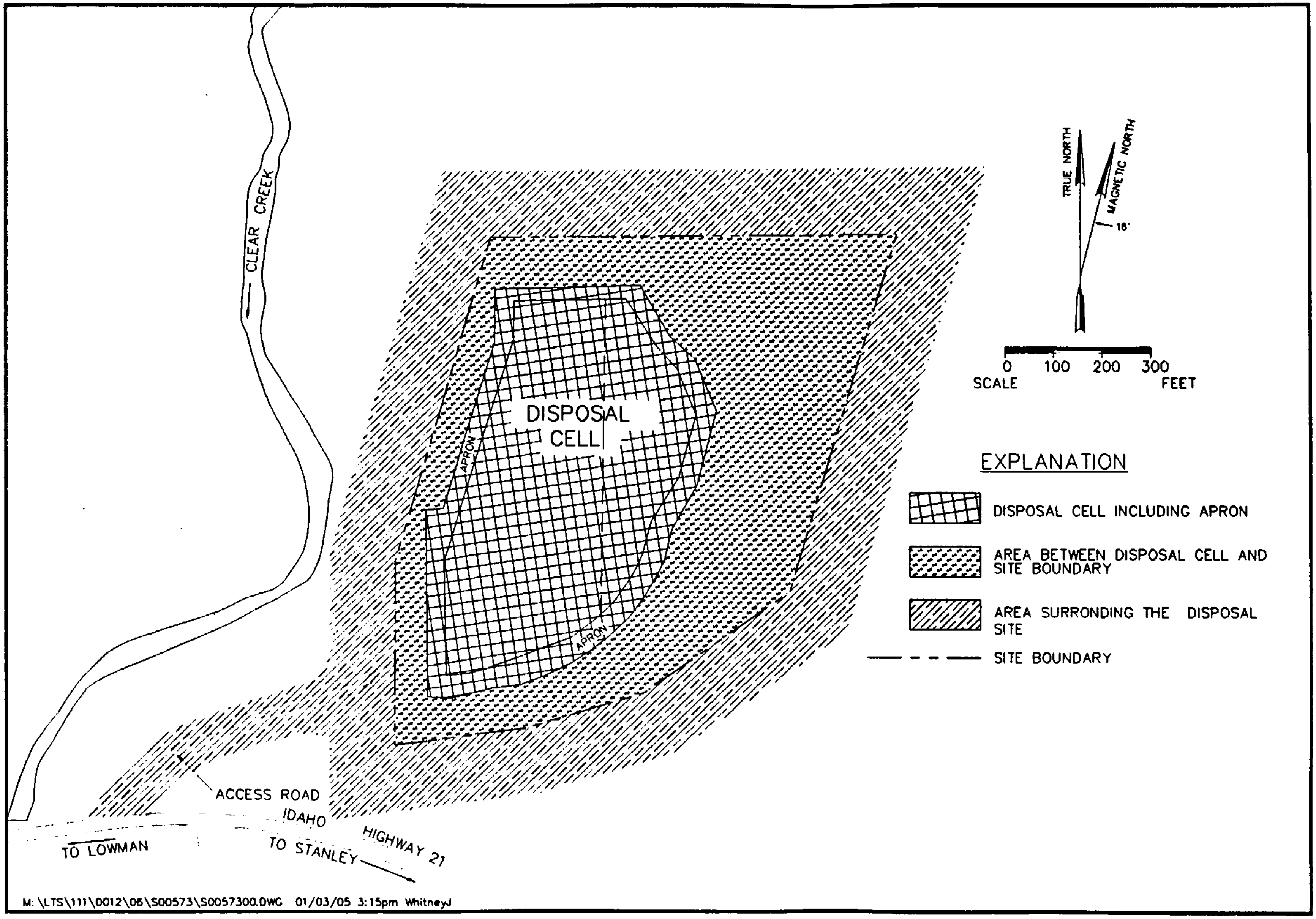

Figure 3–1. Transects Used During Inspection of the Lowman, Idaho, Disposal Site

3.3.4 Personnel

A team of two or more inspectors performs annual inspections. Inspectors are trained and experienced scientists and engineers. Training includes participation in previous site inspections. Engineers will typically be civil, geotechnical, or geological engineers. Scientists will typically be geologists, hydrologists, biologists, or environmental scientists. The inspection team will be selected on the basis of skills and experience appropriate to the issues or concerns at the site. If serious or unique problems develop at the site, additional inspectors, specialized in specific fields, may be assigned to the inspection team.

3.3.5 Annual Compliance Report

An annual regulatory compliance report for all Title I disposal sites, including results of the annual Lowman disposal site inspection, will be submitted to the NRC within 90 days of the last Title I site inspection in the calendar year (10 CFR 40, Appendix A, Criterion 12). In the event that the report cannot be submitted in accordance with 10 CFR 40, DOE will notify the NRC. Annual reports are available to the public and other agencies and include the following:

- Compliance Summary: A brief description of the inspection performed.
- Compliance Requirements: Provides the license requirements governing the site's long-term surveillance and maintenance, the regulations mandating their implementation, and the plan and procedures used to perform them.
- Compliance Review: Describes the inspection, presents findings and observations made for each item, identifies any issue or problem, discusses corrective actions required, repairs needed, and details any follow-up inspections performed.

3.4 Follow-Up Inspections

Follow-up inspections are in response to significantly new or changed conditions at the site.

3.4.1 Criteria for Follow-Up Inspections

The LTSP is required to include criteria for follow-up inspections in accordance with 10 CFR 40.27(b)(4). DOE will conduct a follow-up inspection when:

- A condition is identified during the annual inspection (or other site visit) that requires personnel, perhaps with special expertise, to return to the site to evaluate the condition and whether additional testing is necessary as a result of the condition identified.
- DOE is notified by a citizen or outside agency that conditions at the site are substantially changed.

With respect to citizens and outside agencies, DOE has established lines of communication with local law enforcement, USFS (Lowman District), and emergency response agencies to facilitate notification in the event of significant trespass, vandalism, severe storm, flood, or other natural disaster. These agencies will notify DOE or provide information should a significant event occur that might affect the security or integrity of the site.

DOE may request the assistance of local agencies to confirm the seriousness of a condition before conducting a follow-up inspection or emergency response. The public may use the 24-hour DOE telephone number posted prominently on the entrance sign to request information or to report a problem at the site.

Once a new or changed condition is identified, DOE will evaluate the information and determine whether a follow-up inspection is warranted. Conditions that may require a routine follow-up inspection include changes in vegetation, erosion, storm damage, low-impact human intrusion, minor vandalism, or the need to evaluate, design, or perform certain maintenance projects.

Conditions that threaten the safety of the site or the integrity of the disposal cell may require a more urgent follow-up inspection. Slope failure, disastrous storm, major seismic event, and deliberate human intrusion are among these conditions.

DOE will use a graded approach with respect to follow-up inspections. Urgency will be proportional to the potential seriousness of the condition. For example, a follow-up inspection to investigate or control vegetation may be postponed until a particular time during the growing season. A follow-up inspection to evaluate erosion may be scheduled to avoid snow cover.

In the event of "unusual damage or disruption" (10 CFR 40, Appendix A, Criterion 12), damage that may compromise or threaten the safety, security, or integrity of the site, DOE will

- Notify NRC pursuant to 10 CFR 40, Appendix A, Criterion 12, or 10 CFR 40.60, whichever is determined to apply;
- Begin DOE's internal occurrence notification process (DOE Order 232.1A);
- Respond with an immediate follow-up inspection or emergency response team; and
- Implement emergency measures, as necessary, to prevent or contain exposure to or dispersal of radioactive materials (Section 3.6).

3.4.2 Personnel

DOE will assign inspectors to follow-up inspections on the same basis as the annual site inspection.

3.4.3 Reports

Results of routine follow-up inspections will be in the annual Title I compliance report to NRC. Separate reports will not be issued unless DOE determines that is it advisable to notify NRC and other agencies of a potentially serious problem at the site.

If follow-up inspections are required for more urgent reasons, DOE will submit a preliminary report of the follow-up inspection to NRC within the 60-day period required by 10 CFR 40, Appendix A, Criterion 12.

3.5 Site Maintenance

Sites remediated under UMTRCA are designed and constructed so that "ongoing active maintenance is not necessary to preserve isolation" of radioactive material (10 CFR 40,

Appendix A, Criterion 12). No recurrent or regularly scheduled active maintenance is required at the Lowman disposal site. Maintenance activities, when required, will be described in annual reports to NRC.

Routine Maintenance—Routine maintenance may include: upgrade of the entrance gate; sign replacement; and erosion and vegetation control measures.

Vegetation Control—In 1994, inspectors first observed encroachment of ponderosa pine and other plants on the apron and cover of the disposal cell. It was postulated that plant roots could increase the saturated hydraulic conductivity of the relatively impermeable radon barrier that overlies the contaminated materials. If the saturated hydraulic conductivity were to increase, meteoric water could flow downward through the cover and into the tailings where it might leach contaminants into the uppermost aquifer. However, vegetation establishment has been shown to decrease water flux and may be advantageous in infiltration control (Waugh 2002). At issue was whether to institute a practice of controlling the vegetation by cutting and removal. Plant control would not be necessary if plant encroachment and increased hydraulic conductivity posed no additional risk to human health and the environment.

DOE reviewed the evaluation of the consequences of water infiltration that was prepared in support of the Remedial Action Plan. Program scientists concluded that establishment of the native forest plant community on the disposal cell might increase infiltration, but this would likely not result in leaching of contaminants from the disposal cell (DOE 2002). This conclusion was based on four lines of evidence.

1. The tailings are "resistates" or end-state weathering products, highly resistant to physical and chemical weathering that might contribute to leaching of contaminants.
2. In the tailings pore fluid, concentrations of possible contaminants with MCLs were all below their respective MCL.
3. Results of batch leach tests confirm that leaching of radium and other potential contaminants is limited at pH values expected in pore fluids even with establishment of forest. Over time, development of forest and associated organic soils might decrease pH to a value of 6 in the root zone. But only at pH values lower than would occur naturally would leaching of radium reach significant levels (the 2002 report postulates that acidic solutions with an initial pH of 2 or 3 were used in the acidic batch leaching tests because the final pH of the leach solutions ranged from about 3 to 5 and feldspars would buffer strongly acidic solutions).
4. No ground water contamination occurred at the site during the 30-year period that the radioactive sands were exposed to the environment.

Ground water protection at the site does not depend on controlling infiltration through the contaminated material in the cell. The cover is designed to shed water and thereby reduce infiltration. However, as stated in the "Water Resources Protection Strategy" section of the Remedial Action Plan, although the radon barrier is relatively impermeable, because the cell contents will not leach contaminants to the uppermost aquifer, impermeability to water percolation is not necessary for ground water protection (DOE 1991b). The Remedial Action Plan also states, "Because the radioactive sands are chemically inactive and do not weather and release hazardous constituents, controlling infiltration through the disposal cell is not critical to the design of the disposal cell" (DOE 1991b, Appendix B, Attachment 4).

Based on these observations, active intervention to prevent establishment of forest on the disposal cell is not warranted for the purpose of protecting site ground water. Therefore, DOE will not remove the vegetation encroaching on the cell cover. DOE expects forest duff to accumulate and an organic soil to form on the cover that may eventually fill the interstices in the filter layer and riprap. Along with soil formation will come the progressive establishment of the native plant community on the cover of the cell. DOE will allow this process to occur without intervention.

DOE must preserve the physical integrity of the cell to prevent dispersion of contaminated materials. The possibility of mature trees being blown down and exposing cell contents was evaluated. Ponderosa pine trees, which are beginning to establish on the cell cover, have deep root systems and do not tend to uproot when damaged by wind. Therefore, DOE does not anticipate the need to log the trees, which is an activity that could damage the cell cover. However, DOE will repair any damage that may occur to the riprap cover and underlying cover layers to maintain protection from erosion and possible consequent dispersion of cell contents. This level of maintenance is less than that required if DOE must implement active vegetation control. The need to control trees and plants will be reevaluated if unexpected problems develop.

Radon emanation will not exceed EPA standards if plant roots penetrate the radon barrier. The disposal cell contains 12 curies of radium-226, and the more-contaminated material (e.g., the abandoned stocks of processed and unprocessed sands) is located in the bottom of the cell and covered by less-contaminated material (windblown and vicinity property material). The average radon flux measured after placement of the radon barrier was 0.058 picocuries per square meter per second (pCi/m^2/sec); the standard is 20 pCi/m^2/sec (DOE 1993). Soil formation should enhance radon attenuation by interspersing additional material in the path of radon percolating toward the cell surface and by possibly allowing moisture levels to increase in materials that lie in the path of radon beyond moisture contents used to model radon transport.

The effect of soil formation on water infiltration is not important. Soil formation may result in ultimately lowering the hydraulic conductivity of the filter layer and thus reducing the conductivity contrast between the filter layer and the underlying radon barrier. However, the cell was designed to shed water by maintaining sloped surfaces, and the hydraulic conductivity contrast cited by cell designers in the remedial action plan as essential to controlling infiltration will be enhanced by soil formation at the soil/atmosphere interface. Additionally, vegetation establishing on the cell cover will remove water through evapotransporation.

Soil formation should not create a source of sediment transport. Riprap on the cover will control erosion as demonstrated at sites covered with a soil/rock matrix, and the apron will dissipate energy and reduce the load-carrying capacity of runoff. Undisturbed slopes east and south of the site are stable, with no discernable sediment transport.

3.6 Emergency Response

Emergency response is action DOE will take in response to "unusual damage or disruption" that threatens or compromises site safety, security, or integrity (10 CFR 40, Appendix A, Criterion 12).

3.6.1 Criteria for Emergency Response

Short-term catastrophic events (i.e.; earthquakes, floods, forest blow-down) capable of causing significant site damage requiring reconstruction, although possible, are unlikely. Long-term progressive events (i.e.; erosion, settling, riprap degradation) are more likely.

Conceptually, there is a continuum in the progression from small-scale, minor, routine maintenance to large-scale intervention that might include reconstruction of the disposal cell following an unlikely disaster. Although required by 10 CFR 40.27(b)(5), criteria for initiating specific responses to progressively more serious problems are not easily established because the nature of all potential problems is unforeseeable and highly scale-dependent. The information in Table 3–3 is a guide to the actions DOE may take in response to increasingly more serious problems.

