Department of Energy
Washington, DC 20585

April 12, 2012

ATTN: Document Control Desk
Deputy Director
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Mail Stop T8F5

Subject: Transmittal of Draft *Long-Term Surveillance Plan for the Split Rock, Wyoming, (UMTRCA Title II) Disposal Site, Fremont County, Wyoming*

To Whom It May Concern:

Please find enclosed for U.S. Nuclear Regulatory Commission (NRC) review, the draft *Long-Term Surveillance Plan for the Split Rock (UMTRCA Title II) Disposal Site, Fremont County, Wyoming* (LTSP). This draft LTSP captures information provided in site documents and demonstrates how the U.S. Department of Energy (DOE), as the future long-term custodian of the Split Rock, Wyoming, disposal site, will fulfill the requirements of the general license at Title 10, *Code of Federal Regulations*, Part 40.28. In accordance with these regulations, this draft LTSP is submitted to NRC as one of the final steps in transitioning the site to DOE for custody and long-term care.

The draft LTSP is complete except for "placeholders" in Appendix A for 1) the warranty deed for transfer of title to the licensee's fee land at the site and 2) the Public Land Order Notice of Permanent Withdrawal for the federally-owned land within the site's long-term care boundary. Once any NRC comments have been resolved and the warranty deed has been completed and a copy inserted into the document, the revised preliminary final LTSP will be submitted to NRC for acceptance.

DOE evaluated the licensee's (Western Nuclear Incorporated [WNI]) groundwater and surface water monitoring program as well as historical monitoring results, and also the alternate concentration limit (ACL) application. This evaluation (Appendix E of the LTSP) provides the basis for the long-term monitoring program presented under Section 3.7.1 of the draft LTSP. The evaluation resulted in the following recommended modifications to the licensee's current monitoring program:

1) Reduce groundwater monitoring locations from 16 wells to 10 wells within the site's 3,868-acre long-term care boundary.
2) Reduce surface water monitoring locations on the Sweetwater River from five sampling points to one sampling point.
3) Reduce the constituents monitored for both groundwater and surface water from 22 to 6 analytes.

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4) Reduce the monitoring frequency for both groundwater and surface water from semi-annual to annual for the first year. Annual monitoring continues at all locations in the long-term monitoring network except at wells SWAB-22, SWAB-29, SWAB-31, and WN-41B, and surface water location SW-3, where monitoring will be conducted every fifth year.
5) Reevaluate the long-term monitoring program after five years (and periodically thereafter based on site conditions) to determine if any modifications to analytes, locations, frequency, or duration are technically warranted. The reevaluation also will address whether the criteria for discontinuing monitoring have been met, as specified in the draft LTSP.
6) The trigger levels established for groundwater and surface water should not be incorporated into the long-term monitoring program as no basis for their application is found within the regulations. Instead, monitoring results in the wells closest to the point-of-exposure (POE) (i.e., the site's long-term care boundary) should be compared to groundwater protection standards applicable offsite, and surface water results should be compared to water quality standards applicable to the Sweetwater River, to ensure compliance continues to be maintained.

DOE found that nitrate concentrations in groundwater have been in excess of the ACL at the site in two wells directly downgradient of the point-of-compliance (POC) in the Southwest Valley flow regime. Concentrations of nitrate above the ACL occurred in well SWAB–2 (downgradient of POC well WN–21) and in well SWAB–1R (downgradient of well SWAB–2) since their installation in 1996 and 2009, respectively. DOE is not aware of these concentrations of nitrate above the ACL having been considered a regulatory out-of-compliance event for WNI, presumably because nitrate concentrations did not exceed the ACL at the designated POC wells. Correspondence between the licensee and NRC seems to indicate there was awareness that elevated contaminant concentrations were present downgradient of the POC. Groundwater modeling predicted that concentrations of nitrate (and all other hazardous constituents) will not exceed background values at the long-term care boundary and therefore, protection of human health and the environment would be ensured at the POE.

To ensure that continued nitrate concentrations in excess of the ACL at these two wells under long-term monitoring will not be viewed as an out-of-compliance event, this issue is explicitly addressed in the draft LTSP. The draft LTSP states that compliance with the ACLs is only required at POC wells; other standards are provided that must be met at the POE.

The long-term surveillance program presented in the draft LTSP entails performing the following long-term surveillance activities: annual site inspection and reporting, annual groundwater and surface water monitoring and reporting (10 wells, 1 surface water location, 6 constituents at each location), and minor maintenance (periodic warning/no trespassing sign replacement). DOE's estimated annual cost for conducting these long-term surveillance activities will be provided under separate submittal. This is being done to facilitate DOE's understanding that NRC has agreed to not make the cost estimate available to the public.

Please call me at (720) 377-9682 or scott.surovchak@lm.doe.gov if you have any questions. Please send any correspondence to:

U.S. Department of Energy
Office of Legacy Management
2597 Legacy Way
Grand Junction, CO 81503

Sincerely,

Scott R. Surovchak
2012.04.10 09:27:59
-06'00'

Scott R. Surovchak
Site Manager

Enclosure

cc w/enclosure:
J. Shepherd, NRC
File: SPR 505.15(A)

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D. Orlando, NRC
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T. Pauling, DOE
C. Carpenter, Stoller (e)
S. Hall, Stoller (e)
M. Widdop, Stoller (e)

Surovchak/Split Rock/4-4-12 Draft LTSP to NRC.doc

LMS/SPR/S02613-0.0

Office of Legacy Management

Long-Term Surveillance Plan for the Split Rock (UMTRCA Title II) Disposal Site Jeffrey City, Wyoming

April 2012

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Office of Legacy Management

Long-Term Surveillance Plan

for the

Split Rock (UMTRCA Title II) Disposal Site
Jeffrey City, Wyoming

April 2012

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Contents

Draft

Figures

Tables

Draft

Appendixes

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Abbreviations

ACL	alternate concentration limit
ALARA	as low as reasonably achievable
BLM	U.S. Bureau of Land Management
CAP	Corrective action program
CFR	*Code of Federal Regulations*
COC	constituent of concern
D_{50}	median diameter
DOE	U.S. Department of Energy
EMS	environmental management system
EPA	U.S. Environmental Protection Agency
FONSI	finding of no significant impact
ft	feet, foot
ft/yr	feet per year
LM	Office of Legacy Management
LTS&M	long-term surveillance and maintenance
LTSP	Long-Term Surveillance Plan
MCL	maximum contaminant level
mg/L	milligram(s) per liter
NRC	U.S. Nuclear Regulatory Commission
pCi/L	picocurie(s) per liter
PMP	probable maximum precipitation
POC	point of compliance
POE	point of exposure
TDS	total dissolved solids
UMTRCA	Uranium Mill Tailings Radiation Control Act
USC	*United States Code*
WDEQ	Wyoming Department of Environmental Quality
WNI	Western Nuclear Incorporated

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1.0 Introduction

1.1 Purpose

This Long-Term Surveillance Plan (LTSP) explains how the U.S. Department of Energy (DOE) will fulfill general license requirements of Title 10 *Code of Federal Regulations* Part 40.28 (10 CFR 40.28) as the long-term custodian of the Split Rock disposal site (formerly known as the Western Nuclear Incorporated [WNI] Split Rock uranium mill tailings disposal site) in Fremont County, Wyoming. DOE is responsible for preparing, revising, and implementing this LTSP, which specifies procedures for inspections, monitoring, maintenance, 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 (Title 42 *United States Code* Section 7901 [42 USC §7901] as amended, provides for the remediation (or reclamation) and regulation of uranium mill tailings regulated under Title I and Title II of UMTRCA. Title I addresses former uranium mill sites that were unlicensed as of January 1, 1978, and essentially abandoned. Title II addresses uranium-milling sites under specific license as of January 1, 1978. In both cases, the licensing agency is the U.S. Nuclear Regulatory Commission (NRC), or in the case of certain Title II disposal sites, an Agreement State. The Split Rock disposal site is regulated under Title II of UMTRCA. The State of Wyoming is not an Agreement State.

Federal regulations at 10 CFR 40.28 provide for the licensing, custody, and long-term care of uranium and thorium mill tailings sites closed (reclaimed) under Title II of UMTRCA.

A general license (10 CFR 40.28) is issued by NRC for custody and long-term care—including monitoring, maintenance, and emergency measures—necessary to ensure that uranium and thorium mill tailings disposal sites will be managed in a manner that protects public health, safety, and the environment after closure (completion of reclamation activities).

The general license becomes effective when NRC or an Agreement State approves the site reclamation and terminates the specific license, and when NRC accepts a site-specific LTSP (such as this document). The long-term custodian will implement site surveillance and provide care for the site in accordance with provisions of the LTSP.

In accordance with the general license, specific information is required to be included in the LTSP (10 CFR 40.28 [b][1] – [b][5]), along with other long-term custodian requirements (10 CFR 40.28 [c][1] – [c][5]). These general license requirements for the Split Rock disposal site are addressed in various sections of the LTSP (Table 1).

The plans, procedures, and specifications in this 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). The rationale and procedures presented in the guidance document are considered part of this LTSP.

Table 1. General License Requirements for the Split Rock Disposal Site

10 CFR 40.28 (b) Requirements		
	Requirement	*LTSP Section*
1.	Description of final site conditions	Section 2.0
2.	Legal description of the site	Appendix A
3.	Description of the long-term surveillance program	Section 3.0
4.	Criteria for follow-up inspections	Section 3.5.1
5.	Criteria for routine site maintenance and emergency measures	Section 3.6.3
10 CFR 40.28 (c) Requirements		
	Requirement	*LTSP Section*
1.	Implementation of the LTSP	Section 1.2
2.	Care for the site in accordance with provisions of the LTSP	Section 1.2
3.	Notification to NRC of any changes to the LTSP	Section 3.1
4.	Guarantee NRC permanent right-of-entry	Section 3.1
5.	Notification to NRC of significant construction, actions, or repairs at the site.	Sections 3.5 and 3.6

1.3 Role of the U.S. Department of Energy

The DOE Office of Legacy Management (LM) is the program office responsible for managing the long-term surveillance and maintenance (LTS&M) of DOE disposal sites that contain regulated low-level radioactive materials and portions of sites that do not have a DOE mission after cleanup, as well as other sites (including Title II sites) as assigned, and to establish a common office for the security, surveillance, monitoring, and maintenance of those sites.

The LM mission includes "...implementing long-term surveillance and maintenance at sites to ensure sustainable protection of human health and the environment." LM is responsible for implementing this LTSP after it is accepted by NRC and the site becomes regulated under the general license.

According to the objectives of DOE Order 450.1A, *Environmental Protection Program*, or current guidance, DOE sites must implement sound stewardship practices protective of the air, water, land and other natural and cultural resources potentially affected by their operations. DOE Order 450.1A requires DOE sites to have an environmental management system (EMS) to implement these practices. The LM EMS incorporates federal mandates specified in Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* and DOE Order 430.2B, *Departmental Energy Renewable Energy and Transportation Management*.

2.0 Final Site Conditions

Decommissioning and reclamation of the former WNI Split Rock mill facility in Jeffrey City, Wyoming, began in 1988 and was completed in 2007 when the final evaporation pond was reclaimed in accordance with the NRC approved reclamation plan. During reclamation activities mill facilities were decommissioned and demolished, windblown tailings and contaminated topsoil were removed and placed in the tailings impoundment, the tailings impoundment was covered, and groundwater corrective actions were completed. Most of this information is reported in the site reclamation construction completion report (Shepherd Miller 1999a).

2.1 Site History

WNI milled uranium ore at the Split Rock site from 1957 through 1981 under NRC source materials license number SUA-56. In 1981 the mill was placed on standby status and in 1986 it was placed in possession-only status and the license was amended to complete tailings disposal. Decommissioning and demolition commenced in 1988 (Shepherd Miller 1999b). Most of the ore for the mill came from open pit mine operations in the Gas Hills district, approximately 20 miles north of the mill site. Other ore supplies came from underground mining operations in the Crooks Gap area, approximately 12 miles south of the mill site (Merritt 1971). The Split Rock mill was an acid-leach, ion-exchange, and solvent-extraction operation that processed approximately 7.7 million tons of ore from 1957 to 1981 with a uranium extraction rate of approximately 95 percent. The facility, originally designed to process 400 tons of ore per day, underwent two capacity upgrades; by 1967 the milling capacity had been increased to 1,200 tons per day and by the 1970s the capacity had reached 1,700 tons per day (Shepherd Miller 1999b).

During the milling period, process waste in the form of tailings solids and acidic liquids were discharged to the unlined tailings disposal areas. These tailings disposal areas or ponds were designed in 1957 when the design philosophy was to eliminate process effluent through seepage, thereby maximizing solid tailings storage while decreasing water storage and handling requirements. Waste estimates at the peak of milling indicated a ratio of 5 parts process effluent to 1 part solids were being discharged to the disposal areas. A total of approximately 7.7 million tons of tailings and billions of gallons of process effluent were deposited into three primary tailings disposal areas, known as the Main, Old, and Alternate Tailings Impoundments, that were used during the operational life of the mill (Shepherd Miller 1999b).

Groundwater corrective action at the site began in 1990 with the extraction of contaminated groundwater in the area directly downgradient of the tailings impoundment. Recovered groundwater was piped to an evaporation pond and then to an evaporation misting system (Shepherd Miller 1999b). The primary purpose of the system was to accelerate dewatering of the tailings impoundment, with an ultimate goal of achieving background concentrations in the groundwater. In 1999 this was determined to be unachievable and alternate concentration limits (ACLs) were applied for and subsequently approved in 2006 by the NRC. The groundwater corrective action program was terminated in 2006 after removing a total of 375.3 million gallons of groundwater. Additional information regarding groundwater corrective action is provided in Section 2.5.3.

In 2007, reclamation of the Split Rock site was considered complete when NRC approved the reclamation of the final evaporation pond that had been used for groundwater corrective action.

2.2 General Description of the Disposal Site Vicinity

The Split Rock disposal site is located approximately 2 miles northeast of Jeffrey City in Fremont County, Wyoming, and about 58 miles east southeast of Lander, Wyoming (Figure 1). The site lies in the high plains of central Wyoming and encompasses approximately 3,868 acres (Figure 2). The site elevation ranges from a low of about 6,300 feet (ft) to a high of about 6,800 ft (Figure 3). Topographically the disposal cell itself lies at the base of a saddle between two of the granite peaks located on site. At the northern boundary of the site property is the Sweetwater River (NRC 1980).

The climate of the Jeffrey City area is semi-arid, with average annual precipitation of approximately 11 inches. More than 40 percent of the annual precipitation occurs during the months of April, May, and June in the form of wet snow and rain. The average annual snowfall is approximately 52 inches. The average annual temperature in this region is 42 °F, with the average monthly temperatures ranging from a low of 15 °F in January to a high of 66 °F in July. The prevailing wind direction is from the west to southwest, with maximum wind speeds exceeding 60 miles per hour (mph) and monthly averages ranging from 10 to 17 mph. Net evaporation at the site averages approximately 36 inches per year (Shepherd Miller 1999b).

The primary land uses in the immediate surrounding vicinity are cattle ranching, recreation, and wildlife habitat. Mineral exploration and oil and gas development also occurs in the surrounding area. Jeffrey City, the former mill town with a current population of 64 (2009 estimate), lies directly southwest of the site.

2.3 Disposal Site Description

2.3.1 Site Ownership

Upon completion of reclamation work and acceptance of the site under the NRC general license, the Split Rock disposal site was transferred to the U.S. Government for custody and long-term care; DOE assumed this responsibility for the federal government.

The area within the Split Rock disposal site's long-term care boundary is 3,868 acres. Of the 3,868-acres within the long-term care boundary, 3077 acres are owned by the federal government, i.e., 645 acres were withdrawn from the Bureau of Land Management (BLM) (in process) and 2,432 acres were obtained in fee from WNI (in process). The remaining 791 acres of land within the long-term care boundary are privately owned and subject to groundwater use restrictive covenants.

Supporting real estate information is presented in Appendix A, which includes copies of the following:

- Legal description for the disposal site property.
- Warranty deed.
- Public Land Order Notice of Permanent Withdrawal (Transfer of Public Land for the Gas Hills East, Wyoming, Uranium Repository).

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- Institutional controls (ICs) restricting groundwater use on privately held lands within the long-term care boundary (i.e., restrictive covenants).
- Pre-Transition Land Ownership and Restrictive Covenants Map (Figure A-1).

Access to the disposal site is from the west by way of an unpaved county road (referred to as the "Ore Road" that leads north out of Jeffrey City, Wyoming; see below for directions to the site).

2.3.2 Directions to the Disposal Site

From Casper, Wyoming, travel southwest on State Highway 220 approximately 75 miles to Muddy Gap Junction (Figure 1). At Muddy Gap Junction turn west on U. S. Highway 287 and travel 23 miles to Jeffrey City. At Jeffrey City turn north on the county road (referred to locally as Ore Road) and travel 2 miles to the site entrance, located on the east side of the road.

Alternatively from Lander, Wyoming, travel southeast on U.S. Highway 287 for 9 miles to the junction with State Highway 28 (Figure 1). Turn left and continue on U.S. Highway 287 for 30 miles to Jeffrey City, then turn north on Ore Road for 2 miles to the disposal site as described above.

2.3.3 Description of Surface Conditions

The land surface of the disposal cell area at the Split Rock site was reclaimed to achieve gentle topography with a series of diversion channels that distribute storm water away from the reclaimed tailings impoundment. The final surface at the site combines grading and rock armoring to achieve the necessary surface water run-on and run-off control and erosion protection to satisfy the longevity design requirements. Although not required by the NRC-approved reclamation plan, all areas of the site disturbed by construction, with the exception of the disposal cell, were revegetated (Shepherd Miller 1999b). The surface configuration and topography for the site are presented on Figure 2 and Figure 3, respectively.

The reclaimed tailings impoundment, or disposal cell, is an irregular shaped area of approximately 265 acres that lies between granite outcrops to the north, south, and east. On the west side a granite outcrop splits the reclaimed impoundment to form two lobes, one which protrudes to the northwest of the outcrop and one which protrudes to the southwest of the outcrop. The erosion protection for the surface of the tailings impoundment consists primarily of rock mulch.

Four diversion channels, known as the North Diversion Channel, the South Diversion Channel, the North Central Diversion Channel, and the South Central Diversion Channel, were designed and constructed to divert stormwater flood flows away from the tailings impoundment. The diversion channels were armored with riprap for erosion protection (Shepherd Miller 1999a). Additional information regarding the tailings impoundment design, including the storm water diversion system, is provided in Section 2.4.

There are ten long-term monitoring wells and one livestock well located within the Split Rock site's long-term care boundary. The Sweetwater River bounds the site on the north. Portions of the site property are enclosed by a barbed-wire stock fence to manage local livestock.