Table 3–3. DOE Criteria for Maintenance and Emergency Measures[a]

Priority	Description	Example	Response
1	Breach of disposal cell with dispersal of radioactive material.	Side slope of disposal cell fails and radioactive materials are dispersed.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to prevent further dispersal, recover radioactive materials, and repair breach.
2	Breach without dispersal of radioactive material.	Partial or threatened exposure of radioactive materials.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to repair the breach.
3	Erosion or instability of slopes surrounding the site.	Erosion on slopes above the site, possibly after forest fire, or erosion on slopes below the site due to flooding or severe storm.	Assess damage and perform risk assessment if warranted. Stabilize eroded slopes, divert runoff, or take similar actions if integrity or future performance of the disposal cell is threatened.
4	Breach of site security with or without excavation or removal of materials.	Willful human intrusion, significant vandalism.	Repair damage. Evaluate current level of institutional control and increase security if necessary.
5	Minor problems, small scale changes.	Minor erosion, undesirable plant encroachment (noxious weeds), minor vandalism, incidental trespass.	Routine maintenance.

[a]Other changes or conditions will be evaluated and treated similarly on the basis of perceived risk.

The table shows that the difference between routine maintenance and various emergency responses is primarily one of risk or urgency. Priorities are listed in the table in inverse order relative to the probability of occurrence. The highest priority responses are the least likely to be required.

3.6.2 Notification

In accordance with 10 CFR 40.60, DOE will notify

Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Security
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

within 4 hours of discovery of a Priority 1 or 2 event in Table 3–3. The telephone number for the NRC Operations Center is 301-816-5100.

3.6.3 Procedure for Emergency Response

In the event of a Priority 1 or 2 Event, an emergency response team will assess the damage and decide whether evaluation of the problem is required or if immediate intervention (additional remedial action) is essential. This decision will be based on the emergency team's evaluation of the adequacy of the damaged feature to perform its intended function.

To make this decision, the emergency response team will assess and evaluate the following. The evaluation may include risk analysis.

1. Adequacy of the design specification(s) for the damaged feature to control or accommodate the observed problem(s).

2. Extent of the damage, degradation, or departure from the design (or as-built condition) of the damaged feature.

3. Ability of the feature, in its damaged condition, to withstand a design-basis event. DOE will provide NRC with a clear, technical explanation for its decision to study and evaluate or intervene with additional remedial action (DOE 2001).

3.7 Environmental Monitoring

Ground water monitoring was the only environmental monitoring required at the site (DOE 1994). The ground water monitoring network consists of six monitor wells and one spring. Background monitor wells 0583 and 0641 are hydrologically upgradient of the disposal cell. Monitor wells 0548, 0549, 0575, and 0580, and spring 0561 are downgradient of the cell. Antimony was the target analyte for demonstration of both ground water compliance and initial performance of the disposal cell. In addition, TDS, pH, calcium, chloride, iron, magnesium, manganese, potassium, sodium, and sulfate were monitored as indicator parameters to observe potential changes in ground water quality.

Revision 1 of the LTSP (DOE 1994) stated that periodic performance evaluations would be conducted to determine: (1) the effectiveness of the disposal cell ground water compliance strategy, (2) the effectiveness of the ground water monitoring plan, and (3) the need for continued ground water monitoring. As described in Revision 1, it was expected that the design of the disposal cell was sufficient to provide long-term protection against future ground water contamination that might result from infiltration and leaching; and that the proposed concentration limit for antimony, 0.007 mg/L, would be met through attenuation in subsoils beneath the disposal cell and by dilution from ground water underflow (DOE 1991b).

Monitoring results for antimony, total dissolved solids, and pH are shown as time-concentration plots in Appendix C. Ground water monitoring results since completion of the disposal cell in 1992 were evaluated to determine if the performance requirements of Revision 1 of the LTSP have been met.

Cell performance monitoring has not indicated that contaminants have leached from the cell. As explained in Sections 2.4.3 and 3.5, this is probably the result of cell contents having a low potential for leaching. As demonstrated in *Leaching Characteristics of Radioactive Sands, Long-Term Surveillance and Maintenance Program, Lowman, Idaho, Site* (DOE 2002), hazardous constituents are not readily leached from cell contents until pH falls to concentrations more acidic then would be created by passage of water through cover materials. The pH of pore water samples was not low enough to leach radium from contaminated material when compared to laboratory leachability test results. The arithmetic average of antimony in neutral batch leach tests was greater than the detection limit but less than the standard at 40 CFR 141.51.

Concentrations of antimony in ground water from all locations have been less than 0.006 mg/L with the exception of an observation of 0.017 mg/L in background monitor well 0583 in 1994. This elevated measurement was considered to be anomalous and did not indicate a change in background water quality. These results indicate that antimony has not leached from the disposal cell; or, if in the unlikely event that minor leaching has occurred, antimony is being attenuated in soils beneath the disposal cell, or diluted by underflow, as predicted.

Concentrations of other indicator parameters in ground water have generally been consistently low and provide no indication of any anomalous behavior of constituents in the vicinity of the disposal cell. The other constituents in downgradient ground water had the same median or mean concentrations as in background water. This situation was observed also with the unprotected radioactive sand piles that were left at the site and suggests that upgradient and downgradient water chemistry is of the same population with no detectable contribution from the disposal cell or, previously, the uncontrolled sands.

Based on the water quality results and the evaluation of the results, the disposal cell is (1) performing as designed and the site is in compliance with ground water protection standards; and (2) the ground water monitoring program has demonstrated that no site-related contamination exists in ground water near the site. Ground water monitoring results since 1992 have been consistent and indicate no site-related impact on ground water quality near the site, and there is no unacceptable risk to human health and the environment. Consequently, there is no need to continue ground water monitoring at the Lowman disposal site.

Upon regulatory concurrence to discontinue ground water monitoring, the six monitor wells and the small diameter wellpoint remaining at the site will be decommissioned as soon as practicable in accordance with State of Idaho ground water protection requirements.

3.8 Records and Data Management

DOE maintains records at their office in Grand Junction, Colorado, to support post closure maintenance of the closure site. These records are being maintained by DOE because they contain critical information required to protect human health and the environment, manage land and assets, protect legal interests of DOE and the public, and mitigate community impacts resulting from the cleanup of legacy waste. DOE will include records generated during site operations in the LM site collection. Inactive or retired site records will be stored in a federal records center. The records are managed in accordance with the following requirements.

- Title 44, United States Code, Chapter 29, Records Management by the Archivist of the United States and by the Administrator of General Services, Chapter 31, "Records Management by Federal Agencies,"; and Chapter 33, "Disposal of Records"
- Title 36 CFR Chapter XII, Subchapter B, "Records Management"
- DOE G 1324.5B, *Implementation Guide*
- *LM Information and Records Management Transition Guidance*

3.9 Quality Assurance

The long-term care of the Lowman disposal site and all activities related to the annual surveillance, monitoring, and maintenance of the site comply with DOE Order 414.1A, *Quality Assurance (QA)* and ANSI/ASQC E4-1994, *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs* (*American Society for Quality Control 1994*).

QA requirements are transmitted to subcontractors through procurement documents when appropriate.

3.10 Health and Safety

Long-term surveillance and maintenance activities are conducted in accordance with health and safety procedures established for all sites managed by DOE-LM. These procedures are consistent with DOE orders, regulations, codes, and standards.

Health and safety concerns specific to work at the Lowman disposal site are in the *Office of Land and Site Management Project Safety Plan* (DOE 2004). This plan contains a list of emergency telephone numbers and addresses for local fire, hospital, ambulance, and police or sheriff agencies, as well as a map to the nearest emergency medical facility. Personnel are briefed on health and safety requirements during a pre-inspection meeting.

Maintenance subcontractors are advised of health and safety requirements through appropriate procurement documents. Subcontractors must submit health and safety plans for all activities subject to Occupational Safety and Health Administration requirements. Subcontractor health and safety plans are reviewed and approved before contracts are awarded.

End of current text

4.0 References

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End of current text

Appendix A

NRC Concurrence Documentation

Acceptance of Revision 1 of the LTSP

Acceptance of Revision 2 of the LTSP

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 30, 1994

Mr. Albert R. Chernoff, Project Manager
Uranium Mill Tailings Remedial Action
Project Office
U. S. Department of Energy
Albuquerque Operations Office
P. O. Box 5400
Albuquerque, New Mexico 87185-5400

SUBJECT: ACCEPTANCE OF THE LONG-TERM SURVEILLANCE PLAN FOR THE LOWMAN, IDAHO SITE

Dear Mr. Chernoff:

The U.S. Nuclear Regulatory Commission staff hereby accepts the U.S. Department of Energy's (DOE's) final Long-Term Surveillance Plan (LTSP) for the Lowman, Idaho, Uranium Mill Tailings Remedial Action Project site. This action establishes the Lowman site under the general license in 10 CFR Part 40.27.

The acceptance of the LTSP is based on the staff's determination that all of the open issues have been adequately addressed in the page changes to the April 1994 final LTSP. These changes were transmitted by DOE's letters dated September 7 and 19, 1994. The LTSP for the Lowman site satisfies the requirements set forth in the Uranium Mill Tailings Radiation Control Act of 1978 for long-term surveillance of a disposal site, and all requirements in 10 CFR Part 40.27 for an LTSP.

In accordance with DOE's guidance document for long-term surveillance, all further NRC/DOE interaction on the long-term care of the Lowman site will be conducted with the DOE's Grand Junction Projects Office. If you have any questions, please contact the NRC Project Manager, Mohammad Haque at (301) 415-6640.

Sincerely,

Joseph J. Holonich

Joseph J. Holonich, Chief
High-Level Waste and Uranium
Recovery Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

cc: C. Smythe, DOE Alb
W. Woodworth, DOE Alb
D. Bierley, TAC Alb
L. Nielson, ID DEQ
K. Feldman, EPA

Acceptance Letter of Revision 2

Pending NRC Concurrence

Appendix B

Real Estate Documentation

Acquisition

Remedial action for the Lowman disposal site consisted of consolidation and stabilization of the contaminated materials on site. The State of Idaho acquired the designated site property in two portions. The larger portion of the site, comprising 37 acres, was acquired from NWI Land Management Corporation. The smaller portion of the site, comprising 4.32 acres, was acquired from the U.S. Forest Service (USFS). Acquisition of this tract was in fee simple title (DOE 1994).

Upon completion of the remedial action, the State of Idaho conveyed ownership of the disposal site, an area of 18.07 acres, to the federal government under the jurisdictional control of the DOE. DOE understands that the state still holds land north of the disposal site and may eventually re-convey this land to the USFS.

Legal Description

Disposal Site. The Lowman disposal site is located on an 18-acre parcel of land in the Southeast ¼ of Section 27, the Southwest ¼ section of Section 26, and a portion of Homestead Entry Survey No. 490; all in Township 9 North (T9N), Range 7 East (R7E), Boise Meridian, Boise County, Idaho, and is more particularly described as,

> Beginning at a U.S. Forest Service Brass Cap marking the Section Corner common to Sections 26, 27, 34, and 35, T.9 N., R. 7 E., B. M.;
>
> thence, along the section line common to Sections 26 and 27, N. 1°01'36" W. 1342.69 feet to a Bureau of Land Management Brass Cap marking Corner No. 2 of Said H.E.S. No. 490;
>
> thence, leaving said section line, S. 26°46'59" E. 96.16 feet to a point, being the Real Point of Beginning, said point being witnessed by an Aluminum Cap bearing N. 44°48'40" W., 14.16 feet from the true corner;
>
> thence, S. 54°22'20" W. 369.09 feet to a point, said point being witnessed by an Aluminum Cap bearing N. 45°15'04" W. 14.18 feet from the true corner;
>
> thence, S. 72°38'46" W. 251.45 feet to a point, said point being witnessed by an Aluminum Cap bearing N. 45°09'29" W. 14.19 feet from the true corner;
>
> thence, S. 81°43'27" W. 277.89 feet to a point, said point being witnessed by an Aluminum Cap bearing N. 45°21'48" E. 14.27 feet from the true corner;
>
> thence, N. 0°45'14" W. 380.03 feet to a point, said point being witnessed by an Aluminum Cap bearing S. 45°29'56" E. 14.09 feet from the true corner;
>
> thence, N. 15°49'57" E. 696.42 feet to a point, said point being witnessed by an Aluminum Cap bearing S. 45°32'26" E. 14.24 feet from the true corner;
>
> thence, N. 88°38'10" E. 840.24 feet to a point, said point being witnessed by an Aluminum Cap bearing S. 44°29'21" W. 14.20 feet from the true corner;

thence, S. 15°50'35" W. 769.22 feet to the Real Point of Beginning;
said parcel contains 18.08 acres, more or less;

said parcel is subject to any rights-of-ways or easement of record, or in use.

Repository

The deed transferring the Lowman disposal site to the Federal government was recorded as Instrument No. 153307, on September 12, 1994, at Boise, Idaho.

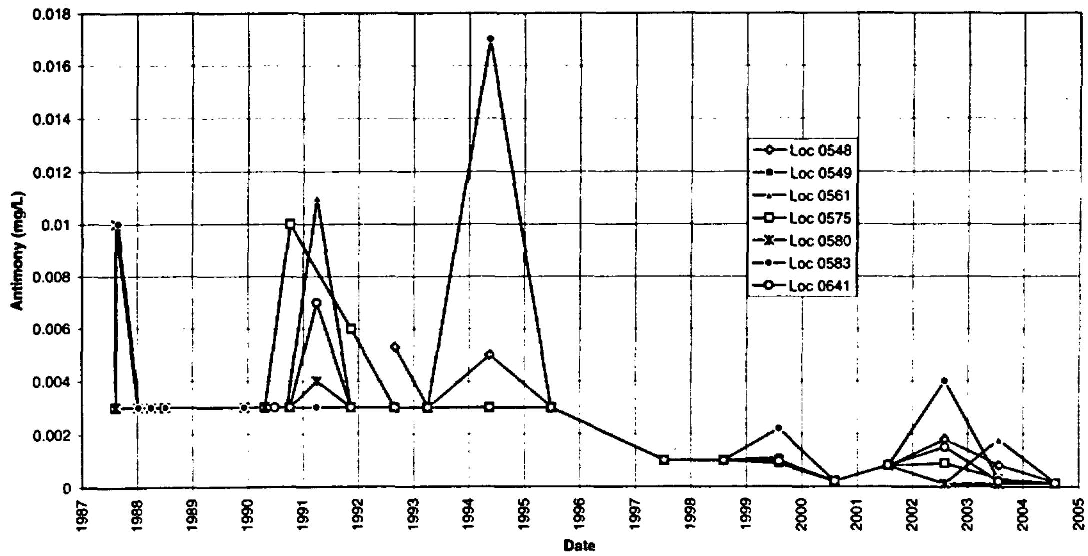
Documentation and correspondence related to property acquisition are on file at the U.S. Department of Energy office in Grand Junction, Colorado (2597 B ¾ Road, Grand Junction, Colorado 81503).