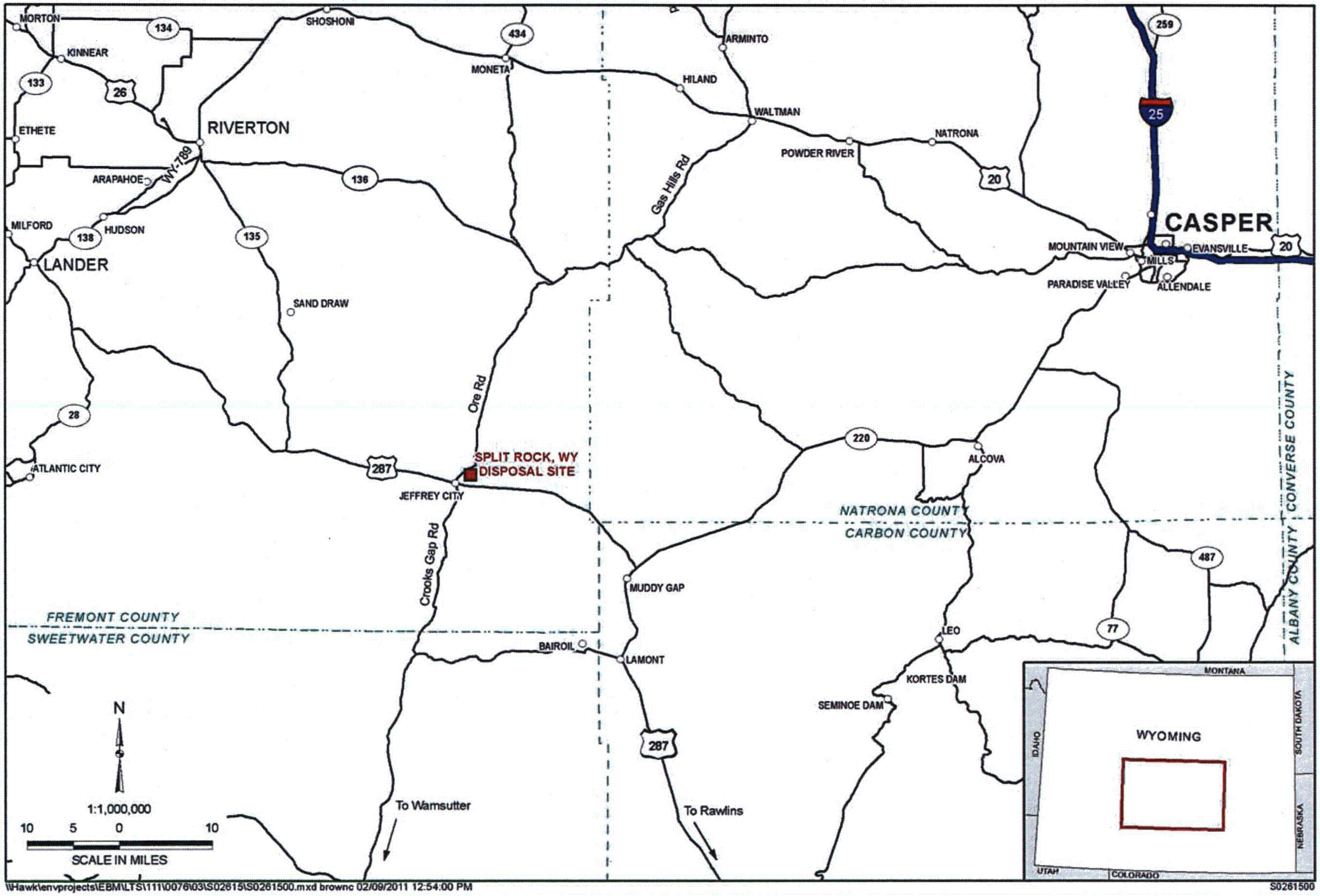

Figure 1. General Location Map of the Split Rock, Wyoming, Disposal Site

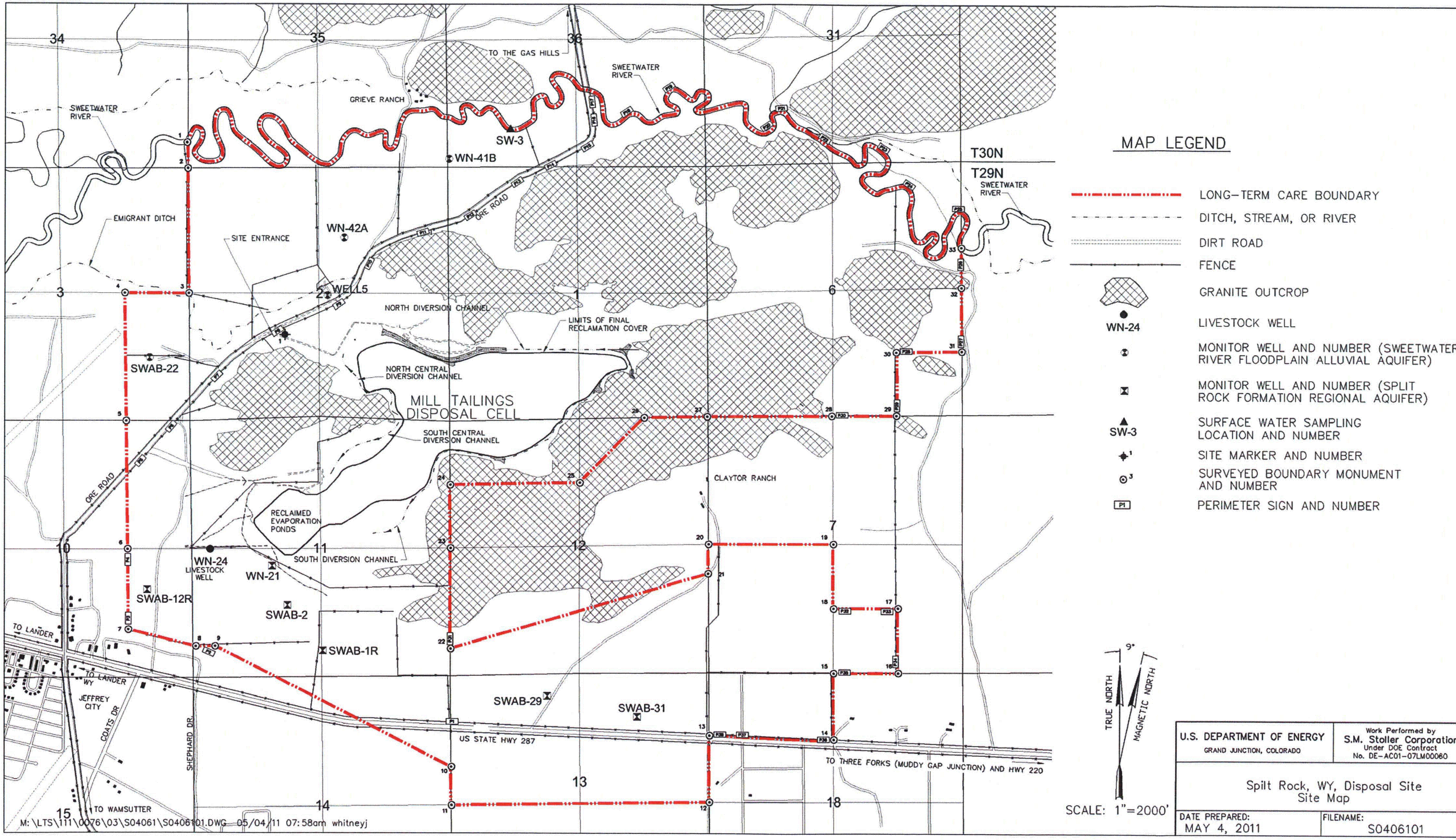

Figure 2. Split Rock, Wyoming, Disposal Site Map

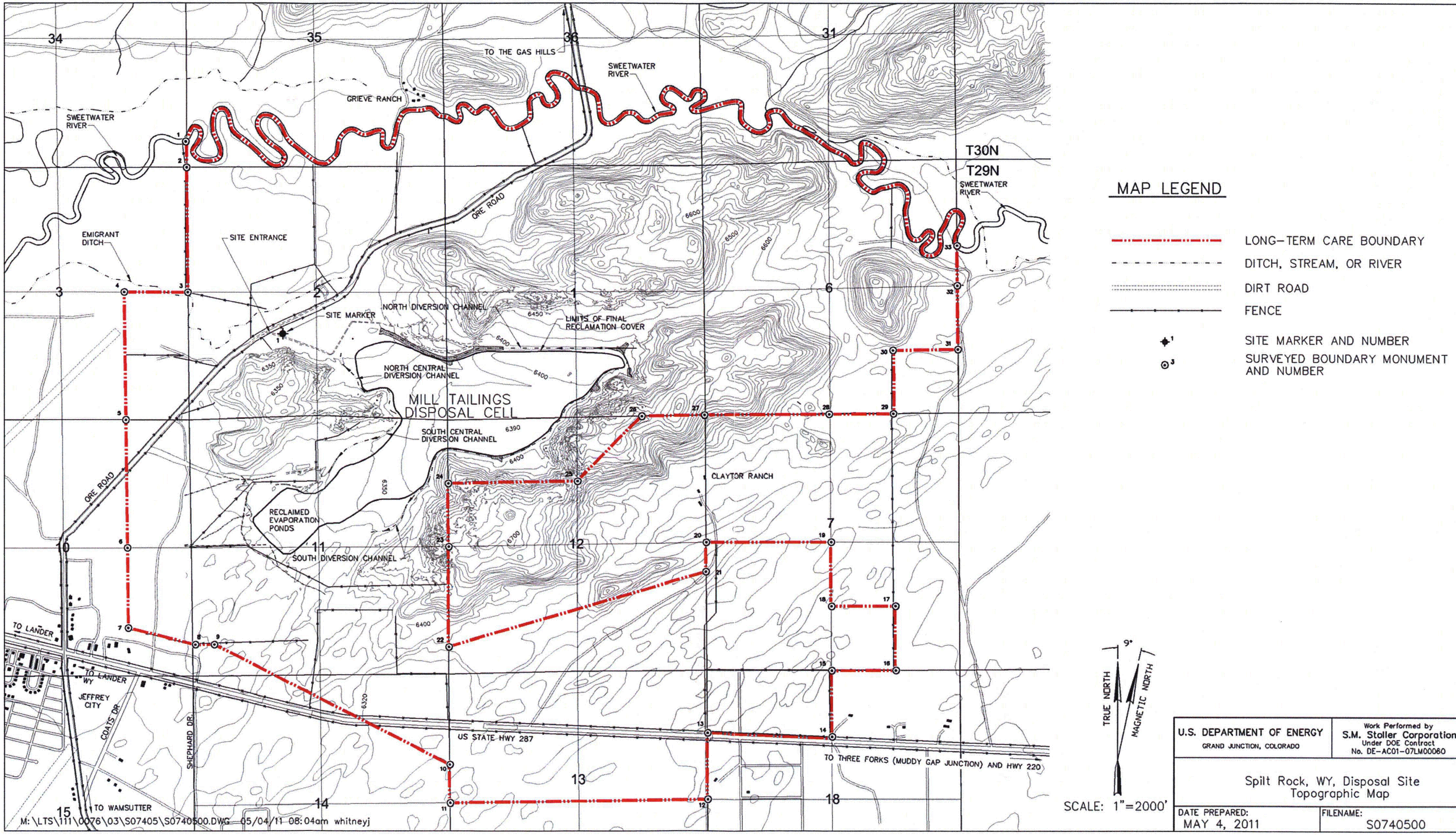

Figure 3. Split Rock, Wyoming, Disposal Site Topographic Map

2.3.4 Permanent Site Surveillance Features

Survey boundary monuments, a site marker, and posted perimeter warning signs are the permanent surveillance features at the Split Rock disposal site. These features will be inspected and maintained as necessary as part of the passive ICs for the site.

Thirty-three survey boundary monuments mark the final long-term care boundary on the west, south, and east sides of the site. The centerline of the meandering course of the Sweetwater River defines the site's northern boundary.

One unpolished granite marker with an incised message identifying the site of the Split Rock disposal area is placed just inside the main entrance gate adjacent to the county road on the western portion of the site where a person entering the property would likely discover it. The message on the granite site marker is shown on Figure 4.

A perimeter warning sign displaying the DOE 24-hour telephone number (Figure 5) was placed near the entrance to the site. Thirty-seven additional perimeter warning signs were placed around the perimeter of the site at locations where access to the site is most likely to occur.

The locations of the permanent site surveillance features are shown on Figure 2.

2.4 Tailings Impoundment Design

The tailings impoundment at the Split Rock site is located in two alluvial valleys, known as the Northwest Valley and the Southwest Valley, situated between surrounding granite outcrops. The final impoundment combines the three former tailings disposal areas (known as the Main, Old, and Alternate Tailings Impoundments) that had been in use at various times over the 1958 to 1981 operating period (Shepherd Miller 1999b).

By the end of operations the three former disposal areas encompassed approximately 180 acres and contained approximately 7.7 million tons of tailings. An estimated 1.67 million pounds of uranium were deposited into the tailings impoundments (based on the processing mill achieving a uranium extraction rate of approximately 95 percent). In 1999, it was estimated that 36 percent of the deposited uranium remained in the tailings impoundment while the other 64 percent had migrated out of the impoundment. There is also an estimated 2,750 curies of radioactivity (based on the activity of radium-226). Billions of gallons of process effluent were also discharged into these tailings disposal areas over the 24 years of milling operations. The maximum thickness of the tailings deposited into these disposal areas was approximately 80 ft (Shepherd Miller 1999b).

Decommissioning and demolition of the mill was conducted in 1988. Contaminated materials from the mill were crushed or cut into smaller pieces and buried in the tailings impoundment. Dissipation of standing water in the tailings impoundment began in 1982 and was completed in 1989. Standing water was evaporated with the use of sprinklers, an enhanced mist evaporation system, and an enhanced spray evaporation system (Shepherd Miller 1999a).

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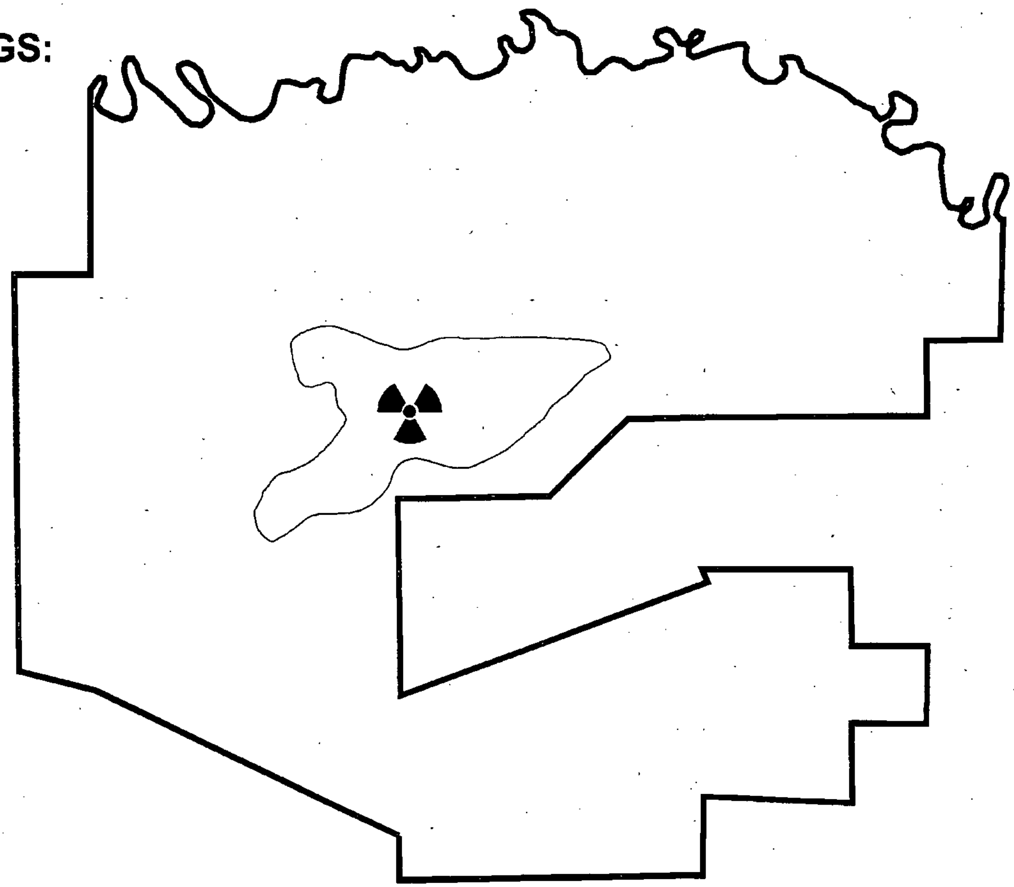
SPLIT ROCK, WYOMING

DATE OF CLOSURE: OCTOBER 2006

TONS OF TAILINGS: 7,700,000

RADIOACTIVITY: 2,750 Ci RA-226



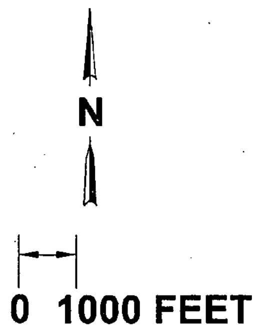


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Figure 4. Site Marker at the Split Rock, Wyoming, Disposal Site

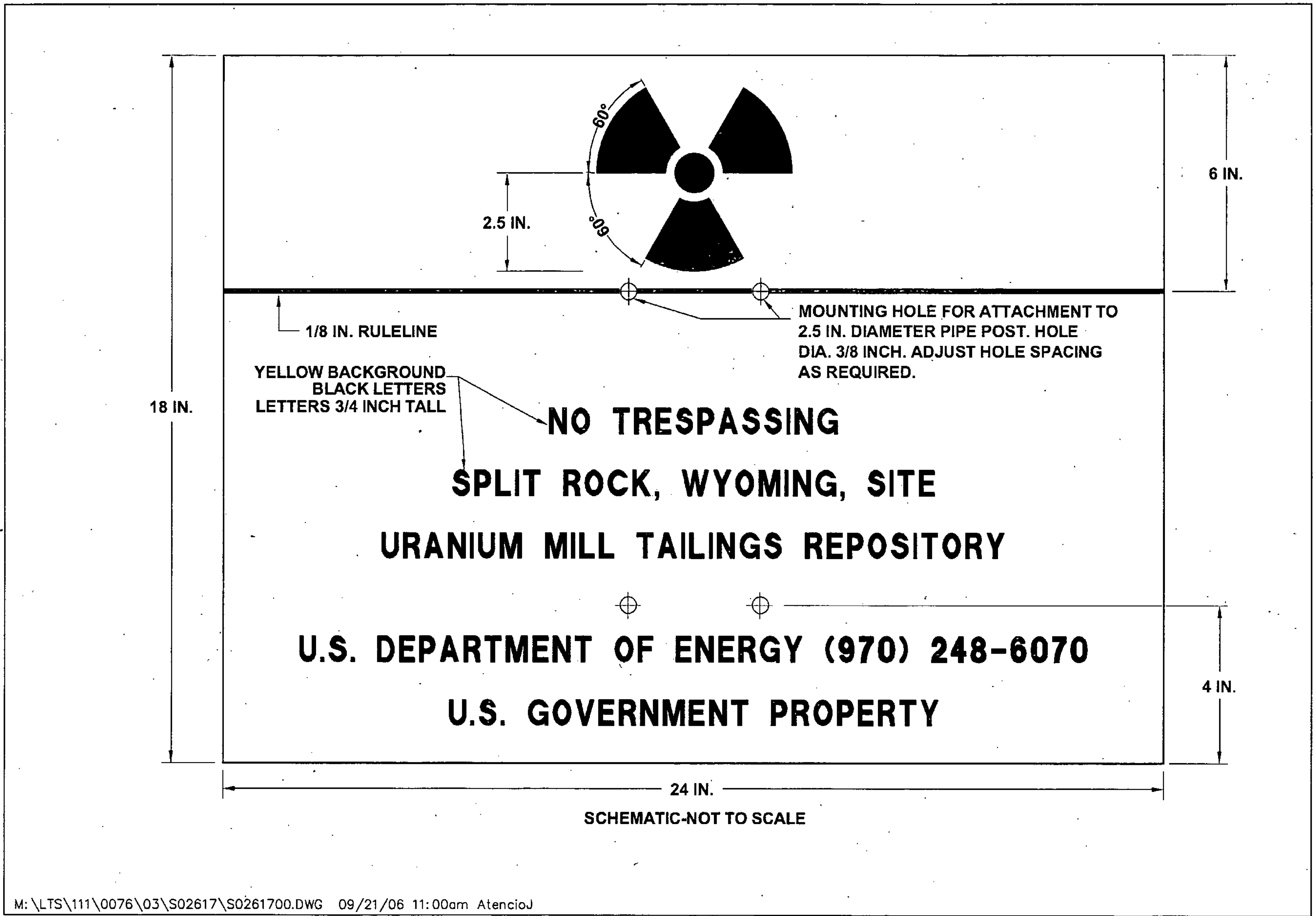

Figure 5. Warning Sign at Split Rock, Wyoming, Disposal Site

Regrading and reshaping of the tailings began in 1990. This included the placement of coarse tailings over fine tailings, and the retrieval and disposal of windblown and contaminated soils from outside the impoundment area. Borrow soils were placed over the regraded tailings to achieve the desired final reclamation subgrade. Vertical band drains (wicks) were installed in 1992 to accelerate settlement and dewatering of the tailings impoundment. Primary settlement was complete in 1996 (Shepherd Miller 1999a).

The radon barrier material selected for the Split Rock site was Cody Shale. Material that met design requirements was transported to the site and moisture-conditioned for use in the radon barrier. Rock used as erosion protection material came from an on-site granite source on the north side of the tailings impoundment (Shepherd Miller 1999a).

2.4.1 Encapsulation Design

The objective of the tailings impoundment cover is long-term isolation of the uranium mill tailings from the surrounding environment. This is accomplished by reducing radon gas emission rates to below the regulatory standard of 20 picocuries per square meter per second, minimizing infiltration of precipitation that could potentially leach contaminants into the subsurface, and physically containing the contaminated materials to prevent dispersion caused by erosion.

An interim cover was placed over both the regraded tailings and the former mill area in order to minimize the potential for windblown dispersal of the tailings and contaminated materials until the final cover was installed. The interim cover consisted of compacted borrow soil placed at a thickness which varied from between 1 and 2 ft. No credit was taken for any radon attenuation afforded by the interim cover when determining design specifications of the final cover for controlling radon gas emissions (Shepherd Miller 1999a).

The final reclamation cover consists of a radon barrier layer, a borrow soil layer, and a rock mulch layer (or soil/rock matrix layer in some areas) for erosion protection. The radon barrier was placed on top of a 4-inch sacrificial clay layer that was used to establish the final desired subgrade on top of the tailings. The radon barrier thickness varies from 6-inches to 45-inches depending on the radium content of the tailings in the area being covered. The borrow soil layer thickness varies from 8 to 15 inches. The erosion protection layer consists of either a 4-inch thick rock layer overlain by a 2-inch thick soil layer (i.e., a soil/rock matrix) or just a 4-inch thick rock layer (i.e., without the overlain soil component) (Note: Following the first year of construction, NRC approved WNI's request to discontinue the application of the soil component of the soil/rock matrix; the northwest lobe of the cell includes a soil/rock matrix for erosion protection, the remaining portion of the cell consists of only a 4-inch thick rock layer for erosion protection). The median stone diameter (D_{50}) of the granite rock used for erosion protection was 2 inches. Rock with a D_{50} of 3 inches was required for a small area in the northwest portion of the tailings impoundment and rock with a D_{50} of 6 inches was required for the tailings area east and south of the North Diversion Channel. The 3 and 6-inch rock size layers were 4 inches and 12 inches thick, respectively (Shepherd Miller 1999a).

A typical cross-section of the final cover for the tailings impoundment is shown on Figure 6.

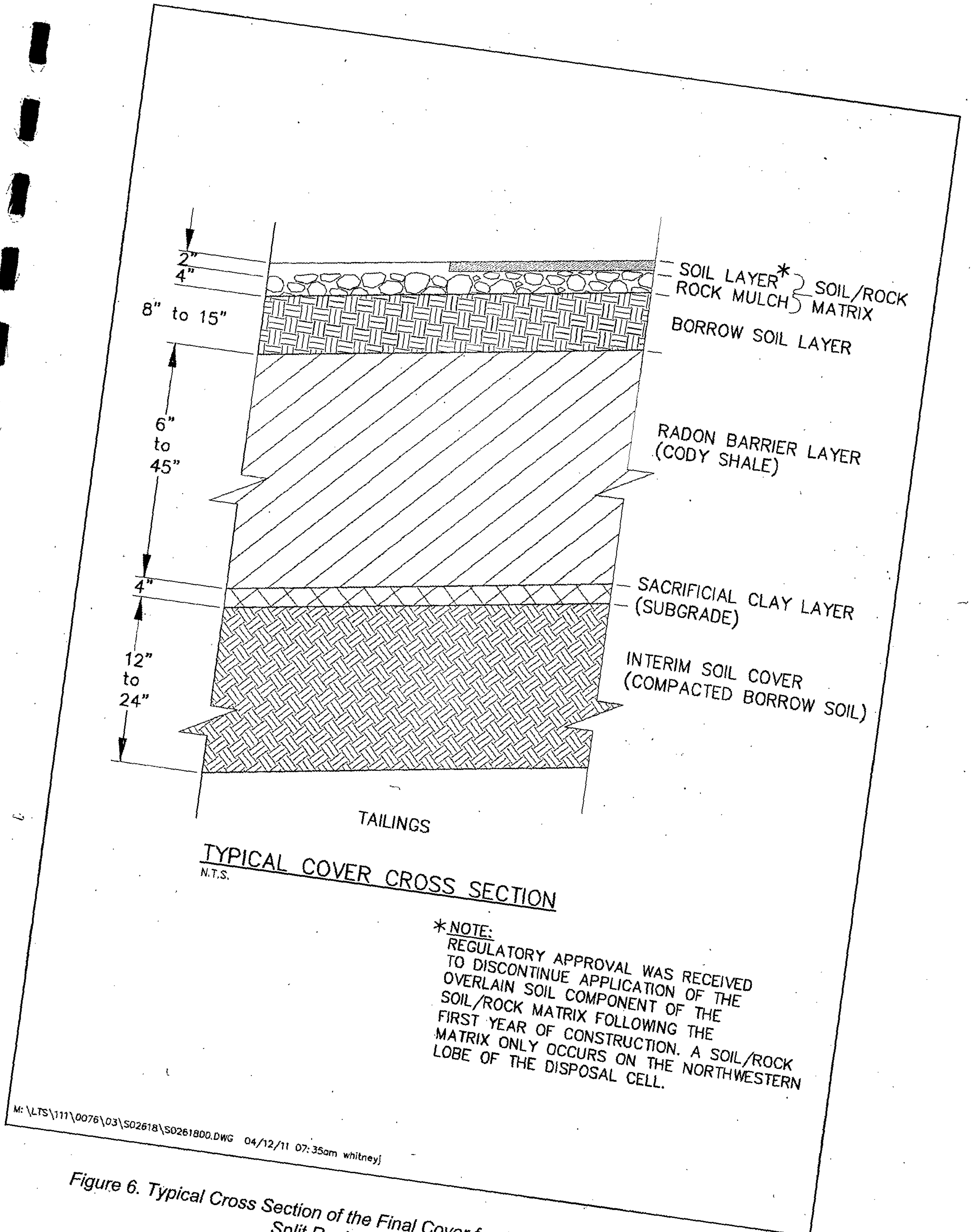

Figure 6. Typical Cross Section of the Final Cover for the Tailings Impoundment at the Split Rock, Wyoming, Disposal Site

Deep-rooted vegetation has been allowed to established on the tailings impoundment before transition of the site to DOE. The vegetation could change the performance of the disposal cell cover as designed (see Appendix B for additional information regarding potential impacts to low-permeability covers). Maintenance of deep-rooted vegetation on the tailings impoundment is discussed in Section 3.6.2.

2.4.2 Storm Water Diversion System

A site-wide grading plan was developed to determine the final grades and diversion structures that would be used to control surface water flows from impacting the disposal area. The final grade established for the site forms the basis of the surface water diversion system. The storm water diversion system for the site consists of four diversion ditches; the North Diversion Channel, the South Diversion Channel, the North Central Diversion Channel, and the South Central Diversion Channel (Figure 2). In addition, a riprap lined swale was constructed on top of the reclaimed tailings impoundment to direct flood flows into the North Diversion Channel. Riprapped erosion aprons and scour trenches were constructed at the outlets of all the diversion ditches to prevent head cutting and long-term erosion. The purpose of all these features is to convey surface water runoff away from and off of the reclaimed tailings impoundment.

To prevent erosion, each diversion channel was lined with a layer of riprap placed over one or two filter layers depending on the D_{50} size of the riprap. The as-built D_{50} of the riprap varied from 3 inches to 18 inches, depending upon the estimated flow velocities, and the riprap layer thickness varied from 6 inches to 27.5 inches.

The North Diversion Channel intercepts flow coming from the higher terrain north and east of the tailings impoundment and conveys it to the northwest. The South Diversion Channel intercepts flow coming from the higher terrain south of the tailings impoundment and conveys it to the southwest.

The North Central Diversion Channel and the South Central Diversion Channel protect the impoundment from flows coming from the higher terrain to the west of the impoundment and drain water that flows off the impoundment cover. These channels convey the flow to the northwest and southwest, respectively.

The storm water diversion system is shown on Figure 2.

2.5 Site Geology, Hydrogeology, and Groundwater Conditions

2.5.1 Geology

The Split Rock disposal site is located approximately 2 miles south of the crest of the Granite Mountains in Fremont County, Wyoming. The Granite Mountains are bounded on the north by the Wind River Basin and on the south by the Great Divide Basin. The major structural features in the area surrounding the site are the Granite Mountains Uplift, the North and South Granite Mountains Fault Systems, and the Split Rock Syncline. The movement of these structures over time controlled depositional environments and the resulting stratigraphy at the Split Rock disposal site (Shepherd Miller 1999b).

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The Granite Mountains are a major anticlinal uplift in south-central Wyoming. The exposed Precambrian core trends west-northwest and is about 85 miles long and 30 miles wide. The uplift has a gentle north flank and a steep south and west flank. The mountains remain partly buried by upper Cenozoic sedimentary deposits. The Split Rock site is located within narrow valleys near the crest of the uplift (Shepherd Miller 1999b).

During Miocene time, the southern portion of the Granite Mountains began to subside into the Split Rock Syncline. Simultaneously, an enormous volume of tuffaceous sandstone was deposited across most of Wyoming. These deposits became known as the Split Rock Formation in central Wyoming. The Granite Mountains were largely buried by the sandstones of the Split Rock Formation; only the highest peaks remained exposed. In the area of the Split Rock site, the Split Rock Formation lies directly on the Precambrian granite (Shepherd Miller 1999b).

A regional uplift event began in late Pliocene time, beginning the present cycle of erosion in most of central Wyoming that has resulted in the crest of the buried mountains being exposed to a maximum height of approximately 1,000 feet in the area. The easterly course of the Sweetwater River was also established at this time along the trough line of the Split Rock Syncline. During Pleistocene time, as the climate became more arid, wind erosion increased, scooping out some undrained depressions in the exposed sandstone of the Split Rock Formation in and around the protruding granite knobs. The Sweetwater River's reduced flow and low channel gradient now allows transport and deposition of sand, silt, and clay.

A stratigraphic column for the Split Rock site area is shown on Figure 7.

2.5.2 Regional Hydrogeology

There are two geologic units that occur within the area of the site that yield significant quantities of groundwater and have distinct baseline groundwater quality characteristics: Quaternary deposits (Sweetwater River floodplain alluvium) and Miocene rocks (Split Rock Formation). On a regional basis the Sweetwater River floodplain alluvial aquifer is a minor component to the overall hydraulic system, whereas, the Split Rock Formation covers an area of approximately 1,500 square miles and its aquifer contains potentially large supplies of groundwater. Reported yields from wells completed in the Split Rock aquifer range from 3 to 1,100 gallons per minute (Shepherd Miller 1999b).

The Split Rock Formation aquifer is considered the regional aquifer and is divided into two hydrostratigraphic units referred to as the Upper Split Rock Unit and the Lower Split Rock Unit due to distinct lithologic and geologic characteristics, though they are hydraulically similar. Both regional and local groundwater flows, when forced up against the granite formation, move upward, creating an upward vertical gradient (Shepherd Miller 1999b).

The saturated thickness of the regional Split Rock Formation aquifer ranges from approximately 500 to 3,000 ft south of the Sweetwater River to 200 to 600 ft north of the river. The areas of greatest thickness are along the axis of the Split Rock Syncline, south of the site. The thickness can be much less where it comes up against the granite outcrops, as is the case in the area of the tailings impoundment. In the two valleys between the granite outcrops where the tailings impoundment was constructed, the thickness of the Split Rock Formation varies from 0 to 150 ft in the upper portion of the valleys to more than 500 ft at the mouth of the southwestern valley and approximately 330 ft at the mouth of the northwestern valley (Shepherd Miller 1999b).

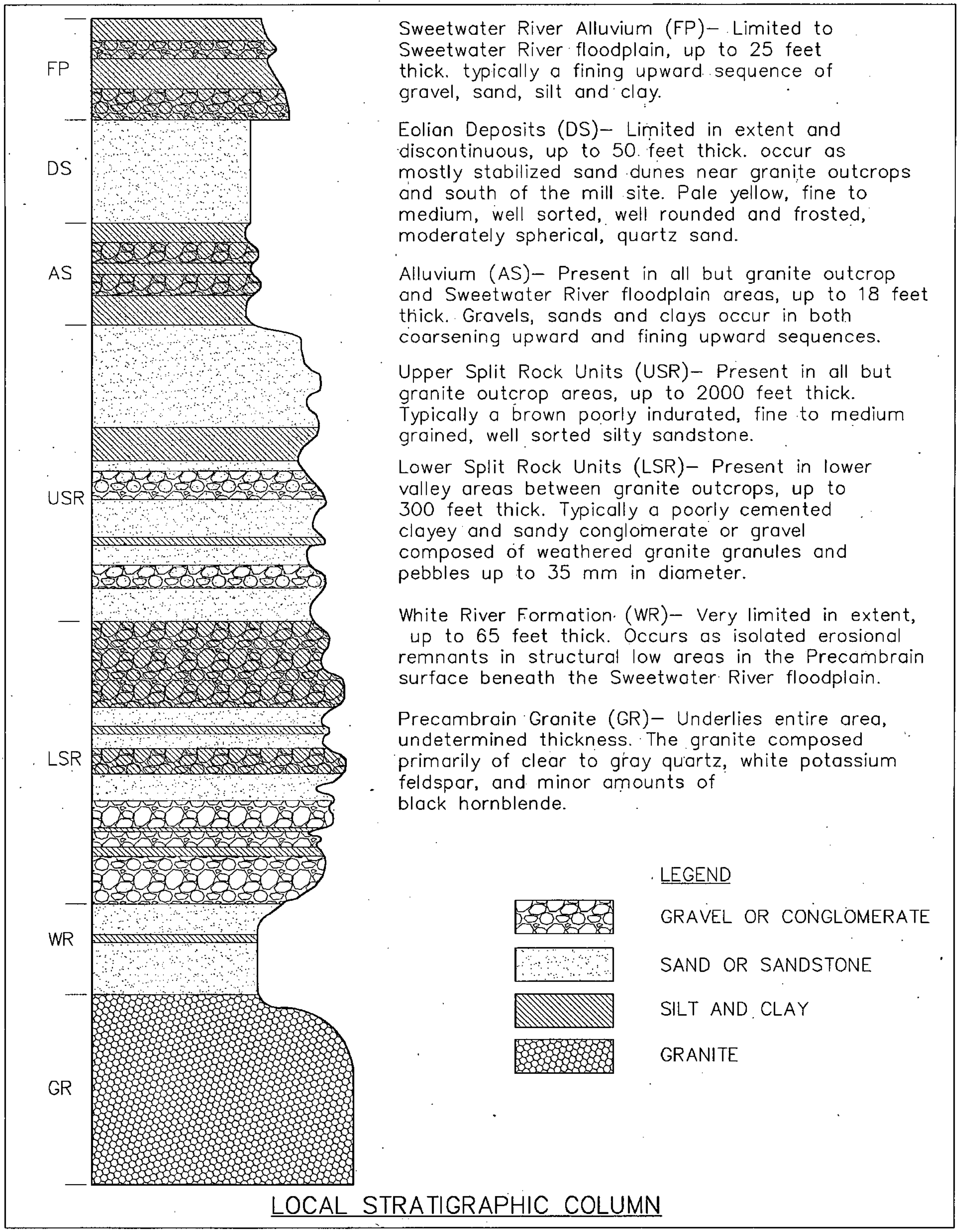

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Figure 7. Partial Stratigraphic Column of the Split Rock, Wyoming, Disposal Site

Hydrogeologic characteristics for the various aquifers (or aquifer units) at or near the site are provided in Table 2.

Table 2. Aquifer Hydrogeologic Characteristics for the Split Rock, Wyoming, Disposal Site

Unit	Hydraulic Conductivity (ft/day)	Transmissivity (ft^2/day)	Storativity
Upper Split Rock	19	2,337	0.021
Lower Split Rock	6.6	1,153	0.003
Floodplain	248	4,185	0.21
Alluvial deposits	9.8	710	0.005

Data Source; Letter from NRC to Western Nuclear Incorporated, Re: License Amendment 105, *Approving Request to Modify Groundwater Protection Standards*, Source Material License SUA-56, Western Nuclear Incorporated, Split Rock Site, Jeffrey City, Wyoming, February 24, 2010.

The movement of groundwater in the Sweetwater Basin is controlled by the location of recharge and discharge areas, by the thickness, gradient, and hydraulic conductivity of the geologic units, and by the location of impermeable and relatively impermeable units. Both the alluvial and regional aquifers discharge to the Sweetwater River that defines the site's northern boundary. The Sweetwater River is reported to gain approximately 17 cubic feet per second between the gaging station near Sweetwater Station (approximately 11 miles upstream of the site) and the gaging station near Alcova (approximately 40 miles downstream of the site). However, reported discharge measurements indicate that the Sweetwater River loses water in the middle portion of this stretch from Alkali Creek to Jeffrey City and then returns to gaining water from Jeffrey City to Alcova (Shepherd Miller 1999b).

The general direction of groundwater movement in the regional Split Rock Formation aquifer (within the Sweetwater Basin) is to the east and northeast, toward and in the direction of flow within the Sweetwater River (additional information regarding the localized groundwater flow direction at the site is provided below in Section 2.5.3). Uplifts along the southern boundary of the basin, including the Green Mountains and the Ferris Mountains, serve as recharge areas. Deep recharge near the site also occurs from direct precipitation and from precipitation runoff from the surrounding granite hillsides (Shepherd Miller 1999b).

Where the Sweetwater River has meandered through the valleys between the granite outcrops it has left deposits of sand, silt, and clay river sediments ranging from approximately 15 to 30 ft in thickness over the Split Rock Formation. The floodplain alluvial aquifer occurs within these river sediments (Shepherd Miller 1999b). This shallow floodplain alluvial aquifer is hydrologically connected to the underlying regional Split Rock Formation aquifer and is highly permeable (Shepherd Miller 1999b).

2.5.3 Local Groundwater Conditions

The reclaimed tailings area at the Split Rock disposal site is located at the head of a natural drainage that is bounded by steep granite outcrops located to the north and the south of the tailings impoundment. Toward the outlet of this drainage, an additional granite outcrop separates the flow into two valleys that are referred to as the Northwest Valley and the Southwest Valley. Drainage from the Northwest Valley intersects the alluvial floodplain aquifer of the Sweetwater

River, while drainage from the Southwest Valley intersects a plain of alluvial deposits in the regional Split Rock aquifer (Shepherd Miller 1999b).

Horizontal groundwater flow gradients are directed out of the area of high elevation that surrounds the tailings impoundment and toward either the Northwest Valley or Southwest Valley. Groundwater in the Upper Split Rock unit underlying the tailings impoundment is primarily directed down the Northwest Valley (90 percent of the flow), with the balance of the flow (10 percent) directed down the Southwest Valley. This split in the flow is due to the presence of a subsurface granite high located at the head of the Southwest Valley and directly west of the tailings impoundment. Outside of either valley groundwater flowing from the tailings impoundment area merges with the east northeast trending regional groundwater flow of the Split Rock aquifer. An upward vertical gradient occurs in the groundwater of the regional Split Rock aquifer in this area due to the presence of the granite outcrops. This upward vertical gradient results in seepage from the tailings impoundments occurring primarily within the groundwater of the Upper Split Rock Unit in this area (Shepherd Miller 1999b).

Groundwater flow (100 percent) exiting the Northwest Valley merges with the regional groundwater flow of the Split Rock aquifer that is entering the Sweetwater River floodplain alluvial aquifer. The majority of the groundwater flow (80 percent) exiting the Southwest Valley merges with the east northeast trending regional groundwater flow of the Split Rock aquifer. This flow continues along the southern edge of the granite outcrops directly south of the impoundment before migrating beyond the site's eastern boundary where it eventually enters the Sweetwater River floodplain alluvial aquifer. The balance (20 percent) of the groundwater exiting the Southwest Valley flows to the north around the granite outcrops west of the impoundment where it joins the east northeast trending regional groundwater flow of the Split Rock aquifer that is merging with the east flowing groundwater of the Sweetwater River floodplain alluvial aquifer. All groundwater in the immediate area of the tailings impoundment eventually discharges to the Sweetwater River. Groundwater exiting the Northwest Valley reaches the Sweetwater River well before groundwater that exits the Southwest Valley, particularly the majority portion of the flow which travels to the south and joins with the east northeast trending regional groundwater flow of the Split Rock aquifer (Shepherd Miller 1999b). The groundwater flow patterns and affected aquifers are shown on Figure 8 and Figure 9, respectively.

Seepage from the tailings impoundments has impacted the groundwater within the Split Rock Formation (regional aquifer) and the Sweetwater River alluvium (floodplain aquifer) in the area underlying and downgradient of the tailings impoundment. Concentrations of site-related contaminants are typically highest in groundwater at the mouths of both the Northwest Valley and Southwest Valley, directly downgradient of the tailings impoundment. Contaminants (in particular uranium) are typically found at depth in the valleys but not outside the valley mouths. The higher hydraulic conductivity and lateral gradient in the alluvium (as compared to the Split Rock Formation) has allowed for further migration of contaminants in this shallower zone downgradient of the Northwest Valley than it has downgradient of the Southwest Valley. The alluvium may also contain buried channel deposits of coarse-grained material that provides preferred pathways for shallow groundwater flow in the floodplain (Shepherd Miller 1999b).