Appendix C

Time-Concentration Plots

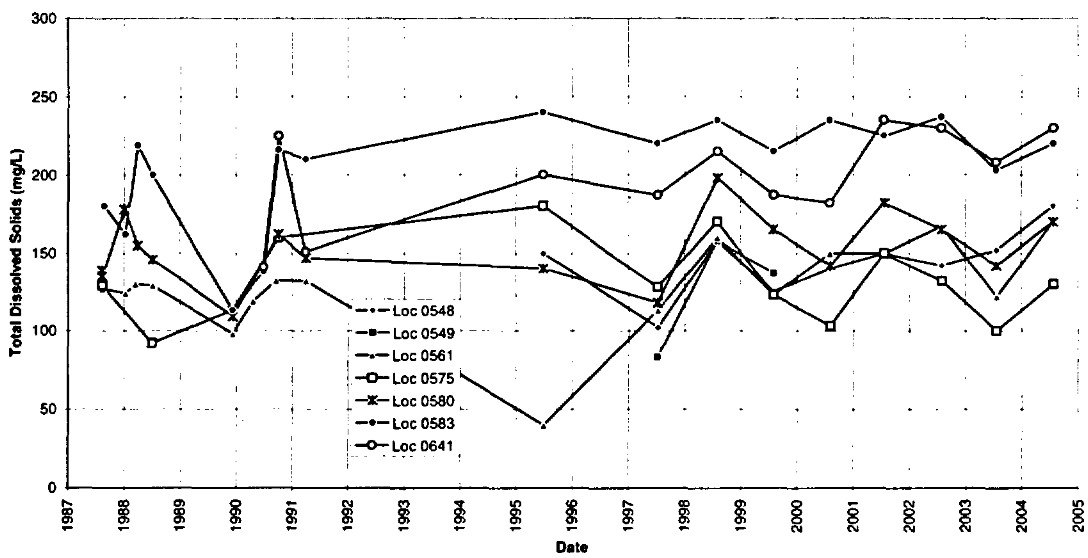
Lowman, Idaho, Disposal Site

Antimony Concentration



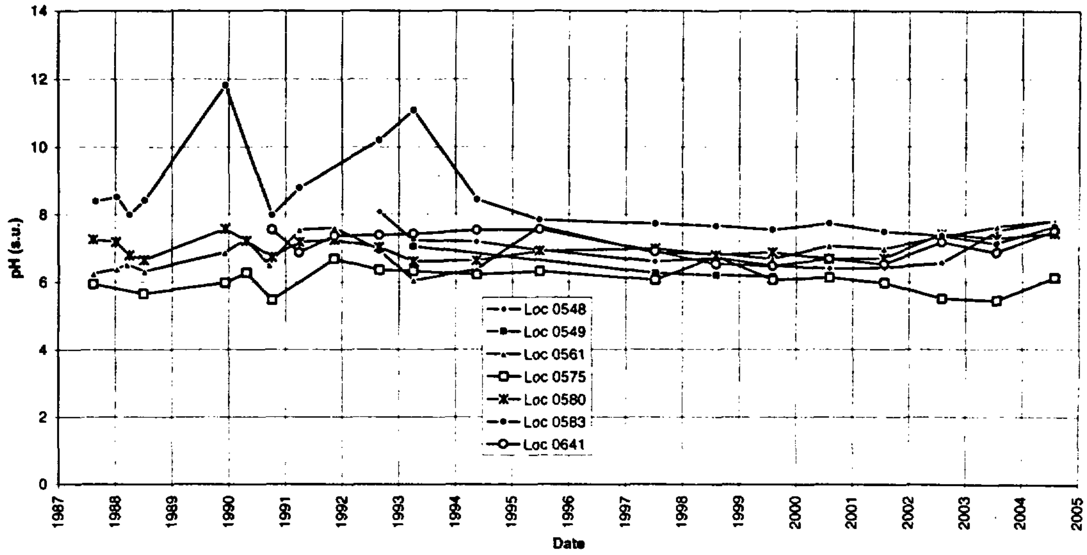
Lowman, Idaho, Disposal Site

Total Dissolved Solids Concentration



Lowman, Idaho, Disposal Site

pH Concentration



Appendix D

Inspection Checklist

Inspection Checklist Items for the Lowman, Idaho, Disposal Site

The inspection will, at a minimum, address the following activities and items.

- Scheduled Date of Inspection
- Scheduled Inspectors
- Protocols: Contact the State of Idaho to inform them of the inspection and to see if a representative will attend the inspection.
- Access: Access is from a public highway and no prior contacts are necessary.
- Safety Briefing: A tailgate safety meeting is required before performing any inspection activities.
- Inspection of the Disposal Cell Top and Side Slopes Transect: Check the condition of the features of this transect pertaining to site integrity and long-term performance. Observations will include evidence of trespassing, settling, slumping, erosion, rock degradation, and vegetation encroachment, including noxious weeds.
- Inspection of the Area Between the Disposal Cell and the Site Boundary Transect: Observations will include evidence of trespassing and erosion, the condition of erosion control features, and the types and extent of noxious weeds.
- Inspection of the Outlying Area Transect: Observations will include evidence of erosion or land use within 0.25 mile of the site that could adversely impact the integrity or security of the site, the condition of erosion control features on the north side of the site, and the types and extent of noxious weeds that could encroach on DOE property.
- Inspection of Specific Site Surveillance Features: Observations will include the condition and security (if applicable) of the following features.
  - Access road: An approximately 650-foot long hard-packed gravel road off of State Highway 21.
  - Access gate: A locked steel gate located approximately 150 feet from State Highway 21.
  - Entrance sign (1): Aluminum sign mounted on a steel post at the southwest corner of the site.
  - Perimeter signs (18): Aluminum signs mounted on steel posts located along the property boundary,
  - Site markers (2): Granite markers SMK–1 at the site entrance and SMK–2 on the cell top.
  - Boundary monuments (4): Aluminum Berntsen A-1 federal survey monuments BM–3 (northeast corner of the site), BM–5 (southeast corner of the site), BM–6 (south end of the site), and BM–7 (southwest corner of the site).
  - Combined boundary/survey monuments (3): Aluminum Berntsen RT-1 markers SM–1/BM–1 (southwest portion of the site against the west boundary), SM–2/BM–2 (northwest corner of the site), and SM–4/BM–4 (southeast portion of the site against the east boundary).
  - Monitor wells (6): 0548 (POC), 0549 (POC), 0575 (POC), 0580 (POC), 0583 (background), and 0641 (background), until they are decommissioned.

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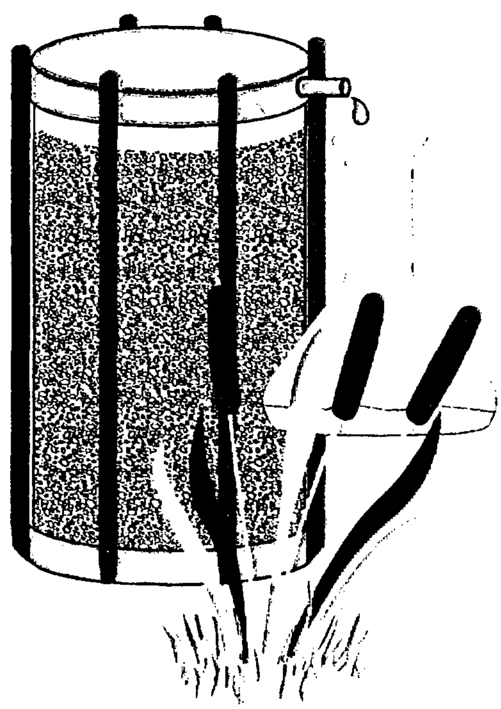
Environmental Sciences Laboratory

Leaching Characteristics of Radioactive Sands

Long-Term Surveillance and Maintenance Program Lowman, Idaho, Site



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Leaching Characteristics of Radioactive Sands

Long-Term Surveillance and Maintenance Program
Lowman, Idaho, Site

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Leaching Characteristics of Radioactive Sands

Long-Term Surveillance and Maintenance Program
Lowman, Idaho, Site

May 2002

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Acronyms

DOE	U.S. Department of Energy
GJO	Grand Junction Office
LTSM	long-term surveillance and maintenance
MCL	maximum concentration limits
µg/L	micrograms per liter
pCi/L	picocuries per liter
Ra-226	radium-226
Ra-228	radium-228
UMTRCA	Uranium Mill Tailings Radiation Control Act

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Executive Summary

Routine inspections of the Lowman, Idaho, Disposal Site in the Long-Term Surveillance and Maintenance Program include observations that plants are being established on the disposal cell. Roots from the plants have penetrated the cover and could cause an increase in infiltration of water into the radioactive sands. We evaluated data collected in previous investigations to determine if contaminants are likely to leach from the radioactive sands and contaminate ground water if the engineered cover were to be breached by biointrusion. Four lines of evidence based on available data suggest that it is unlikely that any significant contamination will occur even if infiltration increases in the future: (1) resistate nature of the mineralogy of the radioactive sands, (2) low concentrations of contaminants in pore fluids, (3) low concentrations of contaminants in effluent from batch leach tests with neutral pH water, and (4) low concentrations of contaminants in ground water beneath the disposal cell. Therefore, termination of the plant control program is not likely to increase risks to human health or the environment.

End of current text

1.0 Introduction

The U.S. Department of Energy Grand Junction Office (DOE–GJO) Long-Term Surveillance and Maintenance (LTSM) Program provides stewardship services for DOE sites across the country that contain low-level radioactive materials (*www.gjo.doe.gov/programs/ltsm/*). Included in the LTSM Program are uranium mill tailings disposal cells constructed under the auspices of the Uranium Mill Tailings Radiation Control Act (UMTRCA) to contain contaminants for 1,000 years. In 1998, the LTSM Program initiated the Cover Monitoring and Long-Term Performance Project to evaluate how changes in UMTRCA disposal cell environments, both observed changes and changes projected over hundreds of years, may alter the performance of disposal cells (DOE 2001a). The LTSM Program and the DOE Environmental Sciences Laboratory at GJO are evaluating the hydrologic performance of the Lowman, Idaho, Disposal Cell. The U.S. Nuclear Regulatory Commission included the Lowman Disposal Cell site under general license in 1994. After 1994, the LTSM Program has been responsible for the long-term safety and integrity of the site (DOE 2002).

Personnel with the LTSM Program recently observed encroachment of vegetation, including ponderosa pine, redosier dogwood, whortleberry, Norway cinquefoil, common mullein, and bull thistle, on the top and side slopes of the Lowman Disposal Cell (DOE 2001b). Roots from these plants could increase the saturated hydraulic conductivity of the cover. If the hydraulic conductivity were to increase, water could penetrate the radioactive sands in the disposal cell and eventually percolate into ground water beneath the site. As part of the regular maintenance activities conducted by the LTSM Program, plants are removed if necessary to protect the integrity of the disposal cell. However, the plant removal would not be required if it is demonstrated that there is no additional risk to human health and the environment by allowing forest vegetation to establish on the cover.

Previous informal internal correspondence among GJO scientists suggested that no significant quantity of hazardous chemicals would be leached from the radioactive sands even if biointrusion were to cause increased water infiltration. This report reviews pertinent data and evaluates the probability that pore fluids in the radioactive sands in the Lowman Disposal Cell could contaminate the ground water. This report does not contain new data but rather compiles and evaluates data generated in previous studies.

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2.0 Processing of Ores and Remedial Action

About 200,000 tons of heavy-mineral placer sands mined from dredging operations in Bear Valley, about 17 miles northeast of the Lowman site, was processed at the former Lowman mill from 1955 to 1960 (Dayvault et al. 1986; DOE 1991a). Ores consisted of resistate minerals derived from quartz monzonite and granite of the Idaho Batholith (Dayvault et al. 1986). The placers, or surficial mineral deposits, were formed from detrital grains deposited following erosion of pegmatite dikes and pods in the batholith. Sedimentary sorting processes concentrated the ore minerals in specific strata because the ore minerals are denser (Table 1 provides specific gravities) than the more abundant labile grains such as quartz and feldspar that both have a specific gravity of about 2.7. Heavy-mineral placer sands such as these are common in sedimentary strata and are infrequently concentrated sufficiently to warrant extraction for mineral processing.

The milling operation at Lowman was relatively small. The U.S. Atomic Energy Commission purchased 365,231 pounds of uranium oxide (as U_3O_8) from the Lowman site between 1957 and 1960 (Albrethsen and McGinley 1982). Only 2 of the 32 uranium mills (Lakeview, Oregon, and Hite, Utah) inventoried by Albrethsen and McGinley (1982) had less uranium production than the Lowman mill; the average uranium production per uranium mill is 10,865,520 pounds of U_3O_8. The combined content of columbite, euxenite, and monazite in the Bear Valley ore sands was 0.14 pound per cubic yard (Kline et al. 1953). The uranium ore ranged in grade from 0.01 to 0.22 percent U_3O_8 (Albrethsen and McGinley 1982).

The Lowman mill was designed to recover columbite, euxenite, and monazite concentrates (Dayvault et al. 1986). By-product concentrates included magnetite, ilmenite, zircon, and garnet (FBD 1981). Mineral concentrates were separated using a variety of wet and dry mechanical processes. Magnetite was separated using an electromagnetic separator (Dayvault et al. 1986). Processed products were sent to the Mallinckrodt chemical works at Hematite, Missouri, where columbium (an earlier name for the element niobium [Nb] [Hawley 1987]) and tantalum (Ta) pentoxides, uranium oxide, other rare-earth elements, titanium, and thorium-iron residues were produced (DOE 1991a).