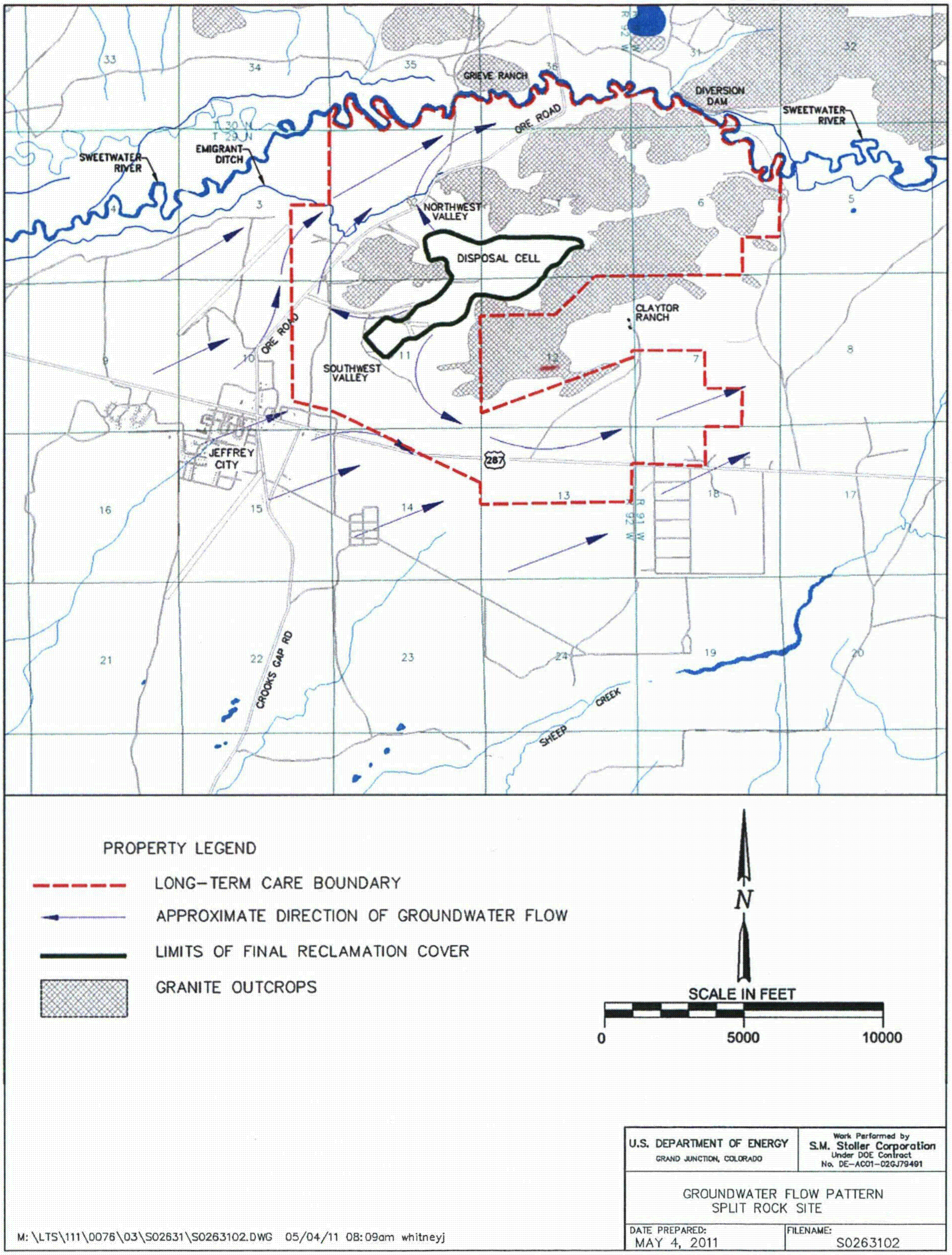

Figure 8. Groundwater Flow Patterns, Split Rock, Wyoming, Disposal Site

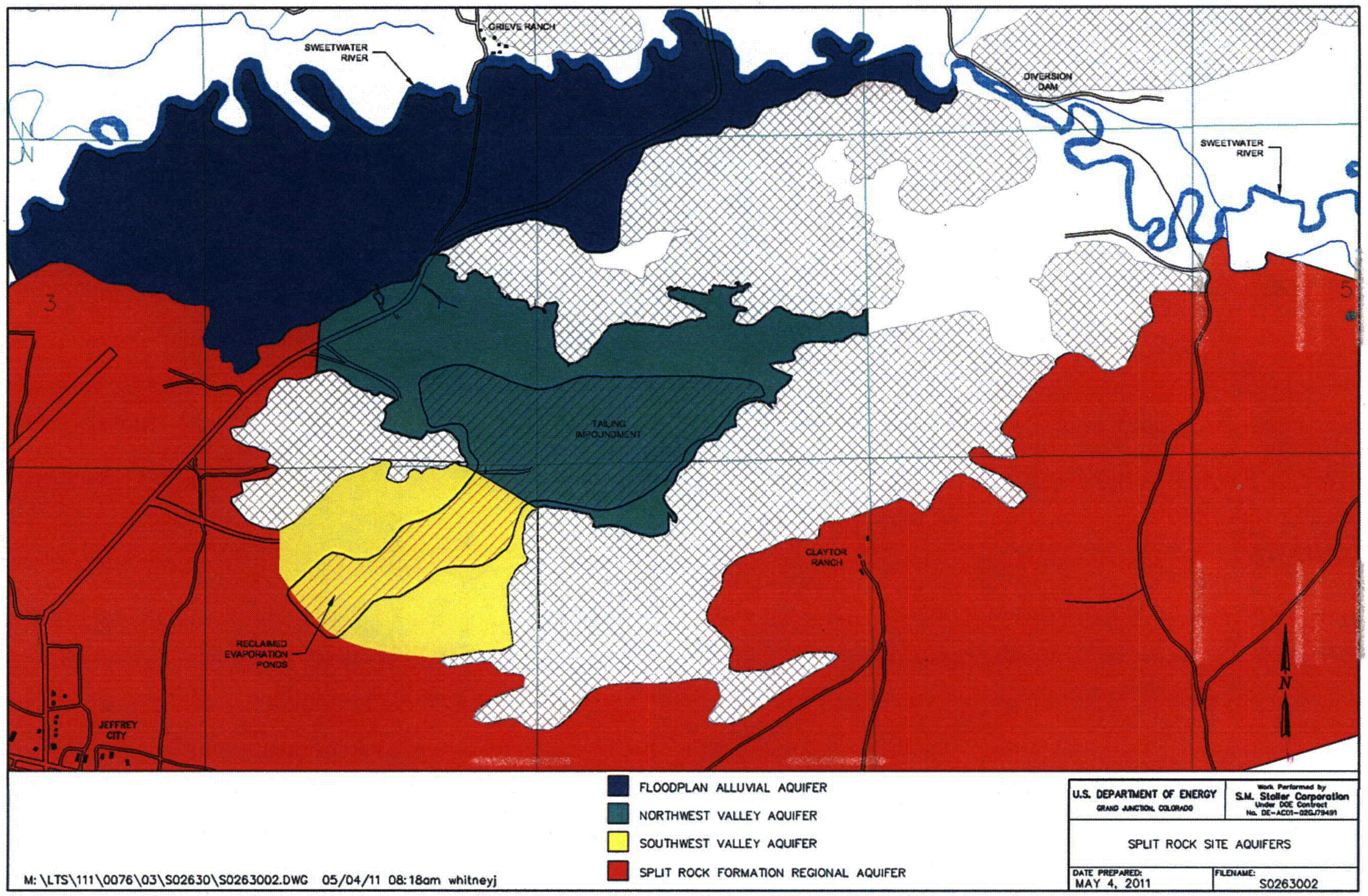

Figure 9. Aquifers in the Vicinity of the Split Rock, Wyoming, Disposal Site

Drainage of the tailings historically input up to 1,400 gallons per minute (gpm) into the underlying groundwater system. Since tailings and water disposal in the impoundments ceased in 1986, drainage into the underlying system has greatly diminished, and the elevated groundwater level (i.e., mound) in the immediate area of the impoundment has largely dissipated. In 1999, tailing seepage rates were estimated to be approximately 150 gpm and expected to reach long-term, steady-state rates of less than 5 gpm in the next 30 years (Shepherd Miller 1999b).

Groundwater near the site is used for drinking water and livestock watering. Most residents of nearby Jeffrey City derive their water supply from municipal wells, which are completed in the regional Split Rock aquifer west of the site. Therefore, these municipal wells are upgradient of the site and unaffected by site-derived contamination. Groundwater beyond the site's long-term care boundary will likely continue to be used for drinking water and livestock watering (NRC 2006a), and is not expected to be impacted from site-related constituents (Shepherd Miller 1999b). The site's long-term care boundary is considered to be the point-of-exposure (POE).

Groundwater within the site long-term care boundary prior to site transition was only used for livestock watering. Although groundwater quality within portions of the site does not meet Wyoming Department of Environmental Quality (WDEQ) Class III livestock standards (i.e., impacted groundwater underlying and directly downgradient of the tailings impoundment), the onsite well used for livestock watering prior to transition (well WN-24, Figure 2) was understood to have produced water that met WDEQ Class III standards (NRC 2006a). Following transition, this water well will likely continue to be used for livestock watering under long-term management of the site, provided its water meets WDEQ Class III livestock standards. Any well within the federally-owned portion of the site that is considered for livestock watering under long-term care will be required to meet WDEQ Class III livestock standards. Agriculture conducted within the long-term care boundary prior to transition was understood to have used surface water obtained from the Sweetwater River (or from a groundwater source outside the long-term care boundary); this is expected to continue as such under long-term care. No groundwater obtained within the federally-owned portion of the site will be considered for agricultural use under long-term management unless it first meets WDEQ Class II agriculture standards. Although, groundwater underlying and directly downgradient of the tailings impoundment did not meet WDEQ agricultural or livestock standards when the site was transitioned to DOE, groundwater quality in other areas within the long-term care boundary did comply with WDEQ Class II and Class III standards (NRC 2006a). NRC reviewed the effects of using groundwater from these other areas within the long-term care boundary for agricultural and livestock purposes and concluded it is not likely to impact human health (NRC 2006a).

In 2002, NRC approved the use of ICs within the long-term care boundary to prevent direct human exposure to site-derived contaminants in groundwater for the duration of the 1,000-year performance period. The ICs control the use of groundwater on privately held lands that lie within the long-term care boundary. In 2012, when the site was transitioned to DOE, three private land owners were impacted. These ICs restrict groundwater from being used for human consumption or any other domestic purpose; although provisions are provided for groundwater to be used for livestock, agriculture, and other ranching purposes on portions of these privately held lands to which the ICs apply (see specific groundwater ICs in place at transition that are provided in Appendix A, restricted use areas are provided on Figure A–1). DOE will maintain these groundwater ICs under long-term care.

2.5.4 Groundwater Corrective Actions and the Establishment of ACLs and Trigger Levels

The groundwater Corrective Action Program (CAP) at the site began in 1990 when pumping of contaminated groundwater from four collection wells was initiated; two extraction wells operated in the Northwest Valley and two extraction wells operated in the Southwest Valley. The primary purpose of the system was to accelerate dewatering of the tailings impoundment. The system was designed to capture from 47.3 million gallons to 66 million gallons of water per year. Beginning in January 1990 the wells operated year round. In February 1992 the pumping duration was reduced to about 6 months per year (April through October), with the required volume of captured water remaining the same as initially specified. Recovered groundwater was piped to an evaporation pond constructed in the Southwest Valley, directly downgradient of the southwestern portion of the disposal cell. From there the contaminated groundwater was pumped to an evaporation misting system that sprayed water over the unreclaimed portion of the tailings impoundments (Shepherd Miller 1999b). The original goal was to achieve background concentrations in the groundwater.

In 1999 WNI concluded that continued corrective action would not be effective in reducing contaminant concentrations in groundwater further and issued a groundwater characterization and evaluation report (Shepherd Miller 1999b) to support the selection of a corrective action alternative. This report is also referred to as the site closure plan. While the groundwater CAP was effective in minimizing seepage from the tailings impoundment, based on the performance to date, it was determined that the continued operation of the system was unlikely to achieve the groundwater protection standards specified in the license (SUA-56). Therefore, WNI proposed that alternate concentration limits (ACLs) be determined for the site's point of compliance (POC) that are protective of human health and the environment, and which would result in compliance with groundwater protection standards (or established background concentrations) at the long-term care boundary (i.e., POE). The 1999 groundwater characterization and evaluation report submitted to NRC is considered the ACL application.

It was also recognized at the time ACLs were being considered that the groundwater remediation system was having no effect on the pulses of contamination that had already migrated beyond the system's extraction wells (Thompson 2005; NRC 2006a). Indeed, it had been established that significant amounts of hazardous constituents from the tailings seepage had become associated with the aquifer solids and would slowly re-mobilize into the groundwater over time, and that at least some of this secondary source term was located downgradient of the edge of the reclaimed tailings (Shepherd Miller 1999b) and the proposed point of compliance. This appears to be in contradiction to regulations at Criterion 5D of Appendix A in 10 CFR 40 that state: "The program must also address removing or treating in place any hazardous constituents that exceed concentration limits in ground water between the point of compliance and the downgradient facility property boundary". Although this legacy contamination is downgradient of the POC and may exceed the ACL (i.e., nitrate, discussed below), contamination was predicted to attenuate and meet maximum concentration limits or other standards at the POE.

Information provided in support of the ACL application (Shepherd Miller 1999b) included a baseline risk assessment which evaluated the current and future environmental and human health risks associated with the establishment of ACLs, as required per 10 CFR 40, Appendix A, Criterion 5B[6]. Based on this evaluation a list of constituents of concern (COCs) was

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determined for which ACLs would be proposed. The COCs determined were natural uranium, combined radium-226 and radium-228, ammonia, manganese, molybdenum, and nitrate.

Flow and transport modeling was also conducted in support of the ACL application. This modeling was conducted in an effort to predict the downgradient behavior of site-related contaminants over time; both those associated with the legacy plume and those anticipated to be released from the tailings impoundment under long-term surveillance. Modeling predictions were intended (and used) to establish a long-term care boundary that would be protective (i.e., one that assured concentrations of site-related constituents would be compliant with applicable groundwater protection standards or established background concentrations at the POE).

To determine the ACLs, maximum contaminant concentrations, from 1996 through 1997 in the immediate vicinity of the tailings impoundment, were used in a groundwater flow and transport model for the site. Flow and transport modeling of uranium and sulfate was conducted. This groundwater model and its predictions were presented in the 1999 groundwater characterization and evaluation report (Shepherd Miller 1999b). Uranium was conservatively used in the transport model because it was determined to be the most mobile COC; sulfate, determined to be another of the more mobile COCs, was also modeled to confirm the assumptions and predictions made regarding uranium's mobility. The remaining COCs were not modeled explicitly, but were modeled implicitly. The behavior of these other COCs were determined from relationships and observations relative to uranium. Results of this modeling demonstrated that the maximum contaminant concentrations would be compliant with water quality standards at the points of exposure (POEs), or would be within with NRC-approved background concentrations (NRC 2006b).

Groundwater modeling also predicted the following: 1) that uranium would mark the maximum extent of site-related contamination in both the floodplain alluvial aquifer and in the regional Split Rock aquifer; 2) that concentrations would be protective at the site's long-term care boundary; 3) that groundwater within the site's long-term care boundary would ultimately discharge into the Sweetwater River; and 4) that if concentrations at the POC stayed below the maximum concentrations observed they would be protective of the river (Shepherd Miller 1999b).

ACLs were proposed for ammonia, manganese, molybdenum, nitrate, combined radium-226 and -228, and natural uranium for both the Northwest Valley and Southwest Valley flow regimes, and would be applicable at designated POC wells located on site (i.e., Well-5 for the Northwest Valley flow regime and well WN-21 for the Southwest Valley flow regime, Figure 2). Several other constituents were included in WNI's license (SUA-56) monitoring program, but did not require ACLs as groundwater concentrations were in compliance with specified standards.

In response to WNI's ACL submittal (i.e., the site's groundwater characterization and evaluation report) on October 29, 1999, NRC replied (by letter dated December 15, 2000) with a request for additional information (RAI). The RAI was with regard to the Red Mule subdivision area and the durability of the ICs (i.e., groundwater restrictive covenants) that were planned for this closest downgradient residential area where human consumption of groundwater was occurring. WNI responded with a supplement (WNI 2000) that discussed "protective levels" in the area of the former Red Mule subdivision (directly east of well SWAB-31, Figure 2). Predicted concentrations of three site-related constituents were provided for this area; uranium was estimated to range from 0.3 to 0.8 mg/L, manganese from 0.5 to 1.0 mg/L, and nitrate from 30 to 50 mg/L. Predictive modeling indicated that groundwater in this area could be impacted by site-related constituents in approximately 100 years (Shepherd Miller 1999b).

In 2006, as a final response to WNI's ACL application submittal (and supplemental information provided), NRC prepared an environmental assessment (EA) for amendment of their source materials license (SUA-56) (NRC 2006a). In the EA, NRC recognizes that the ACLs being established must be as low as reasonably achievable (ALARA) in accordance with requirements set forth in regulations at Criterion 5B(6) of Appendix A in 10 CFR 40. NRC also noted in the EA that "current groundwater constituent concentrations are ALARA…" and issued a subsequent finding of no significant impact (FONSI) approving the establishment of ACLs. NRC concurred in the ACL application on September 28, 2006 (NRC 2006c). Specific actions are to be taken if an ACL is exceeded at a POC under long-term monitoring (see Section 3.7.1).

In approving the ACLs, the NRC also established a set of trigger levels for both groundwater and surface water. Trigger levels were established for each constituent with an ACL; ammonia, manganese, molybdenum, nitrate, combined radium -226 and -228, and uranium. According to WNI's license (SUA-56), trigger levels were applicable at the POE. Specific POE wells to which compliance with the groundwater trigger levels would have been required were not designated in the license for either the Split Rock (regional) aquifer or the Floodplain (alluvial) aquifer, although it is assumed that they would have been applicable at the well closest to the POE for each flow regime. The Sweetwater River, which serves as the POE for the northern portion of the site (because it defines the site's long-term care boundary), is where the surface water trigger levels are presumed to have been applicable, although WNI's license (SUA-56) did not specifically identify a surface water POE. It is also understood that the trigger levels for both groundwater and surface water were established based on maintaining protectiveness at the POE. Although these trigger levels were a license condition for WNI, there appears to have been no other regulatory basis for their application. Therefore, DOE will not incorporate these trigger levels into the long-term monitoring program for the site (see Section 3.7.1).

While not explicitly stated in site documentation, it is assumed that the ACL values to be met at the POCs were set to evaluate future performance of the tailings impoundment (i.e., concentrations of site-related constituents will be compliant with applicable groundwater protection standards or established background concentrations at the POE or site boundary). As long as ACL values are not exceeded at the POCs, the tailings impoundment is judged to be performing acceptably. However, as noted above, it was recognized that a pulse of elevated contamination had moved beyond the POC in the Southwest Valley. Concentrations of nitrate in this area (in well SWAB-2) were in excess of the nitrate ACL value prior to the ACL being established, and continued above the ACL after it was approved (more recently concentrations of nitrate have also been reported above the nitrate ACL in replacement well SWAB-1R). The concentrations of nitrate are believed to be site-related as the ammonia used in the uranium milling process degrades to nitrate in the environment. Based on the above statement from the NRC's 2006 EA, it is assumed that the observed levels of nitrate downgradient of the POC were determined to be acceptable. It is further assumed that the trigger levels discussed above were established as a check on the natural attenuation of this portion of the legacy plume that was not included under the groundwater CAP. It should also be noted that the Split Rock site is the only

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UMTRCA site (that DOE is aware of) where trigger levels were established and included as part of the licensee's monitoring program.

In 2006, following NRC's approval of the ACL application, the groundwater CAP was terminated. WNI extracted a total of 375.3 million gallons of contaminated groundwater under the CAP (NRC 2006a).

In 2008, the concentration of selenium at the POC exceeded the groundwater protection standard of 0.013 mg/L that had been established for the site under WNI's license (SUA-56). As a result, NRC directed WNI to respond to the selenium exceedance. In 2009, WNI responded by submitting a license amendment request proposing the establishment an ACL for selenium at the site equal to the U. S. Environmental Protection Agency (EPA) 40 CFR 141 maximum contaminant level (MCL) for drinking water (0.05 mg/L). As part of the regulatory process, NRC completed an EA for the establishment of the selenium ACL and also to address WNI's license amendment request to modify the uranium trigger level for groundwater (NRC 2010a). The EA was published in the *Federal Register* on February 5, 2010. By letter dated February 24, 2010, NRC accepted WNI's request for an ACL for selenium of 0.05 mg/L (NRC 2010b).

In a concurrent action NRC also; 1) approved WNI's license amendment request to establish groundwater protection standards at the site for several additional constituents (i.e., aluminum 37 mg/L, antimony 0.006 mg/L, arsenic 0.05 mg/L, fluoride 4 mg/L, and thallium 0.002 mg/L), 2) revised the standard for beryllium (i.e., from 0.05 mg/L to 0.01 mg/L), 3) deleted chromium from the list of required monitoring constituents, and 4) increased the trigger level for uranium in groundwater (to reflect background concentrations) from 0.03 mg/L to 0.087 mg/L for the Split Rock regional aquifer and from 0.03 mg/L to 0.044 mg/L for the floodplain alluvial aquifer (NRC 2010b).

ACLs and other groundwater protection standards, along with historical concentrations of constituents (for both background and the tailings area) that were monitored in accordance with WNI's source material license (SUA-56, Amendment No. 105, February 24, 2010) prior to transition of the site to DOE are provided in Table 3. Associated trigger levels for both groundwater and surface water for designated constituents included in WNI's source material license are provided in Table 4.

DOE evaluated WNI's monitoring program and historical results for determining technically valid recommendations for long-term monitoring (see Appendix E and Section 3.7.1).

Table 3. ACLs, Groundwater Protection Standards and Historical Concentrations (Background and Tailings Area) for Constituents at the Split Rock, Wyoming, Disposal Site

Constituent	ACL[a] (applicable at the POC)		Groundwater Protection Standard[b]	Maximum Historical Concentrations[c]		Background Concentrations[c]	
	Northwest Valley	Southwest Valley		Tailings Area	Beyond Tailings Area	Floodplain Alluvial Aquifer	Split Rock Formation Aquifer
Aluminum (mg/L)			37	578	2.02	0.1	0.13
Ammonia (mg/L)	0.61	0.84		0.16	2.35	0.011	0.015
Antimony (mg/L)			0.006	0.017	0.01	0.005	0.005
Arsenic (mg/L)			0.05	2.64	0.058	0.024	0.1
Beryllium (mg/L)			0.01	0.084	<0.01	0.004	0.01
Cadmium (mg/L)			0.01	0.188	0.014	0.008	0.014
Fluoride (mg/L)			4	21.7	1.33	1.04	0.517
Lead (mg/L)			0.05	0.11	0.005	0.005	0.050
Manganese (mg/L)	225	35		126	49.1	2.39	0.53
Molybdenum (mg/L)	0.66	0.22		0.55	0.22	0.1	0.1
Nickel (mg/L)			0.05	2.29	0.11	0.05	0.05
Nitrate (mg/L)	317	70.7		362	201	0.88	3.99
$Ra^{226+228}$ (pCi/L)	7.2	19.9		2950	13.5	4.7	5.3
Selenium (mg/L)	0.05[d]	0.05[d]		0.119	0.061	0.005	0.011
Thallium (mg/L)			0.002	0.075	0.013	0.013	0.003
$Thorium^{230}$ (pCi/L)			0.95	732	5.5	5.5	1.8
Uranium (mg/L)	4.8	3.4		4.055	8.7	0.044	0.087[e]

ACL = alternate concentration limit; POC = point of compliance; mg/L = milligrams per liter;
pCi/L = picocuries per liter; Ra = radium.

[a] ACLs are applicable at the POC (Shepherd Miller 1999b).

[b] Groundwater protection standards obtained from WNI's Source Material License (SUA-56), Amendment No. 105, License Condition 74B&C.

[c] Maximum historical concentrations and background concentrations obtained from Volume 1 of the *Site Ground Water Characterization and Evaluation* (i.e. the ACL application), Table 17 (Shepherd Miller 1999b).

[d] The ACL for selenium is equivalent to the EPA maximum contaminant level (MCL) for drinking water (NRC 2010b).

[e] The background concentration for uranium was revised subsequent the value included in the *Site Ground Water Characterization and Evaluation* (NRC 2010b).

Table 4. Trigger Levels for Groundwater and Surface Water for the Split Rock, Wyoming, Disposal Site

Analyte	Surface Water Trigger Levels (Sweetwater River)	Split Rock Aquifer Trigger Levels (well SWAB-32)	Floodplain Aquifer Trigger Levels (well WN-41B)
Ammonia	0.5 mg/L[a]	0.5 mg/L	0.5 mg/L
Manganese	0.05 mg/L	0.73 mg/L	2.39 mg/L
Molybdenum	0.18 mg/L	0.18 mg/L	0.18 mg/L
Natural Uranium	0.03 mg/L[b]	0.087 mg/L (0.3 mg/L)	0.044 mg/L
Nitrate	10 mg/L	10 mg/L	10 mg/L
Ra-226 + Ra-228	5.00 pCi/L	5.0 pCi/L	5.0 pCi/L

mg/L = milligrams per liter; pCi/L = picocuries per liter.
[a] EPA groundwater risk-based concentration (RBC).
[b] EPA maximum contaminant level (MCL) for drinking water.
Note: WNI's source material license (SUA-56) required compliance with trigger levels at the point of exposure (POE). Trigger levels appear to have been established to be used as a "trigger" for raising concern should these concentrations be reached at the POE; and is likely due to the recognition that a pulse of groundwater contamination had migrated beyond the point of compliance (POC) and beyond the capture zone of WNI's groundwater corrective action program. Therefore, it is understood that trigger levels were to be used to monitor the legacy plume, whereas the alternate concentration limits established were to be used for monitoring the performance of the disposal cell.

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3.0 Long-Term Surveillance Program

3.1 General License for Long-Term Custody

States have right of first refusal for long-term custody of Title II disposal sites (UMTRCA, Section 202 [a]). On July 15, 1994, the State of Wyoming exercised its right of first refusal and declined custody and long-term care of the Split Rock disposal site (State of Wyoming 1994). Because the State declined this right, the site was transferred to DOE for custody and long-term care.

When NRC accepted this LTSP and terminated WNI's license, SUA-56, the site was included under NRC's general license for long-term custody (10 CFR 40.28 [b]). Concurrent with this action, title to the portion of the site within the long-term care boundary owned by WNI was transferred to DOE (Appendix A). The portion of the property within the long-term care boundary, which is federally owned, was withdrawn by BLM from public use and placed under DOE's jurisdiction for custody and long-term care (Appendix A). The remaining balance of the property within the long-term care boundary is privately held and under IC restrictions to prevent human exposure to site-derived contaminants in groundwater (Appendix A).

Although UMTRCA Title II disposal structures (i.e., the disposal cell and its associated surface water diversion structures) are designed to last "for up to 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years (10 CFR 40, Appendix A, Criterion 6)," there is no termination of the general license for DOE's custody and long-term care of the site (10 CFR 40.28 [b]).

Should changes to this LTSP become necessary, NRC must be notified of the changes, and the changes may not conflict with the requirements of the general license. Additionally, representatives of NRC must be guaranteed permanent right-of-entry for the purpose of periodic site inspections. Access to the site, as shown on Figure 2, is unimpeded from public roads.

3.2 Requirements of the General License

To meet the requirements of NRC's license at 10 CFR 40, Section 28, and Appendix A Criterion 12, the long-term custodian must, at a minimum, fulfill the following requirements. The section in the LTSP in which each requirement is addressed is given in parentheses.

- Annual site inspection. (Section 3.3).
- Annual inspection report. (Section 3.4).
- Follow-up inspections and inspection reports, as necessary. (Section 3.5).
- Site maintenance, as necessary. (Section 3.6).
- Emergency measures in the event of catastrophe. (Section 3.6).
- Environmental monitoring. (Section 3.7).

3.3 Annual Site Inspections

3.3.1 Frequency of Inspections

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 this requirement, DOE will inspect the Split Rock disposal site once each calendar year. The date of the inspection may vary from year to year, but DOE will endeavor to inspect the site approximately once every 12 months unless circumstances warrant variance. Any variance to this inspection frequency will be explained in the inspection report. DOE will notify NRC of the inspection at least 30 days in advance of the scheduled inspection date.

3.3.2 Inspection Procedure

For the purpose of inspection, the Split Rock disposal site will be divided into sections called *transects*. Each transect will be inspected individually. Proposed transects for the first inspection of the Split Rock site are listed in Table 5. Specific site features are shown on Figure 2.

Table 5. Transects Used During First Inspection of the Split Rock, Wyoming, Disposal Site

Transect	Description
Tailings Impoundment (top and side slopes).	Cover and rock-mulch integrity; check for any settlement, slumping, erosion, rock displacement or degradation, seeps, evidence of standing water, bio-intrusion, or human activity.
Tailings Impoundment Drainage Diversion Channels, Toe Drains, and Apron.	Riprap placement and integrity, functionality of drainage structures; check for erosion, sedimentation, accumulation of debris, rock displacement or degradation.
Site Perimeter and Balance of Site	Site perimeter including 0.25 mile beyond site boundary, area between tailings impoundment and site boundary, site entrance, boundary monuments, entrance sign, perimeter warning signs, site marker, and monitor wells; check integrity.

The annual inspection will be a visual walk-through, supported by a checklist, photographs, field maps and notes, and reporting. The primary purpose of the site inspection will be to look for conditions that could result in adverse impacts to the disposal site, in particular, evidence of modifying processes that could be detrimental to the performance of the disposal system. This may include degradation or structural discontinuity of the tailings impoundment (erosion, settlement, slumping, cracking, rock degradation, rock displacement, bio-intrusion, or human activity), impairment to the integrity and functionality of the surface water diversion channels (sedimentation, accumulation of debris, rock degradation or displacement, vegetation growth); wind or water erosion; livestock grazing, or human activity. Disposal site and disposal cell inspection techniques are described in detail in Attachment 3 of the *Guidance for Developing and Implementing Long-Term Surveillance Program for UMTRCA Title I and Title II Disposal Sites* (DOE 2001).

In addition to inspection of the site itself, inspectors will note changes and developments in the area surrounding the site, particularly changes within the surrounding watershed basin.

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Significant changes within the surrounding area could include development or expansion of human habitation, erosion, road building, mining and exploration activities, or other changes in land use. Changes in land (or groundwater) use in the area immediately surrounding the site that could result in diminished protectiveness will be evaluated. The effectiveness of the groundwater ICs (restrictive use covenants) that are in place on the three privately held lands within the long-term care boundary will be monitored annually (i.e., verify awareness of the ICs by the current land owners).

It may be necessary to document certain observations with photographs. Such observations warranting photographs may include evidence of vandalism or a slow modifying process, such as rill erosion, that should be monitored more closely during general site inspections. Photographs are documented on the Field Photograph Log. An example of the photograph log is included as Appendix C.

3.3.3 Inspection Checklist

The site inspection is guided by the inspection checklist. The initial site-specific inspection checklist for the Split Rock disposal site is presented in Appendix D.

The checklist is subject to revision as necessary. At the conclusion of an annual site inspection, inspectors will make notes regarding revisions to the checklist, if necessary, in anticipation of the next annual site inspection. Revisions to the checklist will include such items as new discoveries or changes in site conditions that must be inspected and evaluated during the next annual inspection.

3.3.4 Personnel

Annual inspections normally will be performed by a minimum of two inspectors. Inspectors will be experienced engineers and scientists who have been specifically trained for the purpose through participation in previous site inspections.

Engineers typically will be civil, geotechnical, or geological engineers. Scientists will include geologists, hydrologists, biologists, and environmental scientists representing various fields (e.g., ecology, soils, range management). If serious or unique problems develop at the site, more than two inspectors may be assigned to the inspection. Inspectors specialized in specific fields may be assigned to the inspection to evaluate serious or unusual problems and make recommendations.

3.4 Annual Inspection and Monitoring Reports

Results of annual site inspections for all UMTRCA Title I and Title II disposal sites managed by LM will be reported to NRC within 90 days of the last site inspection of that calendar year (10 CFR 40, Appendix A, Criterion 12). Two separate reports are submitted to NRC; one which includes inspection results for all Title I sites licensed under 10 CFR 40.27 and one that includes inspection results for all Title II sites licensed under 10 CFR 40.28. The annual inspection results for the Split Rock disposal site are to be included in the Title II sites report. In the event that the annual report cannot be submitted within 90 days, DOE will notify NRC of the circumstances. The annual inspection reports also will be available to the State and any other stakeholders via the LM website.

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For sites which require groundwater and surface water monitoring to be performed, the results will also be included in the annual report submitted to the NRC. Groundwater and surface water monitoring is required at the Split Rock disposal site, and therefore, will be included in the annual Title II inspection and monitoring report submitted to NRC. DOE will typically provide trends in water quality, in the form of concentration versus time graphs, for all analytes being monitored which have an ACL; results for all wells included in the long-term monitoring program will be presented. In addition, DOE typically provides a table(s) containing groundwater quality data, as well as water level measurements.

3.5 Follow-up Inspections

Follow-up inspections are unscheduled inspections that are targeted to evaluate specific findings or concerns. Follow-up inspections may be required (1) as a result of discoveries made during a previous annual site inspection, or (2) as a result of changed site conditions reported by a citizen or outside agency.

3.5.1 Criteria for Follow-up Inspections

Criteria necessitating follow-up inspections are required by 10 CFR 40.28 (b)(4). Accordingly, DOE will conduct follow-up inspections should any of the following occur:

1. A condition is identified during the annual site inspection or other site visit that requires personnel, perhaps personnel with specific expertise, to return to the site to evaluate the condition.
2. DOE is notified by a citizen or outside agency that conditions at the site are substantially changed.
3. An extreme natural condition such as a significant earthquake (6.5 Richter-scale, or greater) or rainfall event (7 inches or more in an hour).

With respect to citizens and outside agencies, DOE will establish and maintain lines of communication with local law enforcement and emergency response agencies to facilitate notification in the event of significant trespass, vandalism, or natural disaster. Because the Split Rock disposal site is remote, DOE recognizes that local agencies may not necessarily be aware of current conditions at the site. However, these agencies will be requested to notify DOE or provide information should they become aware of a significant event that might affect the security or integrity of the site.

DOE may also 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 condition or concern is identified at the site, DOE will evaluate the information and determine whether a follow-up inspection is warranted. Conditions that may require a routine follow-up inspection include erosion, storm damage, trespassing, minor vandalism, or the need to evaluate, define, or perform maintenance tasks.

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Conditions that threaten the safety or the integrity of the disposal site may require a more immediate (non-routine) follow-up inspection. Slope failure, disastrous storm, wildfire, a major seismic event, and deliberate human disturbance of an engineered structure are among these conditions.

DOE will use a graded approach with respect to follow-up inspections. The urgency of the follow-up inspection will be in proportion to the seriousness of the condition. The timing of the inspection may be governed by seasonal considerations. For example, a routine follow-up inspection to perform maintenance or to evaluate an erosion problem might be scheduled to avoid snow cover and frozen ground or after a large precipitation event.

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

- Notify NRC pursuant to 10 CFR 40, Appendix A, Criterion 12, or 10 CFR 40.60, whichever is determined to apply;
- Begin the DOE Environment, Safety, and Health Reporting process (DOE Order 231.1A, Chg. 1; or most current guidance);
- Respond with an immediate follow-up inspection or mobilization of an emergency response team;
- Implement measures as necessary to contain or prevent dispersion of radioactive materials (Section 3.6).

3.5.2 Personnel

Inspectors assigned to follow-up inspections will be selected on the same basis as for the annual site inspection (see Section 3.3.4).

3.5.3 Reports of Follow-up Inspections

Results of routine follow-up inspections will be included in the next annual inspection and monitoring report (Section 3.4). Separate reports will not be prepared unless DOE determines that it is advisable to notify NRC or other outside agency of a problem at the site.

If follow-up inspections are required for more serious or emergency reasons, DOE will submit to NRC a preliminary report of the follow-up inspection within the required 60 days (10 CFR 40, Appendix A, Criterion 12).

3.6 Routine Site Maintenance and Emergency Measures

3.6.1 Routine Site Maintenance

UMTRCA disposal sites 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). The tailings impoundment, and its associated surface water control structures, at the Split Rock disposal site have been designed and constructed to minimize the need for routine maintenance.

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The surface of the tailings impoundment was constructed with minimal slope to promote positive drainage while minimizing runoff water velocities. The surface was covered with rock mulch that is expected to endure for the long-term. Because of the rock mulch covering the compacted materials, along with mild slopes, adverse wind or water erosion impacts that would require maintenance are not anticipated. Areas adjacent to the impoundment where runoff water could achieve erosional velocities have been armored with riprap. The tailings impoundment area is also isolated by fencing and granite outcrops to prevent damage from livestock grazing. On the portions of the site where livestock grazing is permitted, the grazing leasee(s) will be required to maintain all fencing used for livestock management on site.

If an inspection of the disposal site cell reveals that an as-built structure or feature has failed or degraded in a way that compromises site protectiveness, an evaluation will be conducted to determine an appropriate response action that ensures protectiveness of the disposal system is maintained. DOE will perform routine site maintenance, where and when needed, to maintain protectiveness. Results of routine site maintenance will be summarized in the annual site inspection report.

3.6.2 Control of Deep-Rooted Vegetation on Tailings Impoundment

Vegetation, including deep-rooted plants, began establishing on the tailings impoundment before regulatory closure of the disposal site occurred. There was no indication found in site documents that control of such vegetation was required by the licensee prior to transition to maintain cell performance. Information regarding vegetation management and cover performance on uranium mill tailings disposal cells is provided in Appendix B. This information indicates that recent research suggests that allowing the natural succession of native vegetation to proceed on the disposal cells may actually be beneficial to the long-term performance of the cells by transforming the conventional low-permeability covers into water balance covers, particularly in arid and semiarid environments.

Therefore, monitoring or control of vegetation on the tailings impoundment is not required under long-term management. DOE will continue to allow the natural succession of native vegetation to proceed on the cell cover and the remainder of the site and will note general vegetation conditions in inspection reports.

3.6.3 Emergency Measures

Emergency measures are the actions that DOE will take in response to "unusual damage or disruption" (10 CFR 40, Appendix A, Criterion 12).that threaten or compromise site safety, security, or integrity. DOE will contain or prevent dispersal of radioactive materials in the unlikely event of a breach in cover materials.

3.6.4 Criteria for Routine Site Maintenance and Emergency Measures

Conceptually, there is a continuum in the progression from minor routine maintenance to large-scale reconstruction of the tailings impoundment following a potential disaster. Although 10 CFR 40.28 (b)(5) requires that increasingly serious levels of intervention trigger particular DOE responses, the criteria for those are not easily defined because the nature and scale of all potential problems cannot be foreseen. Nevertheless, with regard to identified potentially threatening situations, DOE will evaluate conditions to determine appropriate actions and notify NRC of any circumstance that threatens the integrity of the disposal system.

The information in Table 6, however, serves as a guide for appropriate DOE responses (to specific example scenarios). The table shows that the primary difference between routine maintenance and emergency response is the urgency of the activity and the degree of threat or risk. DOE's priority (or urgency) in the left column of Table 6, bears an inverse relationship with DOE's estimate of probability; i.e., the highest-priority response is believed to be the least likely scenario to occur.

Table 6. DOE Criteria for Maintenance and Emergency Measures

Priority	Description[a]	Example	Response
1	Breach of disposal cell with dispersal of radioactive material.	Seismic event that exceeds design basis and causes massive discontinuity in cover.	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	Breach of site security.	Human intrusion, vandalism.	Restore security; urgency based on assessment of risk.
4	Maintenance of specific site surveillance features.	Deterioration of signs, markers.	Repair at first opportunity.
5	Minor erosion.	Erosion not immediately affecting disposal cell.	Evaluate, assess impact, respond as appropriate to address problem.

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

3.6.5 Reporting Maintenance and Emergency Measures

Routine maintenance completed during the previous 12 months will be summarized in the annual inspection report.

In accordance with 10 CFR 40.60, within 4 hours of discovery of any Priority 1 or 2 event such as those listed in Table 6, DOE will notify the following group at NRC:

- Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission.

The NRC Operations Center should be called in the event that a Priority 1 or 2 event 4-hour notification is required. The telephone number for the NRC Operations Center is (301) 816-5100.

3.7 Environmental Monitoring

3.7.1 Groundwater and Surface Water Monitoring

The purpose for conducting long-term groundwater monitoring at the Split Rock disposal site is to (1) evaluate the performance of the tailings impoundment, (2) demonstrate that ACLs at the POCs remain protective at the POE (i.e., applicable groundwater standards are being met at the site boundary), and (3) track the predicted natural attenuation of the legacy plume. Surface water monitoring is performed to demonstrate that concentrations of site-related constituents are not above any applicable surface water standards established for the Sweetwater River, and therefore, remain protective.

3.7.1.1 Background

In 2006, following extensive groundwater corrective action, NRC granted ACLs for ammonia, manganese, molybdenum, nitrate, combined radium-226 and -228, and natural uranium (NRC 2006c). In 2010, an ACL for selenium was also granted, along with requested modifications to several other groundwater protection standards and a revision to the groundwater trigger levels for uranium (NRC 2010b) (see Section 2.5.4).

Historical groundwater and surface water monitoring at the site was performed by WNI for many years in accordance with requirements set forth in their source materials license (SUA-56, Conditions 24 and 74, respectively) (NRC 2010b). The license specified compliance with established ACLs and groundwater protection standards at the designated POC wells (i.e., Well-5 for the Northwest Valley flow regime and well WN-21 for the Southwest Valley flow regime), and with trigger levels at the POE (Note: No specific wells were designated as POE wells for groundwater compliance; the POE was understood to be the site's long-term care boundary. The POE for surface water was understood to be the Sweetwater River, which defines the long-term care boundary on the north side of the site.).

WNI's license (SUA-56) specified groundwater monitoring at sixteen wells (JJ-1R, WN-39B, WN-41B, WN-42A, SWAB-1, SWAB-2, SWAB-4, SWAB-12, SWAB-22, SWAB-29, SWAB-31, SWAB-32, Well-1, Well-4R, Well-5, and WN-21) and five surface water locations (SW-1 thru SW-5) along the Sweetwater River. Twenty-two parameters (i.e., analytical constituents) for groundwater and surface water monitoring were specified in the license; aluminum, ammonia, antimony, arsenic, beryllium, cadmium, chloride, fluoride, lead, manganese, molybdenum, nickel, nitrate, pH, combined radium-226 and -228, selenium, sulfate, thallium, thorium-230, total dissolved solids, and uranium. Groundwater monitoring was conducted annually for sulfate and uranium and semi-annually for the remaining constituents, except at Well-1, Well-4R, Well-5, and WN-21 where the full suite of constituents was monitored annually. Surface water monitoring was conducted semi-annually for sulfate and uranium and annually for the full suite of constituents.

3.7.1.2 Evaluation of WNI's Pre-Transition Groundwater and Surface Water Monitoring Requirements

An evaluation of WNI's pre-transition groundwater and surface water monitoring requirements, as specified in source material license SUA-56, Conditions 74 and 24, respectively, was conducted to determine if they were technically suitable for DOE's long-term stewardship responsibilities (Appendix E). The site's groundwater characterization and evaluation report, i.e., ACL application (Shepherd Miller 1999b), was reviewed and historical monitoring data from the site were evaluated. DOE has archived historical WNI monitoring results.

Constituents from all monitoring locations were looked at to determine if any trends were discernible and if the system appeared to be relatively stable. This evaluation provided the basis for the initial long-term monitoring program presented in this LTSP. As a result of the evaluation, the following modifications to the licensee's monitoring program have been incorporated into the LTSP's long-term monitoring program. Further discussion of each modification is provided in Appendix E.