Prior to site remediation, storage areas contained four types of processed sands: black sands, white sands, grey sands, and red sands (Figure 1). In addition, about 5,000 tons of unprocessed mill feed with a concentration of 0.22 percent U_3O_8 remained on the site (Albrethsen and McGinley 1982). Total radioactivity, estimated at 12 curies of radium-226 (Ra-226), is low compared to other UMTRCA sites (DOE 2002). Remedial actions were initiated in 1991 to stabilize the radioactive sands (DOE 1994). The separate piles of radioactive sands were consolidated in a single above-grade 8.2-acre disposal cell on the millsite. Material from the mill yard, ore storage area, windblown/waterborne area, settling ponds, and vicinity properties was placed on top of the black sands (Figure 1). The tailings pile, containing 129,400 cubic yards of radioactive material, was stabilized with a 1.5-foot-thick layer of compacted earth (radon barrier) overlain by a 0.5-foot-thick layer of sandy bedding material and riprap rock cover (DOE 1994).

End of current text

3.0 Characteristics of the Radioactive Sands

Jacobs (1991) indicates that the black sands contain ilmenite, magnetite, and garnet; white sands contain quartz, feldspar, and sphene; grey sands contain quartz, feldspar, and ilmenite; ore sands contain ilmenite, magnetite, quartz, feldspar, garnet, zircon, columbite, euxentite, and monazite; and red sands contain garnet. In contrast, Dayvault et al. (1986) provide a more comprehensive list of minerals in the ore sands including ilmenite, magnetite, garnet, sphene, monazite, zircon, fergusonite, brannerite, xenotime, and columbite with lesser amounts of samarskite, euxenite, ilmenorutile, allanite, spinel, rutile, gold, epidote, and siderite (Table 1). Many of these minerals contain rare earth elements (cerium, lanthanum, neodymium, thorium, and yttrium), but only a few contain uranium. Uranium is not an essential element in any of the ore minerals except brannerite; uranium constitutes 26.5 to 43.6 percent of brannerite (Frondel et al. 1967).

Ra–226 concentrations in samples collected from 64 borings and 320 surface/subsurface soils were determined by gamma spectroscopy. Table 2 provides volume-weighted average values determined in various groups of the residual sands. The unprocessed ores have the highest concentrations of Ra–226, but the concentrations are lower than those for typical uranium ores.

End of current text

4.0 Pore Water Chemistry in the Radioactive Sands

Pore water was collected from 13 lysimeters placed near the bottom of the radioactive sands prior to remediation activities (Figure 1). Jacobs (1991) provides a summary of the results. Fourteen of 26 hazardous constituents did not exceed the method detection limit. For the 12 hazardous constituents that exceeded the method detection limit, means were calculated for each type of radioactive material (black sand, white sand, grey sand, red sand, ore sand, and mill yard). The potential for pore water to contaminate ground water is estimated by comparing the pore water concentrations to maximum concentration limits (MCLs) or, for those constituents that do not have MCLs, to risk-based concentration limits (EPA 2001). This approach is conservative because even if pore waters exceed ground water MCLs, the ground water concentrations can be less than MCLs due to dilution. As discussed below, pore water concentrations measured in lysimeter samples indicate that it is unlikely that the radioactive sands will significantly contribute to ground water contamination.

On the basis of analysis of pore fluids, Jacobs (1991) concluded that no hazardous constituents exceed MCLs; however, antimony and vanadium in pore fluids in the radioactive sands exceeded the statistical maximum for background ground water. Neither antimony nor vanadium has MCLs under the UMTRCA Ground Water Project (EPA 1995). Risk-based concentration limits for antimony and vanadium are 150 and 260 micrograms per liter (µg/L), respectively (EPA 2001). Concentrations of antimony in all pore water samples from 11 lysimeters are less than the risk-based concentration limit (data presented in Appendix A). Some of the vanadium concentrations in the pore fluids exceeded the risk-based concentration limit; the maximum vanadium concentration in a pore fluid sample was 580 µg/L. However, Jacobs (1991) estimated the weighted mean concentration for vanadium in the radioactive sands pore fluids at 149.3 µg/L, which is less than the risk-based concentration limit.

Pore water samples from only five of the lysimeters were analyzed for Ra-226 and Ra-228; all the samples were from the black sands (Appendix A). All concentrations of Ra-226 and Ra-228 were less than the detection limit (1 picocurie per liter [pCi/L]) in these five samples, suggesting that radium is not leaching from the black sands. Concentrations in pore fluids are one of the best indications of the tendency for release of contamination because the water has been in contact with the radioactive sands for long time periods.

End of current text

5.0 Review of Batch Leaching Test Data

Fifteen batch leaching tests were conducted with water with a neutral pH value and eight batch leaching tests were conducted with water with low pH values (DOE 1991b). The 15 samples used for the batch tests conducted under neutral conditions consisted of 4 samples of grey ore, 4 samples of black sand, 2 samples of red sand, 2 samples of grey sand, and 3 samples of white sand (data presented in Appendix A). The eight batch tests conducted under acidic conditions used 2 samples of grey ore, 2 samples of black sand, 2 samples of white sand, and 2 samples of grey sand. Fluid and solids were combined using 37.5 percent solids, by weight, and the mixtures were agitated for 48 hours (DOE 1991b, Table 3.12). The final pH values of the acidic tests ranged from 3.02 to 4.89; neither the initial pH values nor the type of acid used was indicated in the reports. Concentrations of selected hazardous constituents were determined in the effluents.

None of the hazardous constituents in samples from the neutral pH batch leach tests were above MCLs, except one value of radium from one test (DOE 1991a). This effluent was from the grey ore and was barely above the MCL with a combined Ra-226 and Ra-228 concentration of 5.5 pCi/L (MCL for combined Ra–226 and Ra–228 is 5 pCi/L).

Although none of the other constituents exceeded MCLs in the acidic tests, combined Ra-226 and Ra-228 exceeded MCLs in all 8 tests ranging from 8.1 to 47.0 pCi/L (Appendix A). Apparently, some of the radium-bearing material is dissolved or radium desorbs from mineral surfaces at low pH values. Unfortunately, the type of acid used and the starting pH value are not known. Some of the mineral grains, particularly feldspars, would provide some buffering of pH. The initial pH value was probably about 2 or 3. Such low pH values would not occur by the passage of water through the cover materials. Therefore, although radium is released from the radioactive sands at low pH value, this finding does not indicate that pore waters will have high radium values.

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6.0 Review of Ground Water Chemistry

The site formerly occupied by the Lowman mill lies on a terrace consisting of colluvium, alluvium, and glacial outwash, above Clear Creek. The uppermost aquifer is alluvium and weathered granodiorite (DOE 1994). Analyses of samples of ground water collected at the site prior to remediation detected no concentrations of contaminants above background (DOE 1991b).

Antimony was designated as a potential contaminant because its concentration in the pore water of the radioactive sands exceeded the statistical maximum background ground water value of 0.007 milligram per liter (DOE 1994). Analyses of ground water samples collected form the alluvial aquifer at the site from 1994 to 2001 by the LTSM Program did not detect the presence of antimony (DOE 2001b). The ground water compliance strategy for the Lowman site is no remediation based on data that confirmed that no contamination was present in the ground water (DOE 1996).

End of current text

7.0 Discussion

Four lines of evidence suggest that it is unlikely that contaminants will be leached from the radioactive sands: (1) mineralogy of the radioactive sands, (2) contaminant concentrations in pore fluid samples, (3) results of batch leaching tests, and (4) contaminant concentrations in ground water samples.

1. Mineralogy of the Radioactive Sands—The material impounded in the Lowman Disposal Cell is referred to in this report as radioactive sands to distinguish it from "tailings" that are present at most UMTRCA disposal sites. Tailings contain residues from many chemicals used in the milling process; for example, sulfate is often a constituent of tailings that results from sulfuric acid used in milling processes. No chemicals other than water were used at the Lowman mill processing, thus, the only potential for contamination to ground water is from the minerals themselves. Because the Lowman ore is composed primarily of resistate sand grains, there is low potential for dissolution and release of contamination into pore fluids at the Lowman millsite.
2. Concentrations in Pore Water—Concentrations of contaminants measured in pore fluids in the radioactive sands are low compared to concentrations measured in tailings pore fluids at most other UMTRCA sites. On a volume-weighted basis, all concentrations are less than MCLs or risk-based standards. Data from analysis of samples from lysimeters indicate that pore fluids are unlikely to contaminate ground water. Development of pine forest and associated organic soils may reduce pH in the root zone to 6.0 or perhaps even lower. The batch leaching test results suggest that at low pH values (less than 5.0) some leaching of radium could occur. It is unlikely that pH values will be low enough to leach significant concentrations of radium.
3. Results of Batch Leach Tests—One value of radium in neutral pH batch tests effluents was slightly above the MCL. The neutral pH tests confirm that leaching of contaminants is limited at pH values consistent with conditions expected in pore fluids. Radium concentrations in acidic effluents were well above the MCL, but these conditions are not representative of the conditions expected in pore fluids within the radioactive sands.
4. Concentrations in Ground Water—The radioactive sands were exposed to the atmosphere from about 1955 to 1991, during which time there was opportunity for contaminants to leach into the ground water. Analyses of ground water samples from the Lowman site indicate that no contamination is present in the uppermost aquifer, providing compelling evidence that leakage of contaminated pore water from the radioactive sands is unlikely to contaminate the ground water.

Based on the evidence presented, we conclude that termination of the plant control program is not likely to result in significantly increased risk to human health or the environment.

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Table 1. Properties of Ore Minerals

Mineral	Chemical Formula[a]	Specific Gravity[b]
Major Minerals		
Ilmenite	$FeTiO_3$	4.74.5-5
Magnetite	$(Fe,Mg)Fe_2O_4 \pm Ti$	5.168-5.180
Garnet	$(Ca, Mg, Fe^{+2}, Mn^{+2})_3(Al, Fe^{+3}, Mn^{+3}, V^{+3}, Cr)_2(SiO_4)_3$	3.15-5.3
Sphene	$CaTiSiO_5$	3.4-3.56
Monazite	$(Ce, La, Nd, Th)(PO_4, SiO_4)$	4.9-5.3
Zircon	$ZrSiO_4$	4.68-4.70
Fergusonite	$Y(Nb,Ta)O_4 \pm Er, Ce, Fe, Ti, U$	5.8
Brannerite	$(U, Ca, Ce)(Ti, Fe)_2O_6$	4.5-5.4
Xenotime	$YPO_4 \pm Er, Ce, Th, U, Al, Ca, Be, Zr$, and others	4.45-4.56
Columbite	$(Fe, Mn)(Nb, Ta)_2O_6$	5.3-7.3
Minor Minerals		
Samarskite	$(Y, Ce, U, Ca, Fe, Pb, Th)(Nb, Ta, Ti, Sn,)_2O_6$	5.6-5.8
Euxenite	$(Y, Ca, Ce, U, Th)(Nb, Ta, Ti)_2O_6$	4.7-5.0
Ilmenorutile	$(Ti, Nb, Fe)_3O_6$	5.14
Allanite	$(Ce, Ca, Y)(Al, Fe)_3(SiO_4)_3(OH)$	3.0-4.2
Spinel	$(Mg, Fe, Zn, Mn)(Al, Fe, Cr)_2O_4$	3.5-4.1
Rutile	TiO_2	4.18-4.25
Gold	Au	15.6-19.3
Epidote	$Ca_2(Al, Fe)_3Si_3O_{12}(OH)$	3.25-3.5
Siderite	$FeCO_3$ ±Mg, Mn	3.83-3.88

[a]Bates and Jackson (1980).
[b]Dana (1964).

Table 2. Estimated Volumes and Ra–226 Content of Residual Materials Left at the Lowman Site (DOE 1991a)

Location/Source	Estimated Volume (cubic yards)[a]	Area (acres)	Average Ra–226 (pCi/g)
Mill Yard	5,715	2.8	58
Ore Storage	7,132	0.9	438
Pond Area	6,404	0.8	245
White Sands # 1	5,604	0.4	57
White Sands # 2	7,794	1.1	36
Black Sands	28,997	6.0	64
Grey Sands	13,287	1.3	180
Waterborne	3,734	3.0	22
Windblown	3,476	3.2	21
Vicinity Properties	38,730		30
TOTAL	127,481	19.5	

[a]Volume estimates differ slightly between Tables 1.1 and 6.1 in DOE (1991a).
pCi/g – picoCuries per gram

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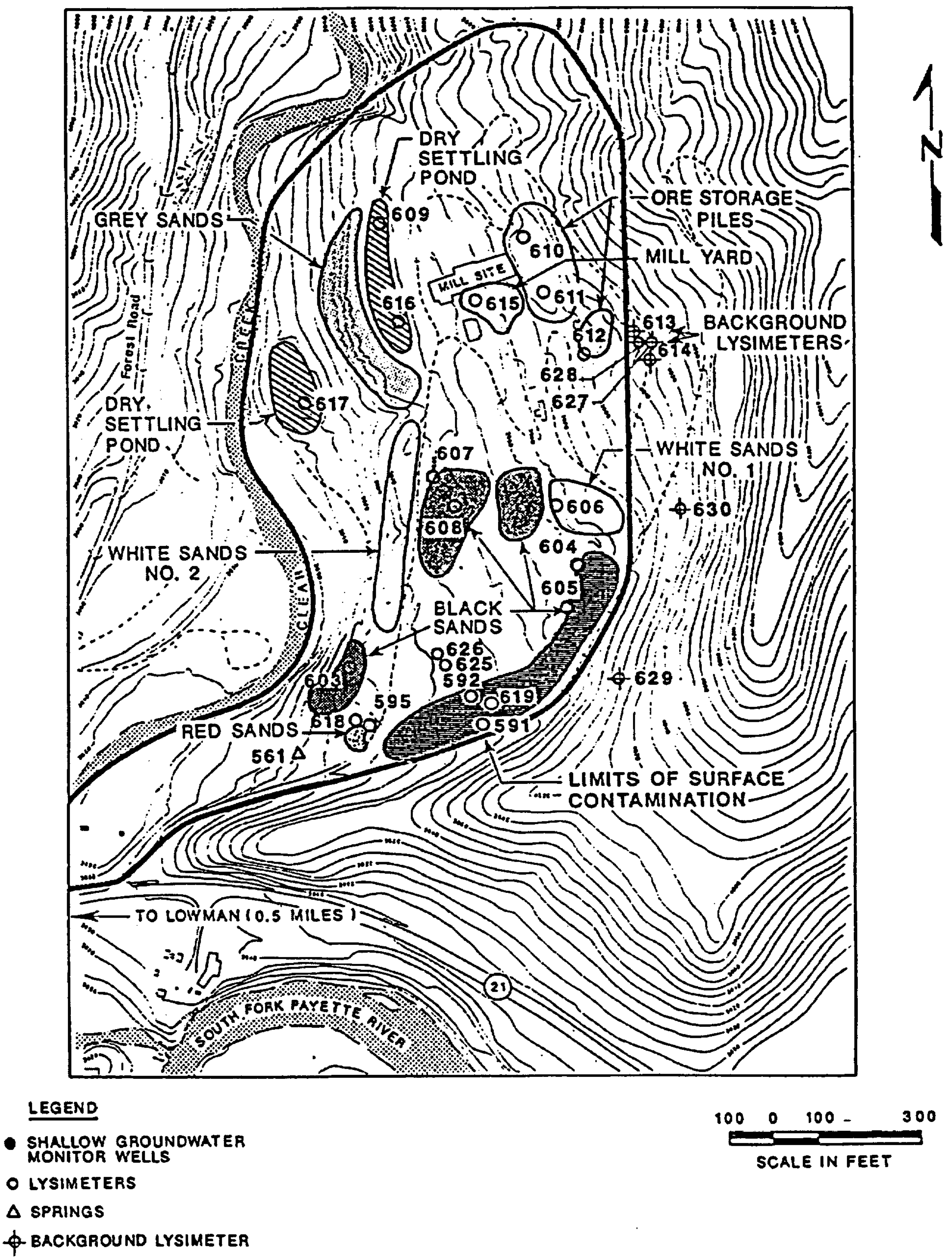

Figure 1. Locations of Piles of Radioactive Sands and Lysimeters Before Consolidation (from Jacobs 1991)

Appendix A

Pore Water Concentrations and Batch Test Results in Radioactive Sands

(DOE 1991b)

Pore Water Concentrations

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0605	Alkalinity	07-Oct-90	21	mg/L	0	
0606	Alkalinity	07-Oct-90	2	mg/L	0	
0610	Alkalinity	07-Oct-90	14	mg/L	0	
0611	Alkalinity	07-Oct-90	7	mg/L	0	
0591	Aluminum	28-Aug-87	0.16	mg/L	0.1	
0591	Aluminum	11-Jan-88	0.06	mg/L	0.1	
0592	Aluminum	11-Jan-88	0.05	mg/L	0.1	
0604	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0604	Aluminum	26-Apr-90	0.05	mg/L	0.1	U
0605	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0605	Aluminum	26-Apr-90	0.05	mg/L	0.1	U
0605	Aluminum	07-Oct-90	0.1	mg/L	0.1	U
0606	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0606	Aluminum	26-Apr-90	0.05	mg/L	0.1	U
0606	Aluminum	07-Oct-90	0.1	mg/L	0.1	U
0608	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0609	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0609	Aluminum	26-Apr-90	0.05	mg/L	0.1	U
0610	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0610	Aluminum	07-Oct-90	0.1	mg/L	0.1	U
0611	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0611	Aluminum	07-Oct-90	0.1	mg/L	0.1	U
0612	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0614	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0615	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0618	Aluminum	10-Dec-89	0.1	mg/L	0.1	U
0618	Aluminum	26-Apr-90	0.05	mg/L	0.1	U
0626	Aluminum	30-Jun-90	0.4	mg/L	0.1	
0591	Ammonium	02-Apr-88	0.1	mg/L	0.1	U
0592	Ammonium	02-Apr-88	0.1	mg/L	0.1	U
0595	Ammonium	02-Apr-88	0.1	mg/L	0.1	U
0604	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0604	Ammonium	26-Apr-90	0.2	mg/L	0.1	
0605	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0605	Ammonium	26-Apr-90	0.1	mg/L	0.1	
0606	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0606	Ammonium	26-Apr-90	0.1	mg/L	0.1	
0608	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0609	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0609	Ammonium	26-Apr-90	0.4	mg/L	0.1	
0610	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0611	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0612	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0615	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0618	Ammonium	10-Dec-89	0.1	mg/L	0.1	U
0618	Ammonium	26-Apr-90	0.1	mg/L	0.1	
0591	Antimony	28-Aug-87	0.01	mg/L	0.01	U
0604	Antimony	10-Dec-89	0.022	mg/L	0.003	
0604	Antimony	26-Apr-90	0.008	mg/L	0.003	
0605	Antimony	10-Dec-89	0.016	mg/L	0.003	
0605	Antimony	26-Apr-90	0.06	mg/L	0.003	