- Aluminum, antimony, arsenic, beryllium, cadmium, fluoride, lead, nickel, thallium, and thorium-230 were eliminated from the analytical suite on the basis that they are present in such low concentrations that they are not capable of posing a substantial present or potential hazard to human health or the environment, in accordance with 10 CFR 40, Appendix A, Criterion 5B(3).
- Of the seven remaining hazardous constituents WNI identified as COCs and for which ACLs were established (i.e., ammonia, manganese, molybdenum, nitrate, combined radium-226 and -228, selenium, and uranium), only the following were retained for continued long-term monitoring; manganese, nitrate, combined radium-226 and -228, and uranium. Ammonia, molybdenum, and selenium were excluded from long-term monitoring.
- Sulfate and total dissolved solids (TDS) were also retained for continued long-term monitoring as indicator constituents.
- All constituents included in the long-term monitoring program will be sampled at all groundwater and surface water monitoring locations in the long-term monitoring network.
- Of the sixteen wells WNI monitored prior to site transition, ten will continue to be sampled under the long-term monitoring. The wells included in the long-term monitoring network are; Well-5, WN-41B, and WN-42A for the Northwest Valley flow regime and WN-21, SWAB-1R, SWAB-2, SWAB-12R, SWAB-22, SWAB-29, and SWAB-31 for the Southwest Valley flow regime. The six WNI wells excluded from the long-term monitoring network are; Well-4R, WN-39B, and JJ-1R in the Northwest Valley flow regime and Well-1, SWAB-4, and SWAB-32 in the Southwest Valley flow regime.
- Well-5 will remain the designated POC well for the Northwest Valley flow regime (the remaining wells in this flow regime will be considered trend wells).
- Well WN-21 will remain the designated POC well for the Southwest Valley flow regime (the remaining wells in this flow regime will be considered trend wells).
- Well WN-41B is the farthest downgradient groundwater monitoring point for the Northwest Valley flow regime, and will be used for demonstrating that site-related contamination exiting the Northwest Valley has not reached the POE at concentrations above applicable standards.
- Well SWAB-31 is the farthest downgradient groundwater monitoring point for the Southwest Valley flow regime, and will be used for demonstrating that site-related contamination exiting the Southwest Valley has not reached the POE at concentrations above applicable standards.

- Of the five surface water locations on the Sweetwater River WNI monitored prior to site transition, one (SW-3) will continue to be sampled under the long-term monitoring. Locations SW-1, SW-2, SW-4, and SW-5 will be excluded from the long-term monitoring network.
- The frequency of monitoring will be reduced from semi-annual to annual for the first year of long-term monitoring. Annual monitoring will continue at all locations in the long-term monitoring network except at wells SWAB-22, SWAB-29, and SWAB-31 in the Southwest Valley flow regime, well WN-41B in the Northwest Valley flow regime, and surface water location SW-3, where monitoring will be reduced to once every five years. The five year frequency at these farthest downgradient locations is based on groundwater flow and transport modeling which determined that site-related constituents would not reach these locations for many years (i.e., in the Southwest Valley flow regime) or because stability below groundwater protection standards has been demonstrated and upgradient locations being sampled annually provide protection.
- Compliance with ACLs and other groundwater protection standards established under WNI's license (SUA-56) will continue under long-term monitoring. Compliance with ACLs will continue to be applicable at the designated POC wells as specified under Criterion 5B(5) of 10 CFR 40, Appendix A.
- Trigger levels established for manganese, nitrate, combined radium -226 and -228, and uranium will not be incorporated into the long-term monitoring program as no basis for trigger levels is found within the regulations. Instead, DOE will compare monitoring results in the wells closest to the POE (i.e., site long-term care boundary) to groundwater protection standards applicable offsite to ensure compliance continues to be maintained. Surface water monitoring results will be compared to water quality standards applicable to the Sweetwater River to ensure compliance continues to be maintained.
- For groundwater monitoring, the designated POE remains the long-term care boundary. However, the well closest to the POE in each flow regime will be used as the monitoring point for which concern will be raised should a groundwater protection standard be exceeded (i.e., well WN-41B for the Northwest Valley flow regime and well SWAB-31 for the Southwest Valley flow regime).
- For surface water monitoring, the designated POE remains the long-term care boundary. However, the Sweetwater River will continue to be recognized as the effective surface water POE for contaminated groundwater exiting the Northwest Valley.
- Uranium and sulfate results will be used for continued validation of the groundwater contaminant transport model under long-term monitoring.
- Continued concentrations in excess of the ACL for nitrate at wells SWAB-2 and SWAB-1R (directly downgradient of the POC for the Southwest Valley) will not be considered a regulatory out-of-compliance event under long-term monitoring. Concentrations above an applicable groundwater protection standard at the POE (for any site-related hazardous constituent) will be considered a regulatory out-of-compliance event under long-term monitoring.
- The long-term monitoring program will be reevaluated after five years for technically warranted modifications, and periodically thereafter, based on site conditions. Modifications in the number and location of monitoring points, constituents, frequency, and duration will be considered, along with the need to continue monitoring.

3.7.1.3 Long-Term Groundwater and Surface Water Monitoring Program

Based on conclusions and recommendations from the evaluation of WNI's pre-transition groundwater and surface water monitoring program, the following long-term monitoring program was developed. Table 7 and Table 8 summarize DOE's long-term monitoring requirements for the Split Rock disposal site. Table 7 provides the long-term groundwater and surface water monitoring plan. Table 8 provides established ACLs and other groundwater protection standards. The locations of the monitoring wells and the surface water monitoring point in the long-term monitoring program can be found on Figure 2.

Monitoring results will be used to 1) to verify that the ACLs are not exceeded at the designated POC wells (i.e., Well-5 for the Northwest Valley flow regime and well WN-21 for the Southwest Valley flow regime), 2) to verify that concentrations of site-related constituents remain below applicable groundwater protection standards at the wells located closest to the site's long-term care boundary (i.e., well WN-41B for the Northwest Valley flow regime and well SWAB-31 for the Southwest Valley flow regime), and 3) to verify that concentrations of site-related constituents are below any applicable surface water standards for the Sweetwater River.

DOE understands that ACLs were established to ensure protectiveness at the POE (the site's long-term care boundary) and monitor long-term performance of the disposal cell. Compliance with ACLs is applicable at the designated POC well for each groundwater flow regime (i.e., Well-5 for the Northwest Valley and well WN-21 for the Southwest Valley) as specified under Criterion 5B(5) of 10 CFR 40, Appendix A.

Table 7. Long-Term Monitoring Plan for the Split Rock, Wyoming, Disposal Site

Groundwater Monitoring		
Wells*	**Analytes**	**Frequency**
NWV Flow Regime: Well-5 (POC well), WN-41B (furthest downgradient well), WN-42A **SWV Flow Regime**: WN-21 (POC well), SWAB-1R, SWAB-2, SWAB-12R, SWAB-22, SWAB-29, SWAB-31 (furthest downgradient well)	manganese, nitrate, combined radium-226 and -228, sulfate, TDS, uranium (and standard field measurements; pH, temperature, conductivity, alkalinity, dissolved oxygen, and turbidity)	Annually for all wells except well WN-41B in the NWV flow regime and wells SWAB-22, SWAB-29, and SWAB-31 in the SWV flow regime where monitoring will be reduced to once every five years following the first annual long-term monitoring event.
Surface Water Monitoring[a]		
Location	**Analytes**	**Frequency**
Sweetwater River: SW-3	manganese, nitrate, combined radium-226 and -228, sulfate, TDS, uranium (and standard field measurements; pH, temperature, conductivity, alkalinity, dissolved oxygen, and turbidity)	Annually for the first long-term monitoring event, once every five years thereafter.

NWV = Northwest Valley; SWV = Southwest Valley; TDS = total dissolved solids.

[a] Site-related constituents being monitored in surface water will be compared to the Human Health Values for Fish and Drinking Water that are applicable to Wyoming Class 2AB waters (Section 18, Chapter 1 of the Wyoming Department of Environmental Quality's Water Quality Rules and Regulations).

* Note: Water level measurements will be taken at each well prior to sampling. Wells not otherwise designated are considered trend wells for their respective flow regime. The designations for both the groundwater monitoring wells and the surface water monitoring location were adopted from WNI's historical names used for these monitoring locations to maintain continuity.

Table 8. Alternate Concentration Limits and Groundwater Protection Standards for Long-Term Monitoring at the Split Rock, Wyoming, Disposal Site

Analyte	ACL* Northwest Valley (POC; Well-5)	ACL* Southwest Valley (POC; Well WN-21)	Groundwater Protection Standard
Manganese	225 mg/L	35.0 mg/L	
Nitrate	317 mg/L	70.7 mg/L	100 mg/L[b]
Combined Radium-226 and -228	7.2 pCi/L	19.9 pCi/L	5.0 pCi/L[b]
Sulfate[a]			3,000 mg/L[b]
TDS[a]			5,000 mg/L[b]
Uranium (natural)	4.8 mg/L	3.4 mg/L	

ACL = alternate concentration limit; mg/L = milligrams per liter; pCi/L = picocuries per liter;
POC = point of compliance; POE = point of exposure; TDS = total dissolved solids.
[a] Indicator constituents only.
[b] Standards are Wyoming Class III Groundwater Protection Standards for Livestock and applicable at the POE.
* Note: ACLs are applicable at the designated POC wells, as they were prior to transition under WNI's source material license SUA-56 (Amendment 105, February 24, 2010) and as specified under Criterion 5B(5) of 10 CFR 40, Appendix A. Concentrations in excess of the nitrate ACL have been reported in well SWAB-2 (directly downgradient of the POC) and well SWAB-1R since their installation in 1996 and 2009, respectively. Therefore, continued concentrations in excess of the nitrate ACL in these wells under long-term monitoring will not be considered an out-of-compliance event.

As discussed in Appendix E (the pre-transition monitoring evaluation), historic nitrate concentrations in two non-POC wells (SWAB-2 and SWAB-1R) exceed the established ACL for the upgradient POC well (well WN-21). These concentrations do not appear to have been considered a regulatory non-compliance event, presumably because the designated POC wells remained below the ACL as specified in the source material license (SUA-56) for the site (the nitrate values in excess of the ACL occurred at wells directly downgradient of the Southwest Valley POC, well WN-21). The interpretation that the ACLs apply only to POC wells appears to contradict 10 CFR 40, Appendix A, Criterion 5B(1) which states: "Hazardous constituents entering the ground water from a licensed site must not exceed the specified concentration limits in the uppermost aquifer beyond the point of compliance during the compliance period."

However, correspondence between the licensee and NRC indicate that they were aware of the elevated concentrations of site-related constituents downgradient of the POC in the legacy plume. In addition, site groundwater modeling and the associated determination of the long-term care boundary considered these historical nitrate concentrations above the ACL downgradient of the POC. The groundwater model indicates that concentrations of nitrate (and all other hazardous constituents) will not exceed background values at the long-term care boundary and therefore, protection of human health and the environment would be ensured at the POE.

Therefore, DOE will not consider continued nitrate concentrations in excess of the ACL at wells SWAB-2 or SWAB-1R under long-term monitoring to be a regulatory out-of-compliance event. As stated above, DOE considers compliance with established ACLs to be applicable at the designated POC wells, as it was prior to site transition. However, DOE also understands that an exceedance of an applicable standard at the POE (for any site-related hazardous constituent) will be considered a regulatory out-of-compliance event under long-term monitoring.

Surface water samples are collected from one location on the Sweetwater River every five years following the first annual sampling event. Surface water samples are analyzed for the same constituents as the groundwater samples and are specified in Table 7. The surface water sampling location SW-3 is shown on Figure 2. SW-3 is directly downgradient of monitor well WN41–B (the most downdradient monitoring point for the Northwest Valley flow regime and which is completed in the shallow floodplain alluvial aquifer). Since the Sweetwater River is the POE for contamination exiting the Northwest Valley, the purpose of the surface water sampling is to verify that concentrations continue to fall below any applicable surface water standards (i.e., the Human Health Values for Fish and Drinking Water applicable to the Wyoming Class 2AB waters; Section 18, Chapter 1 of the Wyoming Department of Environmental Quality's Water Quality Rules and Regulations).

Groundwater exiting the Southwest Valley also discharges to the Sweetwater River, but is understood to take several centuries to reach and groundwater modeling indicates concentrations of site-related constituents will not exceed background at the long-term care boundary, the designated POE for this flow regime. Therefore, there are no surface water sampling locations on the Sweetwater River downgradient of long-term care boundary to monitor discharges of groundwater from the Southwest Valley flow regime. However, well SWAB-31, the farthest downgradient well in the Southwest Valley flow regime and closest to the POE, will be monitored to ensure that concentrations meet acceptable levels prior to migrating beyond the site's long-term care boundary.

If sampling results indicate that an ACL is exceeded at a POC well, or trends indicate that either a groundwater protection standard or the established range of background levels will likely be exceeded at the POE (i.e., that offsite protectiveness may be compromised), DOE will inform NRC and Wyoming Department of Environmental Quality (WDEQ) of the results and conduct confirmatory sampling. If the confirmatory sampling (i.e., results from three consecutive, regularly scheduled monitoring events) verifies the exceedance, DOE will develop an evaluative monitoring work plan and submit that plan to NRC for review prior to initiating the evaluative monitoring program. This plan could involve expanding the analyte list to include all ACL constituents or other relevant constituents, increasing monitoring frequency, or some other approach. Results of the evaluative monitoring program will be used, in consultation with NRC, to determine if it is necessary for DOE to perform additional assessment or if implementation of corrective action is warranted.

Results of the groundwater and surface water monitoring program will be included in the annual inspection and monitoring report (Section 3.4).

3.7.1.4 Periodic Long-Term Monitoring Program Evaluations

Following the establishment of a post-transition baseline (5 years), the long-term monitoring program will be reevaluated to determine if there are any modifications to the program that are technically warranted—i.e., to include modifications in its composition (e.g., constituents and locations), frequency, and duration. The evaluation will also include an assessment as to the need for continuing long-term monitoring at the site. The first evaluation will be performed 5 years following the year in which the site transition occurred. Reevaluations of the long-term monitoring program will be conducted periodically, based on site conditions, but at least once every 5 years. Monitoring evaluations and recommended modifications to the long-term program will be submitted to the NRC for concurrence prior to implementation.

3.7.1.5 Criteria for Discontinuing Long-Term Monitoring

Long-term groundwater and surface water monitoring at the site will be discontinued entirely once the following criteria have been met: (1) trends have established that ACLs will not be exceeded at the POC (i.e., concentrations of site-related constituents have stabilized for a sufficient period of time, and remain in compliance); (2) trends have demonstrated that ACLs will remain protective at the POE—no exceedance of groundwater protection standards or concentrations above the established range of background values will occur (i.e., attenuation of site-related contamination is occurring as predicted by the groundwater transport model presented in the ACL application); and (3) monitoring has demonstrated that the disposal system is performing as designed (i.e., there is no evidence that any additional contamination is being mobilized from the cell that will result in an exceedance of groundwater protection standards applicable at the POC or POE). Discontinuing of groundwater monitoring will only occur after NRC technical review of a formal request, and their concurrence that doing so is protective of human health and the environment.

3.8 Institutional Control Monitoring

Federal land ownership is the primary IC which serves to ensure long-term protectiveness at the Split Rock, Wyoming, disposal site. IC monitoring will be performed during the annual inspection. During the inspection, DOE will check the site for unauthorized entry, surrounding land use, and disturbance of site features.

Groundwater monitoring will be used to demonstrate that concentrations of site-related constituents remain below applicable groundwater protection standards within the long-term care boundary. Additionally, in 2006, because groundwater quality within the long-term care boundary was considered unsuitable for human consumption or domestic use, ICs were established by WNI with the owners of properties that lied within the long-term care boundary. These ICs, which were tied to the property and transferred to DOE, are in the form of a restrictive covenant that restricts human consumption or domestic use of groundwater within the site's long-term care boundary. This groundwater use restriction was accomplished by securing all rights and interests to the subsurface portions of the affected property that lied deeper than seven feet. In 2012, when transition of the site to DOE occurred, there were three properties to which these ICs were in place. These three ICs are presented in Appendix A. The ICs apply to the deeded property and automatically transfer to any future owner of the affected property. Figure A–1 in Appendix A shows the location of the three properties for which groundwater restrictive covenants are in place within the long-term care boundary. The remainder of the property within the site's long-term care boundary is owned by the federal government, and therefore, groundwater use restrictive covenants were not considered necessary.

Annually, DOE will verify the effectiveness of the groundwater ICs within the long-term care boundary. Specifically, DOE will verify awareness of the ICs by the current land owners and confirm that groundwater is not being used for domestic purposes. DOE will also confirm that no drinking water wells have been established within the site's long-term care boundary. Groundwater ICs may no longer be needed if the criteria to discontinue long-term groundwater monitoring (as specified in Section 3.7.1.5) have been met and regulatory approval to discontinue monitoring has been received. Termination of any established groundwater IC will only occur if regulatory concurrence to do so has been received.

Once every 10 years, beginning in 2022, DOE will also check the records at the Wyoming State Engineer's Office to determine if there have been significant changes in water demands in the vicinity of the site.

3.9 Records

LM receives and maintains selected records to support post-closure site surveillance and maintenance. Inactive records are preserved at a federal records center. Site records 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.

The records are managed in accordance with the following requirements:

- 44 USC 29, "Records Management by the Archivist of the United States and by the Administrator of General Services."
- 44 USC 31, "Records Management by Federal Agencies."
- 44 USC 33, "Disposal of Records."
- 36 CFR 1220 through 1238, Subchapter B, "Records Management."
- DOE Guide 1324.5B, *Implementation Guide*.
- *Office of Legacy Management Information and Records Management Transition Guidance* (DOE 2004).

3.10 Quality Assurance

All activities related to the surveillance and maintenance of the Split Rock disposal site will comply with DOE Order 414.1C, *Quality Assurance*. Quality assurance requirements are routinely fulfilled by use of a work planning process, standard operating procedures, trained personnel, documents and records maintenance, and assessment activities. Requirements will be transmitted through procurement documents to subcontractors for work to be performed at the site, if and when appropriate.

3.11 Health and Safety

Health and safety requirements and procedures for DOE-LM activities are consistent with DOE Orders, federal regulations, and applicable codes and standards. The DOE Integrated Safety Management process serves as the basis for the contractor's health and safety program.

Specific guidance is contained in the *Health and Safety Manual*, LMS/POL/S04321, or current guidance. This manual identifies specific hazards associated with the anticipated scope of work and provides direction for the control of these hazards. During the pre-inspection briefing, personnel are required to review the plan to ensure that they have an understanding of the potential hazards and the health and safety requirements associated with the work to be performed.

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4.0 References

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Appendix A

Real Estate Information and Institutional Control Instruments

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Site Legal Description

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Legal Description of the Long-Term Care Boundary

The legal description of the 3868-acre Split Rock Disposal site's long-term care boundary follows:

LEGAL DESCRIPTION:

A Tract of land in Sections 1-3, 10-14, Township 29 North, Range 92 West;
Sections 6, 7, and 18; Township 29 North, Range 91 West;
Section 31, Township 30 North, Range 91 West;
Sections 35 and 36; Township 30 North, Range 92 West;
All of the 6th P.M., Fremont County, Wyoming.

Said tract of land is also described as the "Long Term Care Boundary" and is described as follows:

Commencing from Point #1, the Point of Beginning, being a point of intersection southerly bank of the Sweetwater River and the section line common to said Sections 34 & 35, T30N, R92W, which point bears N00°18'03"W,a distance of 555.49' from the Southwest corner of said Section 35;
Thence proceed S00°18'03"E, a distance of 555.49' along said section line to the said Southwest corner of Section 35 to Point 2;
Thence S00°34'42"E, a distance of 2567.23' along the section line common to Point 3, being the common ¼ corner of said Sections 2 and 3, T29N, R92W;
Thence N89°53'13W, a distance of 1308.03' along the E-W centerline of said Section 3 to Point 4, being the CE1/16 corner of said Section 3;
Thence S00°49'12E, a distance of 2624.95' to Point 5, being the E1/16 corner common to said Sections 3 and 10;
Thence S00°42'21"E, a distance of 2639.98' to Point 6, being the CE1/16 corner of said Section 10;
Thence S00°34'57"E, a distance of 1647.60' to Point 7, being a point on the northerly boundary of the "Home on the Range Estates" Subdivision;
Thence S75°57'12"E, a distance of 1408.89' along the northerly boundary of the said subdivision to Point 8, being the Northeast corner of the said "Home on the Range Estates" Subdivision;
Thence N89°29'39"E, a distance of 410.00' to Point 9;
Thence S62°51'04"E, a distance of 5414.58' to Point 10, being a point on the section line common to said Sections 13 and 14, T29N, R92W;
Thence S00°35'38"E, a distance of 772.70' to Point 11, being the ¼ corner common to said Sections 13 and 14;
Thence N89°15'34"E, along the East-West centerline of said Section 13 a distance 5282.83' to point 12, being the ¼ corner common to Section 18, T29N, R91W and said Section 13, T29N, R92W;
Thence N00°23'54"W along the section line common to said Sections 18 and 13, a distance of 1355.86' to point 13, being the intersection of the said section line and the northerly right-of-way of U.S. Highway 287;
Thence S87°28'17"E along the said northerly right-of-way a distance of 2568.22' to Point 14, being the intersection of the said northerly right-of-way of U.S. Highway 287 and the North-South centerline of said Section 18;
Thence N00°34'41"W, a distance of 1389.72' to Point 15, being the ¼ corner common to said Section 18 and Section 7;
Thence N89°43'23"E, along the section line a distance of 1324.49' to Point 16, being the E1/16 corner common to Section 18 and Section 7;
Thence N00°28'03"W, a distance of 1322.79' to Point 17, being the SE1/16 corner of said Section 7;
Thence S89°48'27"W, a distance of 1322.08' to Point 18, being the CS1/16 corner of said Section 7;
Thence N00°21'46"W, a distance of 1324.73' to Point 19, being the C¼ corner of said Section 7;
Thence S89°53'33"W, a distance of 2564.44' to Point 20, being the 1/4 common to Said Sections 7 and 12;
Thence S00°28'22"E, a distance of 607.61' to Point 21, along the section line common to said Sections 7 and 12;
Thence S73°37'45"W, a distance of 5497.92' to Point 22, being on the section line common to said Sections 11 and 12, T29N, R92W;
Thence N00°07'40"W, along the said section line, a distance of 2063.40' to Point 23, being the ¼ corner common to said Sections 11 and 12;
Thence N00°30'06"W along the said section line, a distance of 1304.14' to Point 24, being the N1/16 corner common to said Sections 11 and 12;
Thence N88°58'03"E, a distance of 2639.91' to Point 25, being the CN1/16 corner of said Section 12;
Thence N44°35'39"E, a distance of 1871.55' to Point 26, being the E1/16 corner common to said Sections 1 and 12, T29N, R92W;
Thence N88°47'18"E, along the section line common to said Sections 1 and 12, a distance of 1319.13' to Point 27, being the Southeast corner of Said Section 1;
Thence N89°43'03"E, along the section line common to said Sections 6 and 7, T29N, R91W, a distance of 2561.40' to Point 28, being the ¼ corner common to said Sections 6 and 7;
Thence N89°30'50"E, along the section line common to said Sections 6 and 7, a distance of 1323.05' to Point 29, being the E1/16 corner of said Sections 6 and 7;
Thence N00°29'09"W, a distance of 1303.62' to Point 30, being the SE1/16 of said Section 6;
Thence N89°08'57"E, a distance of 1321.40' to Point 31, being the S1/16 corner common to said Sections 5 and 6;
Thence N00°33'34"W along the section line, a distance of 1312.80' to Point 32, being ¼ corner common to said Sections 5 and 6;
Thence N00°45'44"W along the section line, a distance of 824.75' to Point 33, being the intersection point of the East section line of said Section 6 and the southerly bank of the Sweetwater river;
From the point the "Long Term Care Boundary" follows the southerly bank of the Sweetwater River upstream to Point 1, the Point of Beginning.