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0605	Antimony	07-Oct-90	0.03	mg/L	0.003	
0606	Antimony	26-Apr-90	0.06	mg/L	0.003	
0606	Antimony	07-Oct-90	0.017	mg/L	0.003	
0608	Antimony	10-Dec-89	0.023	mg/L	0.003	
0609	Antimony	10-Dec-89	0.014	mg/L	0.003	
0609	Antimony	26-Apr-90	0.05	mg/L	0.003	
0610	Antimony	10-Dec-89	0.03	mg/L	0.003	
0610	Antimony	07-Oct-90	0.021	mg/L	0.003	
0611	Antimony	10-Dec-89	0.017	mg/L	0.003	
0611	Antimony	07-Oct-90	0.03	mg/L	0.003	
0612	Antimony	10-Dec-89	0.011	mg/L	0.003	
0614	Antimony	10-Dec-89	0.031	mg/L	0.003	
0615	Antimony	10-Dec-89	0.014	mg/L	0.003	
0618	Antimony	10-Dec-89	0.034	mg/L	0.003	
0618	Antimony	26-Apr-90	0.06	mg/L	0.003	
0626	Antimony	30-Jun-90	0.008	mg/L	0.003	
0591	Arsenic	28-Aug-87	0.001	mg/L	0.01	U
0591	Arsenic	11-Jan-88	0.01	mg/L	0.01	U
0591	Arsenic	02-Apr-88	0.001	mg/L	0.01	U
0592	Arsenic	11-Jan-88	0.01	mg/L	0.01	U
0592	Arsenic	02-Apr-88	0.002	mg/L	0.01	
0595	Arsenic	02-Apr-88	0.001	mg/L	0.01	U
0604	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0604	Arsenic	26-Apr-90	0.01	mg/L	0.01	U
0605	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0605	Arsenic	26-Apr-90	0.01	mg/L	0.01	U
0605	Arsenic	07-Oct-90	0.01	mg/L	0.01	U
0606	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0606	Arsenic	26-Apr-90	0.01	mg/L	0.01	U
0606	Arsenic	07-Oct-90	0.01	mg/L	0.01	U
0608	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0609	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0609	Arsenic	26-Apr-90	0.01	mg/L	0.01	U
0610	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0610	Arsenic	07-Oct-90	0.01	mg/L	0.01	U
0611	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0611	Arsenic	07-Oct-90	0.01	mg/L	0.01	U
0612	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0614	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0615	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0618	Arsenic	10-Dec-89	0.01	mg/L	0.01	U
0618	Arsenic	26-Apr-90	0.01	mg/L	0.01	U
0626	Arsenic	30-Jun-90	0.01	mg/L	0.01	U
0591	Barium	28-Aug-87	0.15	mg/L	0.1	
0591	Barium	11-Jan-88	0.19	mg/L	0.1	
0592	Barium	11-Jan-88	0.1	mg/L	0.1	U
0604	Barium	10-Dec-89	0.1	mg/L	0.1	U
0604	Barium	26-Apr-90	0.01	mg/L	0.1	U
0605	Barium	10-Dec-89	0.1	mg/L	0.1	U
0605	Barium	26-Apr-90	0.01	mg/L	0.1	U
0605	Barium	07-Oct-90	0.1	mg/L	0.1	U
0606	Barium	10-Dec-89	0.1	mg/L	0.1	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0606	Barium	26-Apr-90	0.01	mg/L	0.1	U
0606	Barium	07-Oct-90	0.1	mg/L	0.1	U
0608	Barium	10-Dec-89	0.1	mg/L	0.1	U
0609	Barium	10-Dec-89	0.1	mg/L	0.1	U
0609	Barium	26-Apr-90	0.01	mg/L	0.1	U
0610	Barium	10-Dec-89	0.1	mg/L	0.1	U
0610	Barium	07-Oct-90	0.1	mg/L	0.1	U
0611	Barium	10-Dec-89	0.1	mg/L	0.1	U
0611	Barium	07-Oct-90	0.1	mg/L	0.1	U
0612	Barium	10-Dec-89	0.1	mg/L	0.1	U
0614	Barium	10-Dec-89	0.1	mg/L	0.1	U
0615	Barium	10-Dec-89	0.1	mg/L	0.1	U
0618	Barium	10-Dec-89	0.1	mg/L	0.1	U
0618	Barium	26-Apr-90	0.01	mg/L	0.1	U
0626	Barium	30-Jun-90	0.1	mg/L	0.1	U
0604	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0604	Beryllium	26-Apr-90	0.005	mg/L	0.005	U
0605	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0605	Beryllium	26-Apr-90	0.005	mg/L	0.005	U
0605	Beryllium	07-Oct-90	0.01	mg/L	0.01	U
0606	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0606	Beryllium	26-Apr-90	0.005	mg/L	0.005	U
0606	Beryllium	07-Oct-90	0.01	mg/L	0.01	U
0608	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0609	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0609	Beryllium	26-Apr-90	0.005	mg/L	0.005	U
0610	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0610	Beryllium	07-Oct-90	0.01	mg/L	0.01	U
0611	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0611	Beryllium	07-Oct-90	0.01	mg/L	0.01	U
0612	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0614	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0615	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0618	Beryllium	10-Dec-89	0.01	mg/L	0.01	U
0618	Beryllium	26-Apr-90	0.005	mg/L	0.005	U
0626	Beryllium	30-Jun-90	0.01	mg/L	0.01	U
0605	Boron	07-Oct-90	0.1	mg/L	0.1	U
0606	Boron	07-Oct-90	0.1	mg/L	0.1	U
0610	Boron	07-Oct-90	0.1	mg/L	0.1	U
0611	Boron	07-Oct-90	0.1	mg/L	0.1	U
0606	Bromide	07-Oct-90	0.1	mg/L	0.1	U
0611	Bromide	07-Oct-90	0.1	mg/L	0.1	U
0591	Cadmium	28-Aug-87	0.005	mg/L	0.005	U
0604	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0604	Cadmium	26-Apr-90	0.001	mg/L	0.001	U
0605	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0605	Cadmium	26-Apr-90	0.001	mg/L	0.001	U
0605	Cadmium	07-Oct-90	0.001	mg/L	0.001	U
0606	Cadmium	10-Dec-89	0.001	mg/L	0.001	
0606	Cadmium	26-Apr-90	0.001	mg/L	0.001	U
0606	Cadmium	07-Oct-90	0.001	mg/L	0.001	U
0608	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0609	Cadmium	10-Dec-89	0.001	mg/L	0.001	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0609	Cadmium	26-Apr-90	0.001	mg/L	0.001	U
0610	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0610	Cadmium	07-Oct-90	0.001	mg/L	0.001	U
0611	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0611	Cadmium	07-Oct-90	0.001	mg/L	0.001	U
0612	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0614	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0615	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0618	Cadmium	10-Dec-89	0.001	mg/L	0.001	U
0618	Cadmium	26-Apr-90	0.001	mg/L	0.001	U
0626	Cadmium	30-Jun-90	0.001	mg/L	0.001	U
0591	Calcium	28-Aug-87	25.8	mg/L	0.01	
0591	Calcium	11-Jan-88	21.1	mg/L	0.01	
0591	Calcium	02-Apr-88	22	mg/L	0.01	
0592	Calcium	11-Jan-88	7.72	mg/L	0.01	
0595	Calcium	02-Apr-88	28.5	mg/L	0.01	
0604	Calcium	10-Dec-89	3.06	mg/L	0.01	
0604	Calcium	26-Apr-90	1.96	mg/L	0.01	
0605	Calcium	10-Dec-89	42.9	mg/L	0.01	
0605	Calcium	26-Apr-90	3.89	mg/L	0.01	
0605	Calcium	07-Oct-90	15.2	mg/L	0.01	
0606	Calcium	10-Dec-89	1.47	mg/L	0.01	
0606	Calcium	26-Apr-90	0.88	mg/L	0.01	
0606	Calcium	07-Oct-90	6.39	mg/L	0.01	
0608	Calcium	10-Dec-89	4.14	mg/L	0.01	
0609	Calcium	10-Dec-89	19.5	mg/L	0.01	
0609	Calcium	26-Apr-90	3.01	mg/L	0.01	
0610	Calcium	10-Dec-89	2.75	mg/L	0.01	
0610	Calcium	07-Oct-90	8.51	mg/L	0.01	
0611	Calcium	10-Dec-89	5.82	mg/L	0.01	
0611	Calcium	07-Oct-90	1.08	mg/L	0.01	
0612	Calcium	10-Dec-89	57	mg/L	0.01	
0614	Calcium	10-Dec-89	28.6	mg/L	0.01	
0615	Calcium	10-Dec-89	15.4	mg/L	0.01	
0618	Calcium	10-Dec-89	20.6	mg/L	0.01	
0618	Calcium	26-Apr-90	5.13	mg/L	0.01	
0626	Calcium	30-Jun-90	50.3	mg/L	0.01	
0591	Chloride	28-Aug-87	1	mg/L	1	
0591	Chloride	02-Apr-88	1	mg/L	1	U
0595	Chloride	02-Apr-88	10	mg/L	1	
0604	Chloride	10-Dec-89	1	mg/L	1	
0604	Chloride	26-Apr-90	2.5	mg/L	1	
0605	Chloride	10-Dec-89	12	mg/L	1	
0605	Chloride	26-Apr-90	1.4	mg/L	1	
0606	Chloride	10-Dec-89	3	mg/L	1	
0606	Chloride	07-Oct-90	1	mg/L	1	
0608	Chloride	10-Dec-89	3	mg/L	1	
0609	Chloride	10-Dec-89	6	mg/L	1	
0610	Chloride	10-Dec-89	2	mg/L	1	
0611	Chloride	10-Dec-89	2	mg/L	1	
0611	Chloride	07-Oct-90	1	mg/L	1	U
0615	Chloride	10-Dec-89	3	mg/L	1	
0618	Chloride	26-Apr-90	2.1	mg/L	1	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0626	Chloride	30-Jun-90	20	mg/L	1	
0591	Chromium	28-Aug-87	0.01	mg/L	0.01	U
0591	Chromium	11-Jan-88	0.01	mg/L	0.01	U
0592	Chromium	11-Jan-88	0.01	mg/L	0.01	U
0604	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0604	Chromium	26-Apr-90	0.01	mg/L	0.01	U
0605	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0605	Chromium	26-Apr-90	0.01	mg/L	0.01	U
0605	Chromium	07-Oct-90	0.01	mg/L	0.01	U
0606	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0606	Chromium	26-Apr-90	0.01	mg/L	0.01	U
0606	Chromium	07-Oct-90	0.01	mg/L	0.01	U
0608	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0609	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0609	Chromium	26-Apr-90	0.01	mg/L	0.01	U
0610	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0610	Chromium	07-Oct-90	0.01	mg/L	0.01	U
0611	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0611	Chromium	07-Oct-90	0.01	mg/L	0.01	U
0612	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0614	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0615	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0618	Chromium	10-Dec-89	0.01	mg/L	0.01	U
0618	Chromium	26-Apr-90	0.01	mg/L	0.01	U
0626	Chromium	30-Jun-90	0.01	mg/L	0.01	U
0591	Cobalt	28-Aug-87	0.01	mg/L	0.05	U
0604	Cobalt	26-Apr-90	0.03	mg/L	0.05	U
0605	Cobalt	26-Apr-90	0.03	mg/L	0.05	U
0605	Cobalt	07-Oct-90	0.05	mg/L	0.05	U
0606	Cobalt	26-Apr-90	0.03	mg/L	0.05	U
0606	Cobalt	07-Oct-90	0.05	mg/L	0.05	U
0609	Cobalt	26-Apr-90	0.03	mg/L	0.05	U
0610	Cobalt	07-Oct-90	0.05	mg/L	0.05	U
0611	Cobalt	07-Oct-90	0.05	mg/L	0.05	U
0618	Cobalt	26-Apr-90	0.03	mg/L	0.05	U
0591	Copper	28-Aug-87	0.01	mg/L	0.02	U
0604	Copper	10-Dec-89	0.04	mg/L	0.02	
0604	Copper	26-Apr-90	0.03	mg/L	0.02	
0605	Copper	10-Dec-89	0.04	mg/L	0.02	
0605	Copper	26-Apr-90	0.1	mg/L	0.02	
0605	Copper	07-Oct-90	0.04	mg/L	0.02	
0606	Copper	10-Dec-89	0.04	mg/L	0.02	
0606	Copper	26-Apr-90	0.09	mg/L	0.02	
0606	Copper	07-Oct-90	0.03	mg/L	0.02	
0608	Copper	10-Dec-89	0.03	mg/L	0.02	
0609	Copper	10-Dec-89	0.03	mg/L	0.02	
0609	Copper	26-Apr-90	0.14	mg/L	0.02	
0610	Copper	10-Dec-89	0.05	mg/L	0.02	
0610	Copper	07-Oct-90	0.04	mg/L	0.02	
0611	Copper	10-Dec-89	0.02	mg/L	0.02	
0611	Copper	07-Oct-90	0.03	mg/L	0.02	
0612	Copper	10-Dec-89	0.04	mg/L	0.02	
0614	Copper	10-Dec-89	0.11	mg/L	0.02	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0615	Copper	10-Dec-89	0.06	mg/L	0.02	
0618	Copper	10-Dec-89	0.05	mg/L	0.02	
0618	Copper	26-Apr-90	0.13	mg/L	0.02	
0591	Fluoride	28-Aug-87	0.05	mg/L	0.1	U
0604	Fluoride	26-Apr-90	0.1	mg/L	0.1	
0605	Fluoride	26-Apr-90	0.1	mg/L	0.1	
0610	Fluoride	10-Dec-89	0.1	mg/L	0.1	
0611	Fluoride	10-Dec-89	0.1	mg/L	0.1	
0615	Fluoride	10-Dec-89	0.2	mg/L	0.1	
0618	Fluoride	26-Apr-90	0.1	mg/L	0.1	U
0626	Fluoride	30-Jun-90	0.3	mg/L	0.1	
0605	Gross Alpha	26-Apr-90	6.6	pCi/L	1	
0591	Iron	28-Aug-87	0.01	mg/L	0.03	U
0591	Iron	11-Jan-88	0.01	mg/L	0.03	
0592	Iron	11-Jan-88	0.01	mg/L	0.03	
0604	Iron	10-Dec-89	0.03	mg/L	0.03	U
0605	Iron	10-Dec-89	0.04	mg/L	0.03	
0605	Iron	07-Oct-90	0.03	mg/L	0.03	U
0606	Iron	10-Dec-89	0.07	mg/L	0.03	
0606	Iron	07-Oct-90	0.03	mg/L	0.03	U
0608	Iron	10-Dec-89	0.04	mg/L	0.03	
0609	Iron	10-Dec-89	0.03	mg/L	0.03	U
0610	Iron	10-Dec-89	0.05	mg/L	0.03	
0610	Iron	07-Oct-90	0.03	mg/L	0.03	U
0611	Iron	10-Dec-89	0.03	mg/L	0.03	U
0611	Iron	07-Oct-90	0.03	mg/L	0.03	U
0612	Iron	10-Dec-89	0.05	mg/L	0.03	
0614	Iron	10-Dec-89	0.12	mg/L	0.03	
0615	Iron	10-Dec-89	0.05	mg/L	0.03	
0618	Iron	10-Dec-89	0.04	mg/L	0.03	
0591	Lead	28-Aug-87	0.02	mg/L	0.02	U
0591	Lead	11-Jan-88	0.01	mg/L	0.01	U
0592	Lead	11-Jan-88	0.01	mg/L	0.01	U
0604	Lead	10-Dec-89	0.01	mg/L	0.01	U
0604	Lead	26-Apr-90	0.01	mg/L	0.01	U
0605	Lead	10-Dec-89	0.01	mg/L	0.01	U
0605	Lead	26-Apr-90	0.01	mg/L	0.01	U
0605	Lead	07-Oct-90	0.01	mg/L	0.01	U
0606	Lead	10-Dec-89	0.01	mg/L	0.01	U
0606	Lead	26-Apr-90	0.01	mg/L	0.01	U
0606	Lead	07-Oct-90	0.01	mg/L	0.01	U
0608	Lead	10-Dec-89	0.01	mg/L	0.01	U
0609	Lead	10-Dec-89	0.01	mg/L	0.01	U
0609	Lead	26-Apr-90	0.01	mg/L	0.01	U
0610	Lead	10-Dec-89	0.01	mg/L	0.01	U
0610	Lead	07-Oct-90	0.01	mg/L	0.01	U
0611	Lead	10-Dec-89	0.01	mg/L	0.01	U
0611	Lead	07-Oct-90	0.01	mg/L	0.01	U
0612	Lead	10-Dec-89	0.01	mg/L	0.01	U
0614	Lead	10-Dec-89	0.01	mg/L	0.01	U
0615	Lead	10-Dec-89	0.01	mg/L	0.01	U
0618	Lead	10-Dec-89	0.01	mg/L	0.01	U
0618	Lead	26-Apr-90	0.01	mg/L	0.01	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0626	Lead	30-Jun-90	0.01	mg/L	0.01	U
0591	Magnesium	28-Aug-87	3.48	mg/L	0.001	
0591	Magnesium	11-Jan-88	3.01	mg/L	0.001	
0591	Magnesium	02-Apr-88	3.08	mg/L	0.001	
0592	Magnesium	11-Jan-88	1.18	mg/L	0.001	
0595	Magnesium	02-Apr-88	5.89	mg/L	0.001	
0604	Magnesium	10-Dec-89	1.08	mg/L	0.001	
0604	Magnesium	26-Apr-90	0.36	mg/L	0.001	
0605	Magnesium	10-Dec-89	4.81	mg/L	0.001	
0605	Magnesium	26-Apr-90	0.78	mg/L	0.001	
0605	Magnesium	07-Oct-90	1.87	mg/L	0.001	
0606	Magnesium	10-Dec-89	1.4	mg/L	0.001	
0606	Magnesium	26-Apr-90	0.48	mg/L	0.001	
0606	Magnesium	07-Oct-90	0.79	mg/L	0.001	
0608	Magnesium	10-Dec-89	1.14	mg/L	0.001	
0609	Magnesium	10-Dec-89	2.71	mg/L	0.001	
0609	Magnesium	26-Apr-90	0.89	mg/L	0.001	
0610	Magnesium	10-Dec-89	1.48	mg/L	0.001	
0610	Magnesium	07-Oct-90	1.51	mg/L	0.001	
0611	Magnesium	10-Dec-89	1.04	mg/L	0.001	
0611	Magnesium	07-Oct-90	0.49	mg/L	0.001	
0612	Magnesium	10-Dec-89	6.96	mg/L	0.001	
0614	Magnesium	10-Dec-89	6.54	mg/L	0.001	
0615	Magnesium	10-Dec-89	2.75	mg/L	0.001	
0618	Magnesium	10-Dec-89	4.25	mg/L	0.001	
0618	Magnesium	26-Apr-90	1.38	mg/L	0.001	
0626	Magnesium	30-Jun-90	15.2	mg/L	0.001	
0591	Manganese	28-Aug-87	0.01	mg/L	0.01	
0591	Manganese	11-Jan-88	0.01	mg/L	0.01	
0592	Manganese	11-Jan-88	0.01	mg/L	0.01	U
0604	Manganese	10-Dec-89	0.03	mg/L	0.01	
0604	Manganese	26-Apr-90	0.01	mg/L	0.01	
0605	Manganese	10-Dec-89	0.04	mg/L	0.01	
0605	Manganese	26-Apr-90	0.01	mg/L	0.01	
0605	Manganese	07-Oct-90	0.07	mg/L	0.01	
0606	Manganese	10-Dec-89	0.04	mg/L	0.01	
0606	Manganese	26-Apr-90	0.01	mg/L	0.01	
0606	Manganese	07-Oct-90	0.01	mg/L	0.01	
0608	Manganese	10-Dec-89	0.03	mg/L	0.01	
0609	Manganese	10-Dec-89	0.03	mg/L	0.01	
0609	Manganese	26-Apr-90	0.03	mg/L	0.01	
0610	Manganese	10-Dec-89	0.04	mg/L	0.01	
0610	Manganese	07-Oct-90	0.04	mg/L	0.01	
0611	Manganese	10-Dec-89	0.02	mg/L	0.01	
0611	Manganese	07-Oct-90	0.02	mg/L	0.01	
0612	Manganese	10-Dec-89	0.04	mg/L	0.01	
0614	Manganese	10-Dec-89	0.33	mg/L	0.01	
0615	Manganese	10-Dec-89	0.05	mg/L	0.01	
0618	Manganese	10-Dec-89	0.04	mg/L	0.01	
0618	Manganese	26-Apr-90	0.04	mg/L	0.01	
0591	Mercury	28-Aug-87	0.0002	mg/L	0.0002	U
0604	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0604	Mercury	26-Apr-90	0.0002	mg/L	0.0002	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0605	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0605	Mercury	26-Apr-90	0.0002	mg/L	0.0002	U
0605	Mercury	07-Oct-90	0.0002	mg/L	0.0002	U
0606	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0606	Mercury	26-Apr-90	0.0002	mg/L	0.0002	U
0606	Mercury	07-Oct-90	0.0002	mg/L	0.0002	U
0608	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0609	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0609	Mercury	26-Apr-90	0.0002	mg/L	0.0002	U
0610	Mercury	07-Oct-90	0.0002	mg/L	0.0002	U
0611	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0611	Mercury	07-Oct-90	0.0002	mg/L	0.0002	U
0615	Mercury	10-Dec-89	0.0002	mg/L	0.0002	U
0618	Mercury	26-Apr-90	0.0002	mg/L	0.0002	U
0591	Molybdenum	28-Aug-87	0.01	mg/L	0.01	
0591	Molybdenum	11-Jan-88	0.01	mg/L	0.01	U
0591	Molybdenum	02-Apr-88	0.01	mg/L	0.01	U
0592	Molybdenum	11-Jan-88	0.01	mg/L	0.01	U
0592	Molybdenum	02-Apr-88	0.01	mg/L	0.01	U
0595	Molybdenum	02-Apr-88	0.01	mg/L	0.01	U
0604	Molybdenum	10-Dec-89	0.01	mg/L	0.01	U
0604	Molybdenum	26-Apr-90	0.01	mg/L	0.01	U
0605	Molybdenum	10-Dec-89	0.05	mg/L	0.01	
0605	Molybdenum	26-Apr-90	0.01	mg/L	0.01	U
0605	Molybdenum	07-Oct-90	0.01	mg/L	0.01	U
0606	Molybdenum	10-Dec-89	0.04	mg/L	0.01	
0606	Molybdenum	26-Apr-90	0.01	mg/L	0.01	U
0606	Molybdenum	07-Oct-90	0.01	mg/L	0.01	U
0608	Molybdenum	10-Dec-89	0.01	mg/L	0.01	U
0609	Molybdenum	10-Dec-89	0.01	mg/L	0.01	
0609	Molybdenum	26-Apr-90	0.01	mg/L	0.01	U
0610	Molybdenum	10-Dec-89	0.01	mg/L	0.01	
0610	Molybdenum	07-Oct-90	0.01	mg/L	0.01	U
0611	Molybdenum	10-Dec-89	0.01	mg/L	0.01	U
0611	Molybdenum	07-Oct-90	0.01	mg/L	0.01	U
0612	Molybdenum	10-Dec-89	0.03	mg/L	0.01	
0614	Molybdenum	10-Dec-89	0.03	mg/L	0.01	
0615	Molybdenum	10-Dec-89	0.02	mg/L	0.01	
0618	Molybdenum	10-Dec-89	0.04	mg/L	0.01	
0618	Molybdenum	26-Apr-90	0.01	mg/L	0.01	U
0626	Molybdenum	30-Jun-90	0.01	mg/L	0.01	
0591	Nickel	28-Aug-87	0.01	mg/L	0.04	U
0604	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0604	Nickel	26-Apr-90	0.04	mg/L	0.04	U
0605	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0605	Nickel	26-Apr-90	0.04	mg/L	0.04	U
0605	Nickel	07-Oct-90	0.04	mg/L	0.04	U
0606	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0606	Nickel	26-Apr-90	0.04	mg/L	0.04	U
0606	Nickel	07-Oct-90	0.04	mg/L	0.04	U
0608	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0609	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0609	Nickel	26-Apr-90	0.04	mg/L	0.04	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0610	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0610	Nickel	07-Oct-90	0.04	mg/L	0.04	U
0611	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0611	Nickel	07-Oct-90	0.04	mg/L	0.04	U
0612	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0614	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0615	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0618	Nickel	10-Dec-89	0.04	mg/L	0.04	U
0618	Nickel	26-Apr-90	0.04	mg/L	0.04	U
0626	Nickel	30-Jun-90	0.2	mg/L	0.04	
0591	Nitrate + Nitrite as Nitrogen	02-Apr-88	89	mg/L	1	
0592	Nitrate + Nitrite as Nitrogen	02-Apr-88	9	mg/L	1	
0595	Nitrate + Nitrite as Nitrogen	02-Apr-88	61	mg/L	1	
0591	Nitrate as NO3	28-Aug-87	60	mg/L	1	
0591	Nitrate as NO3	02-Apr-88	89	mg/L	1	
0592	Nitrate as NO3	02-Apr-88	9	mg/L	1	
0595	Nitrate as NO3	02-Apr-88	61	mg/L	1	
0604	Nitrate as NO3	10-Dec-89	18.1	mg/L	1	
0604	Nitrate as NO3	26-Apr-90	1.9	mg/L	1	
0605	Nitrate as NO3	10-Dec-89	20.4	mg/L	1	
0605	Nitrate as NO3	26-Apr-90	8	mg/L	1	
0606	Nitrate as NO3	10-Dec-89	1.7	mg/L	1	
0606	Nitrate as NO3	26-Apr-90	2.6	mg/L	1	
0608	Nitrate as NO3	10-Dec-89	1.2	mg/L	1	
0609	Nitrate as NO3	10-Dec-89	29.2	mg/L	1	
0609	Nitrate as NO3	26-Apr-90	1	mg/L	1	U
0610	Nitrate as NO3	10-Dec-89	0.1	mg/L	1	U
0611	Nitrate as NO3	10-Dec-89	1	mg/L	1	
0612	Nitrate as NO3	10-Dec-89	0.1	mg/L	1	U
0615	Nitrate as NO3	10-Dec-89	3	mg/L	1	
0618	Nitrate as NO3	10-Dec-89	19.5	mg/L	1	
0618	Nitrate as NO3	26-Apr-90	2.3	mg/L	1	
0604	pH	10-Dec-89	7.5	s.u.	0	
0604	pH	26-Apr-90	6.36	s.u.	0	
0605	pH	10-Dec-89	7.8	s.u.	0	
0605	pH	26-Apr-90	6.64	s.u.	0	
0605	pH	07-Oct-90	5.65	s.u.	0	
0606	pH	10-Dec-89	7.31	s.u.	0	
0606	pH	26-Apr-90	7.46	s.u.	0	
0606	pH	07-Oct-90	6.78	s.u.	0	
0608	pH	10-Dec-89	7.49	s.u.	0	
0609	pH	10-Dec-89	7.26	s.u.	0	
0609	pH	26-Apr-90	6.43	s.u.	0	
0610	pH	10-Dec-89	7.73	s.u.	0	
0610	pH	07-Oct-90	5.93	s.u.	0	
0611	pH	10-Dec-89	8.29	s.u.	0	
0611	pH	07-Oct-90	6	s.u.	0	
0612	pH	10-Dec-89	8.33	s.u.	0	
0614	pH	10-Dec-89	8.12	s.u.	0	
0615	pH	10-Dec-89	8.21	s.u.	0	
0618	pH	10-Dec-89	8.09	s.u.	0	
0618	pH	26-Apr-90	6.32	s.u.	0	
0591	Potassium	28-Aug-87	1.9	mg/L	0.01	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0591	Potassium	11-Jan-88	2.1	mg/L	0.01	
0591	Potassium	02-Apr-88	1.82	mg/L	0.01	
0592	Potassium	11-Jan-88	0.83	mg/L	0.01	
0595	Potassium	02-Apr-88	16.7	mg/L	0.01	
0604	Potassium	10-Dec-89	1.8	mg/L	0.01	
0604	Potassium	26-Apr-90	0.49	mg/L	0.01	
0605	Potassium	10-Dec-89	2.1	mg/L	0.01	
0605	Potassium	26-Apr-90	1.31	mg/L	0.01	
0605	Potassium	07-Oct-90	2.4	mg/L	0.01	
0606	Potassium	10-Dec-89	1.2	mg/L	0.01	
0606	Potassium	26-Apr-90	0.8	mg/L	0.01	
0606	Potassium	07-Oct-90	0.9	mg/L	0.01	
0608	Potassium	10-Dec-89	0.8	mg/L	0.01	
0609	Potassium	10-Dec-89	2.5	mg/L	0.01	
0609	Potassium	26-Apr-90	1.44	mg/L	0.01	
0610	Potassium	10-Dec-89	1.1	mg/L	0.01	
0610	Potassium	07-Oct-90	1.5	mg/L	0.01	
0611	Potassium	10-Dec-89	1.8	mg/L	0.01	
0611	Potassium	07-Oct-90	0.6	mg/L	0.01	
0612	Potassium	10-Dec-89	2.4	mg/L	0.01	
0614	Potassium	10-Dec-89	4.9	mg/L	0.01	
0615	Potassium	10-Dec-89	1.9	mg/L	0.01	
0618	Potassium	10-Dec-89	3.9	mg/L	0.01	
0618	Potassium	26-Apr-90	3.2	mg/L	0.01	
0626	Potassium	30-Jun-90	3.8	mg/L	0.01	
0604	Radium-226	10-Dec-89	0	pCi/L	1	
0605	Radium-226	10-Dec-89	0	pCi/L	1	
0608	Radium-226	10-Dec-89	0	pCi/L	1	
0609	Radium-226	10-Dec-89	0	pCi/L	1	
0615	Radium-226	10-Dec-89	0	pCi/L	1	
0591	Selenium	28-Aug-87	0.001	mg/L	0.005	U
0591	Selenium	11-Jan-88	0.005	mg/L	0.005	U
0591	Selenium	02-Apr-88	0.005	mg/L	0.005	U
0592	Selenium	11-Jan-88	0.005	mg/L	0.005	U
0592	Selenium	02-Apr-88	0.005	mg/L	0.005	U
0595	Selenium	02-Apr-88	0.005	mg/L	0.005	U
0604	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0604	Selenium	26-Apr-90	0.005	mg/L	0.005	U
0605	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0605	Selenium	26-Apr-90	0.005	mg/L	0.005	U
0605	Selenium	07-Oct-90	0.005	mg/L	0.005	U
0606	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0606	Selenium	26-Apr-90	0.005	mg/L	0.005	U
0606	Selenium	07-Oct-90	0.005	mg/L	0.005	U
0608	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0609	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0609	Selenium	26-Apr-90	0.005	mg/L	0.005	U
0610	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0610	Selenium	07-Oct-90	0.005	mg/L	0.005	U
0611	Selenium	10-Dec-89	0.005	mg/L	0.005	
0611	Selenium	07-Oct-90	0.005	mg/L	0.005	U
0612	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0614	Selenium	10-Dec-89	0.006	mg/L	0.005	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0615	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0618	Selenium	10-Dec-89	0.005	mg/L	0.005	U
0618	Selenium	26-Apr-90	0.005	mg/L	0.005	U
0626	Selenium	30-Jun-90	0.005	mg/L	0.005	U
0591	Silica	11-Jan-88	29.2	mg/L	2	
0591	Silica	02-Apr-88	22	mg/L	2	
0592	Silica	11-Jan-88	20.8	mg/L	2	
0595	Silica	02-Apr-88	21.3	mg/L	2	
0605	Silica	07-Oct-90	24	mg/L	2	
0606	Silica	07-Oct-90	14	mg/L	2	
0610	Silica	07-Oct-90	12	mg/L	2	
0591	Silver	28-Aug-87	0.01	mg/L	0.01	U
0604	Silver	10-Dec-89	0.01	mg/L	0.01	U
0604	Silver	26-Apr-90	0.01	mg/L	0.01	U
0605	Silver	10-Dec-89	0.01	mg/L	0.01	U
0605	Silver	26-Apr-90	0.01	mg/L	0.01	U
0605	Silver	07-Oct-90	0.01	mg/L	0.01	U
0606	Silver	10-Dec-89	0.01	mg/L	0.01	U
0606	Silver	26-Apr-90	0.01	mg/L	0.01	U
0606	Silver	07-Oct-90	0.01	mg/L	0.01	U
0608	Silver	10-Dec-89	0.01	mg/L	0.01	U
0609	Silver	10-Dec-89	0.01	mg/L	0.01	U
0609	Silver	26-Apr-90	0.01	mg/L	0.01	U
0610	Silver	10-Dec-89	0.01	mg/L	0.01	U
0610	Silver	07-Oct-90	0.01	mg/L	0.01	U
0611	Silver	10-Dec-89	0.01	mg/L	0.01	U
0611	Silver	07-Oct-90	0.01	mg/L	0.01	U
0612	Silver	10-Dec-89	0.01	mg/L	0.01	U
0614	Silver	10-Dec-89	0.01	mg/L	0.01	U
0615	Silver	10-Dec-89	0.01	mg/L	0.01	U
0618	Silver	10-Dec-89	0.01	mg/L	0.01	U
0618	Silver	26-Apr-90	0.01	mg/L	0.01	U
0626	Silver	30-Jun-90	0.01	mg/L	0.01	U
0591	Sodium	28-Aug-87	4.12	mg/L	0.002	
0591	Sodium	11-Jan-88	4.05	mg/L	0.002	
0591	Sodium	02-Apr-88	2.34	mg/L	0.002	
0592	Sodium	11-Jan-88	5.34	mg/L	0.002	
0595	Sodium	02-Apr-88	33.5	mg/L	0.002	
0604	Sodium	10-Dec-89	4.19	mg/L	0.002	
0604	Sodium	26-Apr-90	0.77	mg/L	0.002	
0605	Sodium	10-Dec-89	13.2	mg/L	0.002	
0605	Sodium	26-Apr-90	3.5	mg/L	0.002	
0605	Sodium	07-Oct-90	2.48	mg/L	0.002	
0606	Sodium	10-Dec-89	7.5	mg/L	0.002	
0606	Sodium	26-Apr-90	3.4	mg/L	0.002	
0606	Sodium	07-Oct-90	1.82	mg/L	0.002	
0608	Sodium	10-Dec-89	4	mg/L	0.002	
0609	Sodium	10-Dec-89	8.25	mg/L	0.002	
0609	Sodium	26-Apr-90	5.9	mg/L	0.002	
0610	Sodium	10-Dec-89	6.31	mg/L	0.002	
0610	Sodium	07-Oct-90	1.83	mg/L	0.002	
0611	Sodium	10-Dec-89	3.67	mg/L	0.002	
0611	Sodium	07-Oct-90	1.73	mg/L	0.002	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0612	Sodium	10-Dec-89	15.5	mg/L	0.002	
0614	Sodium	10-Dec-89	11.1	mg/L	0.002	
0615	Sodium	10-Dec-89	8.59	mg/L	0.002	
0618	Sodium	10-Dec-89	10.3	mg/L	0.002	
0618	Sodium	26-Apr-90	4.1	mg/L	0.002	
0626	Sodium	30-Jun-90	12.6	mg/L	0.002	
0604	Specific Conductance	10-Dec-89	20	umhos/cm	0	
0604	Specific Conductance	26-Apr-90	10	umhos/cm	0	
0605	Specific Conductance	10-Dec-89	125	umhos/cm	0	
0605	Specific Conductance	26-Apr-90	25	umhos/cm	0	
0605	Specific Conductance	07-Oct-90	100	umhos/cm	0	
0606	Specific Conductance	10-Dec-89	30	umhos/cm	0	
0606	Specific Conductance	26-Apr-90	10	umhos/cm	0	
0606	Specific Conductance	07-Oct-90	42	umhos/cm	0	
0608	Specific Conductance	10-Dec-89	20	umhos/cm	0	
0609	Specific Conductance	10-Dec-89	95	umhos/cm	0	
0609	Specific Conductance	26-Apr-90	30	umhos/cm	0	
0610	Specific Conductance	10-Dec-89	40	umhos/cm	0	
0610	Specific Conductance	07-Oct-90	55	umhos/cm	0	
0611	Specific Conductance	10-Dec-89	30	umhos/cm	0	
0611	Specific Conductance	07-Oct-90	15	umhos/cm	0	
0612	Specific Conductance	10-Dec-89	240	umhos/cm	0	
0614	Specific Conductance	10-Dec-89	175	umhos/cm	0	
0615	Specific Conductance	10-Dec-89	100	umhos/cm	0	
0618	Specific Conductance	10-Dec-89	320	umhos/cm	0	
0618	Specific Conductance	26-Apr-90	48	umhos/cm	0	
0591	Strontium	28-Aug-87	0.123	mg/L	0.1	
0604	Strontium	10-Dec-89	0.01	mg/L	0.1	U
0604	Strontium	26-Apr-90	0.03	mg/L	0.1	
0605	Strontium	10-Dec-89	0.35	mg/L	0.1	
0605	Strontium	26-Apr-90	0.03	mg/L	0.1	
0605	Strontium	07-Oct-90	0.2	mg/L	0.1	
0606	Strontium	10-Dec-89	0.01	mg/L	0.1	U
0606	Strontium	26-Apr-90	0.01	mg/L	0.1	U
0606	Strontium	07-Oct-90	0.1	mg/L	0.1	U
0608	Strontium	10-Dec-89	0.02	mg/L	0.1	
0609	Strontium	10-Dec-89	0.14	mg/L	0.1	
0609	Strontium	26-Apr-90	0.02	mg/L	0.1	
0610	Strontium	10-Dec-89	0.01	mg/L	0.1	U
0610	Strontium	07-Oct-90	0.1	mg/L	0.1	
0611	Strontium	10-Dec-89	0.04	mg/L	0.1	
0611	Strontium	07-Oct-90	0.1	mg/L	0.1	U
0612	Strontium	10-Dec-89	0.48	mg/L	0.1	
0614	Strontium	10-Dec-89	0.17	mg/L	0.1	
0615	Strontium	10-Dec-89	0.09	mg/L	0.1	
0618	Strontium	10-Dec-89	0.13	mg/L	0.1	
0618	Strontium	26-Apr-90	0.03	mg/L	0.1	
0626	Strontium	30-Jun-90	0.31	mg/L	0.1	
0591	Sulfate	28-Aug-87	0.5	mg/L	0.1	
0604	Sulfate	26-Apr-90	1.4	mg/L	0.1	
0605	Sulfate	26-Apr-90	2.3	mg/L	0.1	
0606	Sulfate	07-Oct-90	0.1	mg/L	0.1	U
0611	Sulfate	07-Oct-90	1.6	mg/L	0.1	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0618	Sulfate	26-Apr-90	2.8	mg/L	0.1	
0604	Temperature	26-Apr-90	12	C	0	
0605	Temperature	26-Apr-90	13	C	0	
0605	Temperature	07-Oct-90	16.5	C	0	
0606	Temperature	26-Apr-90	12	C	0	
0606	Temperature	07-Oct-90	14	C	0	
0609	Temperature	26-Apr-90	13	C	0	
0610	Temperature	07-Oct-90	11	C	0	
0611	Temperature	07-Oct-90	11	C	0	
0618	Temperature	26-Apr-90	13	C	0	
0604	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0604	Thallium	26-Apr-90	0.1	mg/L	0.1	U
0605	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0605	Thallium	26-Apr-90	0.1	mg/L	0.1	U
0605	Thallium	07-Oct-90	0.01	mg/L	0.01	U
0606	Thallium	26-Apr-90	0.1	mg/L	0.1	U
0606	Thallium	07-Oct-90	0.01	mg/L	0.01	U
0608	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0609	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0609	Thallium	26-Apr-90	0.1	mg/L	0.1	U
0610	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0610	Thallium	07-Oct-90	0.01	mg/L	0.01	U
0611	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0611	Thallium	07-Oct-90	0.01	mg/L	0.01	U
0612	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0614	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0615	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0618	Thallium	10-Dec-89	0.01	mg/L	0.01	U
0618	Thallium	26-Apr-90	0.1	mg/L	0.1	U
0626	Thallium	30-Jun-90	0.01	mg/L	0.01	U
0591	Thorium-230	11-Jan-88	0.5	pCi/L	1	
0591	Tin	28-Aug-87	0.003	mg/L	0.005	U
0604	Tin	26-Apr-90	0.01	mg/L	0.01	UI
0605	Tin	26-Apr-90	0.01	mg/L	0.01	UI
0605	Tin	07-Oct-90	0.014	mg/L	0.005	
0606	Tin	26-Apr-90	0.01	mg/L	0.01	UI
0606	Tin	07-Oct-90	0.005	mg/L	0.005	U
0609	Tin	26-Apr-90	0.01	mg/L	0.01	UI
0610	Tin	07-Oct-90	0.005	mg/L	0.005	U
0611	Tin	07-Oct-90	0.005	mg/L	0.005	U
0618	Tin	26-Apr-90	0.01	mg/L	0.01	UI
0609	Total Cyanide	10-Dec-89	0.01	mg/L	0.01	U
0591	Total Dissolved Solids	28-Aug-87	125	mg/L	10	
0606	Total Dissolved Solids	07-Oct-90	64	mg/L	10	
0611	Total Dissolved Solids	07-Oct-90	20	mg/L	10	
0626	Total Dissolved Solids	30-Jun-90	318	mg/L	10	
0604	Total Kjeldahl Nitrogen	26-Apr-90	1	mg/L	1	U
0605	Total Kjeldahl Nitrogen	26-Apr-90	1	mg/L	1	U
0606	Total Kjeldahl Nitrogen	26-Apr-90	1	mg/L	1	U
0609	Total Kjeldahl Nitrogen	26-Apr-90	1	mg/L	1	U
0618	Total Kjeldahl Nitrogen	26-Apr-90	2	mg/L	1	
0591	Total Phosphorus as PO4	28-Aug-87	0.1	mg/L	0.1	U
0606	Total Phosphorus as PO4	07-Oct-90	0.1	mg/L	0.1	U

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0611	Total Phosphorus as PO4	07-Oct-90	0.1	mg/L	0.1	U
0591	Uranium	28-Aug-87	0.0003	mg/L	0.003	
0591	Uranium	11-Jan-88	0.0003	mg/L	0.003	U
0591	Uranium	02-Apr-88	0.0003	mg/L	0.003	
0592	Uranium	28-Aug-87	0.0003	mg/L	0.003	U
0592	Uranium	11-Jan-88	0.0003	mg/L	0.003	U
0592	Uranium	02-Apr-88	0.0003	mg/L	0.003	
0595	Uranium	02-Apr-88	0.0003	mg/L	0.003	U
0604	Uranium	10-Dec-89	0.0003	mg/L	0.003	U
0604	Uranium	26-Apr-90	0.003	mg/L	0.003	U
0605	Uranium	10-Dec-89	0.0004	mg/L	0.003	
0605	Uranium	26-Apr-90	0.003	mg/L	0.003	U
0605	Uranium	07-Oct-90	0.0005	mg/L	0.0003	
0606	Uranium	10-Dec-89	0.0003	mg/L	0.003	U
0606	Uranium	26-Apr-90	0.003	mg/L	0.003	U
0606	Uranium	07-Oct-90	0.0003	mg/L	0.0003	
0608	Uranium	10-Dec-89	0.0003	mg/L	0.003	U
0609	Uranium	10-Dec-89	0.0003	mg/L	0.003	U
0609	Uranium	26-Apr-90	0.003	mg/L	0.003	U
0610	Uranium	10-Dec-89	0.0003	mg/L	0.003	U
0610	Uranium	07-Oct-90	0.0003	mg/L	0.0003	
0611	Uranium	10-Dec-89	0.0003	mg/L	0.003	
0611	Uranium	07-Oct-90	0.0004	mg/L	0.0003	
0612	Uranium	10-Dec-89	0.065	mg/L	0.003	
0614	Uranium	10-Dec-89	0.0043	mg/L	0.003	
0615	Uranium	10-Dec-89	0.0027	mg/L	0.003	
0618	Uranium	10-Dec-89	0.001	mg/L	0.003	
0618	Uranium	26-Apr-90	0.003	mg/L	0.003	U
0626	Uranium	30-Jun-90	0.0061	mg/L	0.003	
0591	Vanadium	28-Aug-87	0.22	mg/L	0.01	
0591	Vanadium	11-Jan-88	0.06	mg/L	0.01	
0592	Vanadium	11-Jan-88	0.09	mg/L	0.01	
0604	Vanadium	10-Dec-89	0.09	mg/L	0.01	
0604	Vanadium	26-Apr-90	0.04	mg/L	0.01	
0605	Vanadium	10-Dec-89	0.53	mg/L	0.01	
0605	Vanadium	26-Apr-90	0.05	mg/L	0.01	
0605	Vanadium	07-Oct-90	0.01	mg/L	0.01	U
0606	Vanadium	10-Dec-89	0.48	mg/L	0.01	
0606	Vanadium	26-Apr-90	0.06	mg/L	0.01	
0606	Vanadium	07-Oct-90	0.01	mg/L	0.01	U
0608	Vanadium	10-Dec-89	0.06	mg/L	0.01	
0609	Vanadium	10-Dec-89	0.19	mg/L	0.01	
0609	Vanadium	26-Apr-90	0.05	mg/L	0.01	
0610	Vanadium	10-Dec-89	0.25	mg/L	0.01	
0610	Vanadium	07-Oct-90	0.01	mg/L	0.01	U
0611	Vanadium	10-Dec-89	0.1	mg/L	0.01	
0611	Vanadium	07-Oct-90	0.01	mg/L	0.01	U
0612	Vanadium	10-Dec-89	0.48	mg/L	0.01	
0614	Vanadium	10-Dec-89	0.42	mg/L	0.01	
0615	Vanadium	10-Dec-89	0.23	mg/L	0.01	
0618	Vanadium	10-Dec-89	0.58	mg/L	0.01	
0618	Vanadium	26-Apr-90	0.06	mg/L	0.01	
0626	Vanadium	30-Jun-90	0.31	mg/L	0.01	