Said "Long Term Care Boundary" contains 3,870 acres, more or less, dependant upon the course of the Sweetwater River.

NOTES:

1: Bearings based upon NAD83 Wyoming West Central
2: The river boundary based upon USGS quadrangle maps
3: Acreage determination is an estimate based upon the river boundary from the USGS quads.

The real estate correspondence and instruments are maintained and filed by the U.S. Department of Energy.

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Warranty Deed

(to be inserted upon completion)

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Public Land Order
(Federal Register Notice of Permanent Withdrawal)
(to be inserted upon completion)

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Groundwater Institutional Controls

(Restrictive covenants in place to control domestic groundwater use on privately held lands within the long-term care boundary.)

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McIntosh Restrictive Covenant

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LAND USE RESTRICTIVE COVENANT

THIS COVENANT, effective as of the 31st day of May, 1999, is given by Joe E. McIntosh and Jennifer Ann McIntosh for themselves and all future owners of the property identified in Exhibit "A-1" attached hereto ("Owners") for the benefit of Western Nuclear, Inc., a Delaware corporation, c/o Lawrence J. Corte, 200 Union Blvd., Suite 300, Lakewood, Colorado 80228 as owner of the land set forth in Exhibit "A-2" attached hereto and as holder of Nuclear Regulatory Commission ("NRC") License SUA-56, for the benefit of all future or successor owners of the property described in Exhibit "A-2" and for the benefit of all NRC successor licensees charged with responsibility of the Split Rock mill and tailings site described below ("Licensee"), for the reasons and upon the terms hereinafter set forth.

WITNESS

WHEREAS, Licensee formerly operated a uranium mill which was located in the SE¼ of Section 2, T29N, R92W, 6th Principal Meridian, Fremont County, Wyoming under license SUA-56 from the NRC and its predecessor federal agencies; and

WHEREAS, Licensee is in the process of stabilizing the waste or by-product material which resulted from its previous operation of the mill in accordance with the Uranium Mill Tailings Radiation Control Act of 1978 as required by the NRC; and

WHEREAS, Licensee, in its attempt to comply with that statute, desires to arrange for the control and management of by-product material so it will not pose a hazard to public health and safety or the environment; and

WHEREAS, certain by-product material has entered the groundwater and may now or in the future be located under the McIntosh land identified in Exhibit "A-1"; and

WHEREAS, Owners are willing to assist Licensee in its efforts to limit access to by- product material in groundwater under said land.

NOW THEREFORE, in exchange for good and valuable consideration, the sufficiency and receipt whereof being acknowledged, the Owners for themselves, and their successors and assigns and all future owners of the land described in Exhibit "A-1", agrees to refrain from allowing any human use or consumption or any domestic use of water from any new or existing water wells in or upon the land identified in Exhibit "A-1" except upon prior consent of Licensee or any successor Licensee or any successor owner of the land described in Exhibit "A-2". Owners shall permit signage at any existing or new well identifying such restriction. There is no restriction on usage for agricultural, stock water or other ranching purposes.

The Owners specifically agree that the restriction in the preceding paragraph shall be a burden on the land described in Exhibit "A-1" and shall run in favor of and provide benefit to the land described in Exhibit "A-2" and its owner and run in favor of and provide benefit to Licensee and any successor owner or Licensee.

Done and signed this 29 day of May, 1999.

Joe E. McIntosh

Jennifer Ann McIntosh

STATE OF Wyoming)
)
COUNTY OF Fremont)

This Land Use Restrictive Covenant was acknowledged before me this 29th day of May, 1999 by Joe E. McIntosh and Jennifer Ann McIntosh.

My commission expires: June 3, 2001

Judy A. Quarles
Notary Public

(SEAL) JUDY A. QUARLES NOTARY PUBLIC FREMONT COUNTY, WYO.

EXHIBIT A-1

The following described land in Fremont County, Wyoming, is burdened by the McIntosh/Western Nuclear Land Use Restrictive Covenant:

Township 29 North, Range 92 West
NW1/4SW1/4, Section 2
NE1/4SE1/4, Section 3
Township 30 North, Range 91 West
S1/2SW1/4, Section 31

EXHIBIT A-2

The following described land in T29N, R92W, Fremont County, Wyoming is benefitted by the McIntosh/Western Nuclear Land Use Restrictive Covenant: The SW¼ of Section 1 and the NW¼ of Section 12.

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Peterson Restrictive Covenant

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FILE DATE: 10/10/2000 FILE TIME: 02:17 PAGE #: 0001 OF 0003
FREMONT COUNTY, WY, JULIE A FREESE - COUNTY CLERK DOC #: 1214580 **

RESTATED LAND USE RESTRICTIVE COVENANT AND ACCESS EASEMENT

THIS COVENANT AND ACCESS EASEMENT, effective as of the 1st day of June, 1999, is given by Beulah M. Walker, a/k/a Beulah Peterson Walker, c/o Arliss C. Peterson, 2379 W. Bell Ct., #81, Medford, Oregon 97504 and given by Arliss C. Peterson, 2379 W. Bell Ct., #81, Medford, Oregon 97504, for themselves and all future owners of the property identified in Exhibit A-1 attached hereto ("Owners") for the benefit of Western Nuclear, Inc., a Delaware corporation, c/o Lawrence J. Corte, 17222 South Golden Road, Suite A, Golden, Colorado 80401 as owner of the land set forth in Exhibit A-2 attached hereto and as holder of NRC License SUA-56, for the benefit of all future or successor owners of the property described in Exhibit A-2 and for the benefit of Western Nuclear, Inc. and all NRC successor licensees charged with responsibility of the Split Rock mill and tailings site described below for the reasons and upon the terms hereinafter set forth.

WITNESSETH

WHEREAS, Western Nuclear, Inc. formerly operated a uranium mill which was located in the SE 1/4 of Section 2, T29N, R92W 6th Principal Meridian, Fremont County, Wyoming under license SUA-56 from the Nuclear Regulatory Commission (NRC) and its predecessor federal agencies; and

WHEREAS, Western Nuclear, Inc. is in the process of stabilizing the waste or by-product material which resulted from its previous operation of the mill in accordance with the Uranium Mill Trailings Radiation Control Act of 1978 as required by the NRC; and

WHEREAS, Western Nuclear, Inc. in its attempt to comply with that statute, desires to arrange for the control and management of by-product material so it will not pose a hazard to public health and safety or the environment; and

WHEREAS, certain by-product material has entered the ground water and may now or in the future be located under the Peterson land identified in Exhibit A-1; and

WHEREAS, Owners are willing to assist Western Nuclear, Inc. in its efforts to limit access to by-product material in ground water under said land,

NOW, THEREFORE, in exchange for good and valuable consideration, the sufficiency and receipt whereof being acknowledged, Owners for themselves, and their successors and assigns and all future owners of the land described in Exhibit A-1, agree that permitting, drilling, building, opening, or utilizing any new water wells in or upon the land identified in Exhibit A-1 will not be allowed except upon prior consent of Western Nuclear, Inc. or its successors.

Owners for themselves, their successors and assigns additionally hereby grant Western Nuclear, Inc. and its successors an access easement on, over and through the land described in Exhibit A-1 to drill or put in place monitoring wells and to collect samples of ground water and to take such corrective action as may be necessary or required under the provisions of the Uranium Mill Tailings Radiation Control Act, or as may be required by any federal or state agency having jurisdiction, in order to protect the public health and safety, and the environment.

Owners specifically agree that the provisions in the preceding paragraphs shall be a burden on the land described in Exhibit A-1 and shall run in favor of and provide benefit to the land described in Exhibit A-2 and Western Nuclear, Inc. and its successors owners and run in favor of and provide benefit to Western Nuclear, Inc. and its successor Licensees.

Done and signed this 20th day of Sept, 2000.

Beulah Peterson Walker By. Arliss C. Peterson P.O.A.

Beulah Peterson Walker a/k/a
Beulah M. Walker by Arliss C. Peterson
as her agent and attorney-in-fact pursuant to
the power of attorney recorded in the
Fremont County, Wyoming, real property
records in Book 807 at Page 230.

Arliss C. Peterson, Individually

STATE OF OREGON)
) ss.
COUNTY OF Jackson)

OFFICIAL SEAL
RUTH A. WOOTON
NOTARY PUBLIC-OREGON
COMMISSION NO. 058298
MY COMMISSION EXPIRES OCT. 22, 2000

This Restated Land Use Restrictive Covenant and Access Easement was acknowledged before me this 20th day of Sept, 2000 by Beulah Peterson Walker, a.k.a. Beulah M. Walker acting by and through Arliss C. Peterson as her agent and attorney-in-fact.

My commission expires: 10-22-00

Ruth A. Wooton
Notary Public

STATE OF OREGON)
) ss.
COUNTY OF Jackson)

OFFICIAL SEAL
RUTH A. WOOTON
NOTARY PUBLIC-OREGON
COMMISSION NO. 058298
MY COMMISSION EXPIRES OCT. 22, 2000

This Restated Land Use Restrictive Covenant and Access Easement was acknowledged before me this 20th day of Sept, 2000, by Arliss C. Peterson.

My commission expires: 10-22-00

Ruth A. Wooton
Notary Public

EXHIBIT A-1

The following described land in T29N, R92W, Fremont, County, Wyoming, is burdened by the Walker/Western Nuclear Restated Land Use Restrictive Covenant: NE1/4 of Section 14 located south of US Highway 287; NE1/4 NW1/4 of Section 14; and the S1/2 S1/2 of Section 11 (except the westerly 50 feet thereof), owned by Beulah Peterson Walker.

EXHIBIT A-2

The following described land in T29N, R92W, Fremont County, Wyoming is benefitted by the Walker/Western Nuclear Restated Land Use Restrictive Covenant: The SW 1/4 of Section 1 and the NW 1/4 of Section 12.

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Claytor Restrictive Covenant
(Quitclaim Deed)

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Split Rock, WY

QUITCLAIM DEED

Claytor Livestock & Ranch, Co., a co-partnership, P.O. Box 370, Jeffrey City, Wyoming 82310, Grantor, for and in consideration of ten dollars and other good and valuable consideration, the receipt and sufficiency of which is acknowledged, conveys and quitclaims to Western Nuclear, Inc., a Delaware Corporation having its principle address at 200 Union Blvd., Lakewood, Colorado 80228, Grantee, all of Grantor's right title and interest, now held or hereafter acquired, in and to all the subsurface portion of the property described in Exhibit A lying deeper than seven feet below the surface, hereby releasing, reserving, however, unto the Grantor, its, successors and assigns the right to use, maintain, repair, and operate all existing water wells and related watering facilities located on said property for purposes of watering livestock.

The estate hereby granted shall be deemed the dominant estate, and Grantee, and its successors and assigns, acting through authorized agents or employees, are granted the right and a perpetual license to go upon and utilize the surface of said property for purposes of inspections; for purposes of installing, maintaining and utilizing such groundwater monitoring wells as may be required pursuant to the Uranium Mill Tailings Radiation Control Act, as amended; and for purposes of taking such corrective action as may be required the by United States Nuclear Regulatory Commission, or its successor regulatory agency or any other federal or state body having jurisdiction.

Dated this 13th day of Feb, A.D. ~~1999~~ 2000

Claytor Livestock & Ranch Co., a co-partnership
by [signature]
Lonnie J. Claytor, General Partner

State of Wyoming)
) ss
County of Fremont)

The foregoing instrument was acknowledge before me by Lonnie J. Claytor as General Partner of Claytor Livestock & Ranch Co., a co-partnership on this 13th day of February ~~1999~~ 2000

Witness my hand and official seal.

Wallace Jamerman - Notary Public
County of Fremont State of Wyoming
My Commission Expires April 2, 2002

[signature]
Notary Public

My commission expires: April 2, 2002

Z.E.G.   Exhibit A to Claytor--Western Nuclear Quitclaim Deed

Township 29 North, Range 92 West   ~ proposed Bdy is a little different

Section 12: SE¼ & S½SW¼ (240 acres, more or less)

Township 29 North, Range 91 West

Section 7: SW¼ & that portion of the NW¼ lying south of a line drawn from the West quarter corner of said section to the Northeast corner of said section (200 acres, more or less)

[illegible]

Split Rock, WY

QUITCLAIM DEED

Lonnie J. Claytor and Yvonne I Claytor, husband and wife P.O. Box 370, Jeffrey City, Wyoming 82310, Grantors, for and in consideration of ten dollars and other good and valuable consideration, the receipt and sufficiency of which is acknowledged, convey and quitclaim to Western Nuclear, Inc., a Delaware Corporation having its principle address at 200 Union Blvd., Lakewood, Colorado 80228, Grantee, all of Grantors' right title and interest, now held or hereafter acquired, in and to all the subsurface portion of the property described in Exhibit A lying deeper than seven feet below the surface, hereby releasing and waiving all rights under and by virtue of the homestead exemption laws of this state, reserving, however, unto the Grantors, their heirs, successors and assigns the right to use, maintain, repair, and operate all existing water wells and related watering facilities located on said property for purposes of watering livestock.

The estate hereby granted shall be deemed the dominant estate, and Grantee, and its successors and assigns, acting through authorized agents or employees, are granted the right and a perpetual license to go upon and utilize the surface of said property for purposes of inspections; for purposes of installing, maintaining and utilizing such groundwater monitoring wells as may be required pursuant to the Uranium Mill Tailings Radiation Control Act, as amended; and for purposes of taking such corrective action as may be required by the United States Nuclear Regulatory Commission, or its successor regulatory agency or any other federal or state body having jurisdiction.

Dated this 13th day of Feb., A.D. 1999

Lonnie J. Claytor — Lonnie J. Claytor

Yvonne I. Claytor — Yvonne I. Claytor

State of Wyoming)
) ss
County of Fremont)

The foregoing instrument was acknowledge before me by Lonnie J. Claytor and Yvonne I. Claytor on this 13th day of February ~~1999~~ 2000

Witness my hand and official seal.

Wallace Jamerman - Notary Public
County of Fremont
State of Wyoming
My Commission Expires April 2, 2002

[signature]
Notary Public

My commission expires April 2, 2002

7.2.C
4IC

Exhibit A to Claytor–Western Nuclear Quitclaim Deed

Township 29 North, Range 92 West

Section 13: N½ (320 acres, more or less)

Pre-Transition Land Ownership and Restrictive Covenants Map

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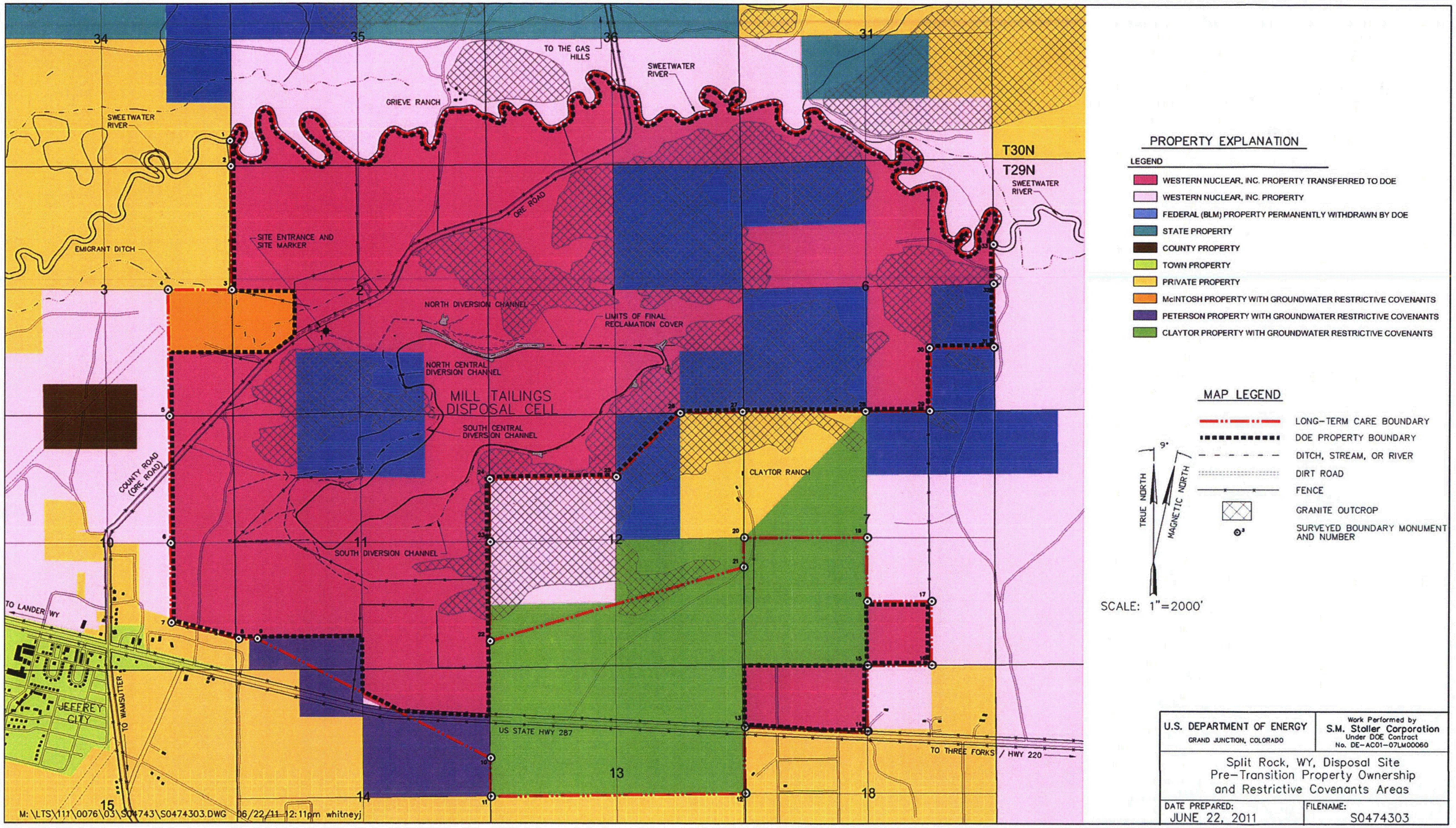

Figure A–1. Pre-Transition Property Ownership and Restrictive Covenants Areas for the Split Rock, Wyoming, Disposal Site

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Appendix B

Vegetation Management and Cover Performance

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B1.0 Introduction

This Appendix explores the state-of-the-science of conventional cover designs with respect to natural degradation processes, alternative designs, and opportunities to enhance long-term performance and reduce long-term maintenance costs, primarily as it pertains to the growth of deep-rooted vegetation on uranium mill tailings disposal cell covers.

Maintenance of disposal cell covers at DOE disposal sites can be costly. Cutting and spraying vegetation growing on covers has been a common practice because of concerns that plant roots will degrade their performance. The cost of herbicide spraying to control deep-rooted vegetation on covers has increased at many sites, and may continue to do so, as ecological conditions become more favorable for plant growth. However, replacement of the low-permeability radon barrier, because of natural degradation processes including root intrusion, could be even more expensive.

Fortunately, recent research indicates that plants may actually be a solution, not a problem. Without human intervention, ecological succession and soil development processes may effectively transform existing conventional covers, with low-permeability radon barriers, into water balance covers. A long-term management option may be to actually enhance this transformation process by anthropogenic means.