Pore Water Concentrations (continued)

Lysimeter	Constituent	Sample Date	Concentration	Units	Detection Limit	Qualifier
0591	Zinc	28-Aug-87	0.038	mg/L	0.005	
0591	Zinc	11-Jan-88	0.047	mg/L	0.005	
0592	Zinc	11-Jan-88	0.04	mg/L	0.005	
0604	Zinc	10-Dec-89	0.043	mg/L	0.005	
0604	Zinc	26-Apr-90	0.043	mg/L	0.005	
0605	Zinc	10-Dec-89	0.051	mg/L	0.005	
0605	Zinc	26-Apr-90	0.045	mg/L	0.005	
0605	Zinc	07-Oct-90	0.104	mg/L	0.005	
0606	Zinc	10-Dec-89	0.689	mg/L	0.005	
0606	Zinc	26-Apr-90	0.04	mg/L	0.005	
0606	Zinc	07-Oct-90	0.074	mg/L	0.005	
0608	Zinc	10-Dec-89	0.043	mg/L	0.005	
0609	Zinc	10-Dec-89	0.037	mg/L	0.005	
0609	Zinc	26-Apr-90	0.103	mg/L	0.005	
0610	Zinc	10-Dec-89	0.073	mg/L	0.005	
0610	Zinc	07-Oct-90	0.055	mg/L	0.005	
0611	Zinc	10-Dec-89	0.025	mg/L	0.005	
0611	Zinc	07-Oct-90	0.041	mg/L	0.005	
0612	Zinc	10-Dec-89	0.043	mg/L	0.005	
0614	Zinc	10-Dec-89	0.257	mg/L	0.005	
0615	Zinc	10-Dec-89	0.376	mg/L	0.005	
0618	Zinc	10-Dec-89	0.051	mg/L	0.005	
0618	Zinc	26-Apr-90	0.116	mg/L	0.005	
0626	Zinc	30-Jun-90	0.038	mg/L	0.005	

U = concentration is less than the detection limit

Batch Test Results (DOE 1991)

Sample (pH)	Source Material	Arsenic (0.05 mg/l)	Molybdenum (0.10 mg/l)	Radium 226 + 228 (5 pCi/l)	Selenium (0.01 mg/l)	Uranium (0.044 mg/l)	Lead (0.05 mg/l)	Polonium-210 (pCi/L)	Barium (1.0 mg/l)	Cadmium (0.01 mg/l)	Chromium (0.05 mg/l)	Mercury (0.002 mg/l)	Silver (0.05 mg/l)
ACID BATCH TESTS													
721 (3.56-4.85)	Gray ore	<0.01	<0.01	20.9	<0.005	0.005	<1.5 (pCi/l)	<1.0	NT[a]	NT	NT	NT	NT
722 (3.52-4.71)	Gray ore	<0.01	<0.01	47.0	<0.005	0.008	<1.5 (pCi/l)	<1.0	NT	NT	NT	NT	NT
723 (3.29-4.80)	Black sand	<0.01	<0.01	23.8	<0.005	0.005	<1.5 (pCi/l)	<1.0	NT	NT	NT	NT	NT
724 (3.21-4.70)	Black sand	<0.01	<0.011	8.1	<0.005	0.010	<1.5 (pCi/l)	<1.0	NT	NT	NT	NT	NT
725 (3.19-4.89)	White sand	<0.01	<0.01	30.5	<0.005	0.005	1.8 (pCi/l)	<1.0	NT	NT	NT	NT	NT
726 (3.02-4.50)	White sand	<0.01	<0.01	44.0	<0.005	0.008	<1.5 (pCi/l)	<1.0	NT	NT	NT	NT	NT
727 (4.41-4.82)	Gray sand	<0.01	<0.01	24.8	<0.005	0.028	1.6 (pCi/l)	<1.0	NT	NT	NT	NT	NT
728 (3.51-4.00)	Gray sand	<0.01	<0.01	42.0	<0.005	0.005	<1.5 (pCi/l)	<1.0	NT	NT	NT	NT	NT
NEUTRAL BATCH TESTS													
449 (6.6)	Gray ore	<0.01	NT	NT	NT	0.322[b]	0.11	NT	0.5	<0.001	0.02	<0.0002	<0.01
450 (6.6)	Gray ore	<0.01	NT	NT	NT	0.005	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
451 (6.6)	Black sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
452 (6.6)	Black sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
453 (6.6)	Red sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
454 (6.6)	Red sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
455 (6.6)	Gray sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
456 (6.6)	Gray sand	<0.01	NT	NT	NT	<0.003	<0.01	NT	<0.1	<0.001	<0.01	<0.0002	<0.01
701 (7.1)	Gray ore	NT	<0.01	5.5	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
702 (7.1)	Gray ore	<0.01	<0.01	3.8	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
703 (7.2)	Black sand	<0.01	<0.01	<1.0	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
704 (7.0)	Black sand	<0.01	<0.01	1.9	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
705 (7.6)	White sand	<0.01	<0.01	1.7	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
706 (7.8)	White sand	<0.01	<0.01	<1.0	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
707 (7.4)	White sand	<0.01	<0.01	<1.0	<0.005	<0.003	NT	NT	NT	NT	NT	NT	NT
		Aluminum (mg/L)	Antimony (mg/L)	Beryllium (mg/L)	Cyanide (mg/L)	Nickel (mg/L)	Thallium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Tin (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	
449 (6.6)	Gray ore	16.7	<0.003	<0.01		<0.04	<0.01	<0.05	0.03	<0.005	0.20	0.231	
450 (6.6)	Gray ore	0.6	<0.003	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	0.20	0.017	
451 (6.6)	Black sand	0.2	0.009	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	0.01	0.014	
452 (6.6)	Black sand	<0.1	0.006	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	<0.01	0.168	
453 (6.6)	Red sand	0.7	0.003	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	<0.01	0.098	
454 (6.6)	Red sand	0.5	0.007	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	<0.01	0.063	
455 (6.6)	Gray sand	0.6	0.004	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	<0.01	0.017	
456 (6.6)	Gray sand	0.2	0.004	<0.01		<0.04	<0.01	<0.05	<0.02	<0.005	<0.01	0.017	

[a]NT – not tested
[b]Analytical result possibly erroneous.