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B2.0 Conventional Cover Performance

As with most conventional engineered covers for uranium mill tailings, the Split Rock cover design relies on a compacted soil layer (low-permeability radon barrier) to limit percolation flux and radon flux. Laboratory studies, field investigations, and other lines of evidence show that a few years after construction, permeabilities of compacted soil layers are typically several orders of magnitude greater than assumed or measured at the time of construction (Albright et al. 2004, Melchoir 1997, Waugh et al. 2007, Waugh et al. 2009, Benson et al. 2011a). The percolation rate into the tailings may also be much higher than anticipated, sometimes by several orders of magnitude (Albright et al. 2006a & 2006b, Waugh et al. 2007). Several reasons are cited:

- Unanticipated ecological consequences of designs that encourage plant and animal intrusion (Hakonson 1986, Suter et al. 1993, Bowerman and Redente 1998, Waugh et al. 1999),
- Compaction either dry or wet of optimum during construction (Benson et al. 1999),
- Desiccation cracking (Albrecht and Benson 2001),
- Differences between laboratory and field saturated hydraulic conductivities (Daniel 1984).
- Freeze-thaw cracking(Kim and Daniel 1992, Benson and Otlman 1993),
- Differential settlement (Jessberger and Stone 1991, Lagata 1992), and
- Retention of borrow soil structure (clods) during construction and pedogenesis (soil development processes) after construction (Benson et al. 2011a).

Deep-rooted plants began growing on conventional uranium mill tailings covers at several sites within a few years after construction (DOE 1992). Roots of woody plants were excavated and found to grow down into or through radon barriers at the Grand Junction, Colorado; Lakeview, Oregon; Burrell, Pennsylvania; Durango, Colorado; Shiprock, New Mexico; and Tuba City, Arizona, disposal sites (DOE 1992, DOE 1999, Waugh et al. 2007). Taproots typically extended vertically through the riprap and bedding layers and then branched and spread laterally at the surface of the compacted soil barrier, following both the source of water and the path of least resistance to penetration and growth. Secondary and tertiary roots extended vertically into the compacted soil barrier, where they became fibrous root mats following cracks and soil structural planes.

In follow-up investigations of root intrusion, DOE evaluated the effects of plant roots and soil development on in situ soil hydraulic conductivity (K_s), a measure of permeability, for compacted soil layers at Burrell, Lakeview, Shiprock, and Tuba City using air-entry permeameters (Setphes et al. 1988). At Burrell, the mean K_s was 3.0×10^{-7} m/s where Japanese knotweed roots penetrated the radon barrier, and 2.9×10^{-9} m/s at locations with no plants (Waugh et al. 1999). The weighted-average K_s for the entire cover, calculated using the community leaf area index for Japanese knotweed, was 4.4×10^{-8} m/s. At Lakeview, the mean K_s for the radon barrier both with and without sagebrush and bitterbrush roots was 3.0×10^{-7} m/s (Waugh et al. 2007). The highest K_s occurred near the top of the compacted soil barrier; the lowest K_s occurred deeper in the barrier. The mean K_s in the top of the Shiprock radon barrier was 4.4×10^{-7} m/s (Glenn and Waugh 2001). Results were higher and more variable where tamarisk and Russian thistle were rooted in the radon barrier. The Shiprock radon barrier was nearly saturated, as measured monthly for 16 months at four locations using a neutron hydroprobe. At Tuba City, K_s of the radon barrier had a mean of 8.7×10^{-8} m/s and ranged from 9.8×10^{-11} to 1.2×10^{-6} m/s. In all of the tests mentioned above, dyes indicated that water moved through macropore cracks in the soil structure of radon barriers.

Short-term changes in cover soil properties are not unique to disposal cells for uranium mill tailings. Exhumations of covers in the U.S. Environmental Protection Agency (EPA) Alternative Cover Assessment Program (ACAP) (Albright et al. 2004) show changes to saturated and unsaturated hydraulic properties after 4- to 8-years. Benson et al. (2011a) reported in-service K_s for storage and barrier layers between 7.5×10^{-8} and 6.0×10^{-6} m/s regardless of the initial K_s. Alterations in K_s occurred in all climates and for barrier and storage layers in all cover types. Wet-dry cycling appears to play a major role in altering K_s. Smaller changes in K_s occurred in storage and barrier layers constructed with soils that have lower clay content, soils that have a fines fraction with a greater proportion of silt-size particles, and soils compacted to lower dry unit weight. Benson et al. (2011a) reported that the porosity of most earthen storage and barrier layers evaluated in the ACAP study was between 0.35 and 0.45 when exhumed, and predicted that densely compacted soil layers in engineered covers would loosen over time and become more permeable.

B3.0 Water Balance Covers

In contrast, with conventional low-permeability covers, DOE, EPA, and others have shown that water balance covers can be very effective at limiting percolation at arid and semiarid sites (Dwyer 2001, Albright et al, 2004, Scanlon et al. 2005a & 2005b, Waugh et al. 2009). For example, the average percolation rate from the water balance cover at the Monticello, Utah, Disposal Site has been approximately 0.6 mm/yr for more than a decade during which the average annual precipitation has been 358 mm/yr (Waugh et al. 2009).

Water balance covers consist of thick, fine-textured soil layers that store precipitation in the root zone where it can be removed seasonally by plants (Albright et al 2010). Capillary barriers composed of coarse-textured sand and gravel placed below this soil "sponge" can enhance soil water-storage capacity and limit unsaturated flow (Nyhan et al. 1990, Ward and Gee 1997, Stormont and Morris 1998). Available water storage capacity has been defined as the difference between the total amount of water retained in a soil at field capacity (*upper limit*) and the amount of water remaining when the soil dries to the permanent wilting point for plants (*lower limit of extraction*) (Riche 1981). At the permanent wilting point, soil water tensions become too high for plants to remove more water. Water balance covers can be designed to accommodate changes in soil hydraulic properties caused by the environmental conditions that damage low-conductivity covers (Benson et al. 2011a).

The sustainability of water balance covers will depend, in part, on the establishment and resilience of a diverse plant community (Waugh et al. 1997). Changes in the plant community inhabiting a cover will influence soil water movement, evapotranspiration (ET) rates, and the water balance of a cover. However, plant community dynamics are complicated and effects are difficult to predict. Even in the absence of large-scale disturbances, seasonal and yearly variability in precipitation and temperature will cause changes in species abundance, diversity, biomass production, and soil water extraction rates on covers (Link et al. 1994). Investigations of natural analogs can provide insights as to how ecological processes may influence the sustainability of alternative covers (Waugh et al. 1994). Evidence from natural analogs can improve our understanding of (1) vegetation responses to climate change and disturbances, (2) effects of vegetation dynamics on ET, soil hydraulic conductivity, soil erosion, and animal burrowing, and (3) effects of soil development processes on water storage, hydraulic conductivity, and site ecology.

B4.0 Cover Enhancement Studies

An ongoing DOE research project is testing methods to accelerate and enhance natural processes that are effectively transforming existing conventional covers, which rely on low-permeability compacted soil layers, into water balance covers, that store water in soil and release it as soil evaporation and plant transpiration (Benson et al. 2011b). The goal is to accommodate ecological processes and, thereby, sustain a high level of performance while reducing long-term maintenance costs.

DOE is also investigating potential effects of root intrusion and soil development on radon flux in compacted soil layers and biouptake of contaminants.

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Appendix C

Field Photograph Log

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Field Photograph Log

Site: Purpose of Visit:

Date of Visit: Photo Type: (film and/or digital)

Photo File Name	Film Frame No.	Azimuth	Field Inspection Photo No.	Trip Report PL No.	Post on Web (Y/N)	Photo Caption

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Lead Inspector: Assistant Inspector:
Remarks:
Electronic File Location:

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Appendix D

Initial Site Inspection Checklist

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Inspection Checklist: Split Rock Disposal Site

Date of This Revision: __________
Last Annual Inspection: __________
Inspectors: __________ and __________

Next Annual Inspection (Planned): __________

No.	Item	Issue	Action
1	Protocols	Inform regulators and interested parties of inspection.	Contact NRC and WDEQ 30 days before inspection.
2	Access	Access is from a gravel county road (labeled Ore Road on site map).	None.
3	Specific site surveillance features	See attached list.	Inspect. Identify maintenance requirements.
4	Tailings Impoundment	The surface of the tailings impoundment has been covered with rock mulch and graded to control wind and water erosion.	Inspect impoundment cover and note condition of rock mulch and look for evidence of displacement, degradation, settlement, or slumping.
5	Diversion Channels (4 surround impoundment , see site map)	The storm water diversion channels have been armored with riprap for erosion protection, and graded and sloped to convey runoff and control velocities.	Inspect channels and note evidence of sedimentation, vegetation, and debris build-up that may impact performance; look for hydraulic scour or bank cutting. Inspect riprap; note evidence of rock displacement or degradation.
6	Vegetation	The tailings impoundment has been covered with rock mulch; a vegetative cover was not used at this site (some vegetation has established, including deep-rooted plants). Growth of deep-rooted existed on the tailings impoundment at the time regulatory closure of the disposal site was approved.	No monitoring or control of vegetation (including deep-rooted plants) on the tailings impoundment will be performed under long-term management. Note condition of vegetation (abundance, diversity, extent). Note occurrence of listed noxious or invasive weeds.
7	Site perimeter and balance of the site	Disturbed areas between the tailings impoundment and site ownership boundary have been contoured and revegetated. Site surveillance features are located in this area. Groundwater ICs (i.e., restrictive use covenants) are in place on the three privately held lands within the long-term care boundary; McIntosh, Peterson, and Claytor (see LTSP, Appendix A, Figure A–1)	Inspect for intrusion or other activity or process that can affect protectiveness. Monitor the effectiveness of the groundwater ICs; verify awareness and compliance by land owners.
8	Outlying area	Visually inspect for 0.25 mile beyond site boundary. Note adjacent land use, particularly groundwater use. Look for changes and developments in the surrounding area that could negatively impact the site.	Inspect. Identify any changes or developments that could negatively impact site protectiveness.

Checklist of Site Specific Surveillance Features: Split Rock Disposal Site

<table>
<tr><th>Feature</th><th colspan="2">Comment</th></tr>
<tr><td>Access Road</td><td colspan="2">Gravel road; verify condition is adequate for vehicular access to the site.</td></tr>
<tr><td>Entrance Gate</td><td colspan="2">Metal gate; verify condition (ensure functionality).</td></tr>
<tr><td>Entrance and Perimeter Signs</td><td colspan="2">Total:38; verify condition (intact and legible).</td></tr>
<tr><td>Perimeter Fence</td><td colspan="2">Barbed-wire stock fence (used for livestock management in many locations; maintenance performed by grazing leasee in accordance with agreement).</td></tr>
<tr><td>Boundary Monuments</td><td colspan="2">Total: 33</td></tr>
<tr><td>Site Marker</td><td colspan="2">One (SM-1); near site entrance</td></tr>
<tr><td rowspan="3">Monitor Wells</td><td colspan="2">Total: 10</td></tr>
<tr><td>Northwest Valley Flow Regime</td><td>Southwest Valley Flow Regime</td></tr>
<tr><td>Well-5
WN-42A
WN-41B</td><td>SWAB-12R
SWAB-22
SWAB-29
SWAB-31
SWAB-1R
WN-21
SWAB-2</td></tr>
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Appendix E

Pre-Transition Groundwater Monitoring at the Split Rock, WY, Disposal Site: Evaluation and Recommendations for Long-Term Monitoring

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E1.0 Purpose

Extensive groundwater monitoring has been conducted at the Split Rock, UMTRCA Title II, Disposal Site near Jeffrey City, Wyoming. Upon the concurrent acceptance of a long-term surveillance plan (LTSP) and termination of Western Nuclear Incorporated (WNI) specific source material license (SUA-56) by the U.S. Nuclear Regulatory Commission (NRC), the site is transferred to the U.S. Department of Energy (DOE) for custody and long-term care, and included under the NRC general license at 10 *Code of Federal Regulations* Part 40.28. In order to develop the groundwater and surface water monitoring program presented in the draft LTSP submitted to NRC for concurrence, DOE performed a review of site background documentation and an evaluation of historical (i.e., pre-transition) groundwater and surface water monitoring data. The results of this review and evaluation are presented below.

E2.0 Background

E2.1 History

Uranium milling at the Split Rock site was conducted from 1957 through 1981, when the mill was placed on standby status. The mill remained in standby status until 1986 when it was placed in possession-only status. Decommissioning and demolition commenced in 1988 (Shepherd Miller 1999). Most of the ore for the mill came from open pit mine operations in the Gas Hills district, approximately 20 miles north of the mill site. Other ore supplies came from underground mining operations in the Crooks Gap area, approximately 12 miles south of the mill site (Merritt 1971). The Split Rock mill was an acid-leach, ion-exchange, and solvent-extraction operation that processed approximately 7.7 million tons of ore from 1957 to 1981. The facility, originally designed to process 400 tons of ore per day, underwent two capacity upgrades and by 1967 the milling capacity had been increased to 1,200 tons per day (Shepherd Miller 1999).

During the milling period, process waste in the form of tailings solids and acidic liquids were discharged to the unlined tailings disposal areas. These tailings disposal areas or ponds were designed in 1957 when the design philosophy was to eliminate process effluent through seepage, thereby maximizing solid tailings storage while decreasing water storage and handling requirements. Three primary tailings disposal areas, known as the Main, Old, and Alternate Tailings Impoundments, were used during the operational life of the mill (Shepherd Miller 1999). The final tailings impoundment was designed and constructed to combine these three former tailings disposal areas into one disposal cell.

E2.2 Groundwater Conditions and Use

The reclaimed tailings area at the Split Rock disposal site is located at the head of a natural drainage that is bounded by steep granite outcrops located to the north and the south of the tailings impoundment (Figure E–1). Toward the outlet of this drainage, an additional granite outcrop separates the drainage into two valleys that are referred to as the Northwest Valley and the Southwest Valley. Drainage from the Northwest Valley intersects the alluvial floodplain of the Sweetwater River, while drainage from the Southwest Valley intersects a plain of alluvial deposits in the regional Split Rock aquifer (Shepherd Miller 1999).

Seepage from the tailings impoundments has impacted the groundwater within the Split Rock Formation (regional aquifer) and the Sweetwater River alluvium (floodplain aquifer) in the area underlying and downgradient of the tailings impoundment. Concentrations of site-related contaminants are typically highest in groundwater at the mouths of both the Northwest Valley and Southwest Valley, directly downgradient of the tailings impoundment. Contaminants (in particular uranium) are typically found at depth in the valleys but not outside the valley mouths. The higher hydraulic conductivity and lateral gradient in the alluvium (as compared to the Split Rock Formation) has allowed for further migration of contaminants in this shallower zone downgradient of the Northwest Valley than it has downgradient of the Southwest Valley. The alluvium may also contain buried channel deposits of coarse-grained material that provides preferred pathways for shallow groundwater flow in the floodplain (Shepherd Miller 1999).

Drainage of the tailings historically input up to 1,400 gallons per minute (gpm) into the underlying groundwater system. Since tailings and water disposal in the impoundments ceased in 1986, drainage into the underlying system has greatly diminished, and the elevated groundwater level (i.e., mound) in the immediate area of the impoundment has largely dissipated. In 1999, tailing seepage rates were estimated to be approximately 150 gpm and expected to reach long-term, steady-state rates of less than 5 gpm in the next 30 years (Shepherd Miller 1999).

Horizontal groundwater flow gradients are directed out of the area of high elevation that surrounds the tailings impoundment and toward either the Northwest or Southwest Valley. Groundwater underlying the tailings impoundment is primarily directed down the Northwest Valley (90 percent of the flow), with the balance of the flow (10 percent) directed down the Southwest Valley. This split in the flow is due to the presence of a subsurface granite high located at the head of the Southwest Valley and directly west of the tailings impoundment. Outside of either valley groundwater flowing from the tailings impoundment area merges with the east northeast trending regional groundwater flow of the Split Rock aquifer. An upward vertical gradient occurs in the groundwater of the regional Split Rock aquifer in this area due to the presence of the granite outcrops. This upward vertical gradient results in seepage from the tailings impoundments occurring primarily within the groundwater of the upper portion of the Split Rock aquifer in this area (Shepherd Miller 1999).

Groundwater flow (100 percent) exiting the Northwest Valley combines with the regional groundwater flow of the Split Rock aquifer that is entering the Sweetwater River floodplain alluvial aquifer. The majority of the groundwater flow (80 percent) exiting the Southwest Valley combines with the east northeast trending regional groundwater flow of the Split Rock aquifer. This flow continues along the southern edge of the granite outcrops directly south of the impoundment before migrating beyond the site's eastern boundary where it eventually enters the Sweetwater River floodplain alluvial aquifer. The balance (20 percent) of the groundwater exiting the Southwest Valley flows to the north around the granite outcrops west of the impoundment where it joins the east northeast trending regional groundwater flow of the Split Rock aquifer that is merging with the east flowing groundwater of the Sweetwater River floodplain alluvial aquifer. All groundwater in the immediate area of the tailings impoundment eventually discharges to the Sweetwater River. Groundwater exiting the Northwest Valley reaches the Sweetwater River well before groundwater that exits the Southwest Valley, particularly the majority portion of the flow which travels to the south and joins with the east northeast trending regional groundwater flow of the Split Rock aquifer (Shepherd Miller 1999). The groundwater flow patterns and affected aquifers are shown on Figure E–2 and Figure E–3, respectively.

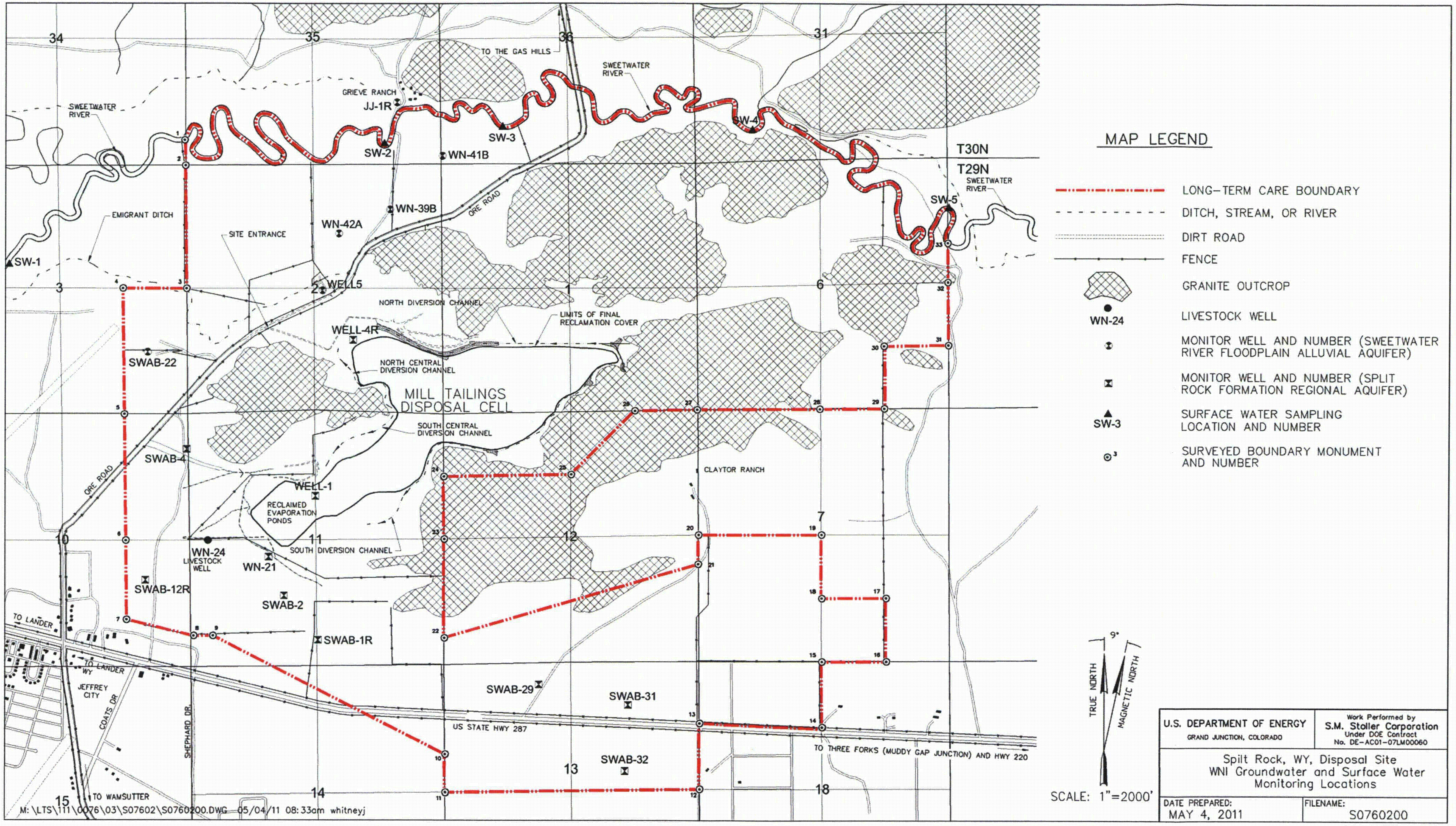

Figure E–1. Split Rock, Wyoming, Disposal Site WNI Groundwater and Surface Water Monitoring Locations

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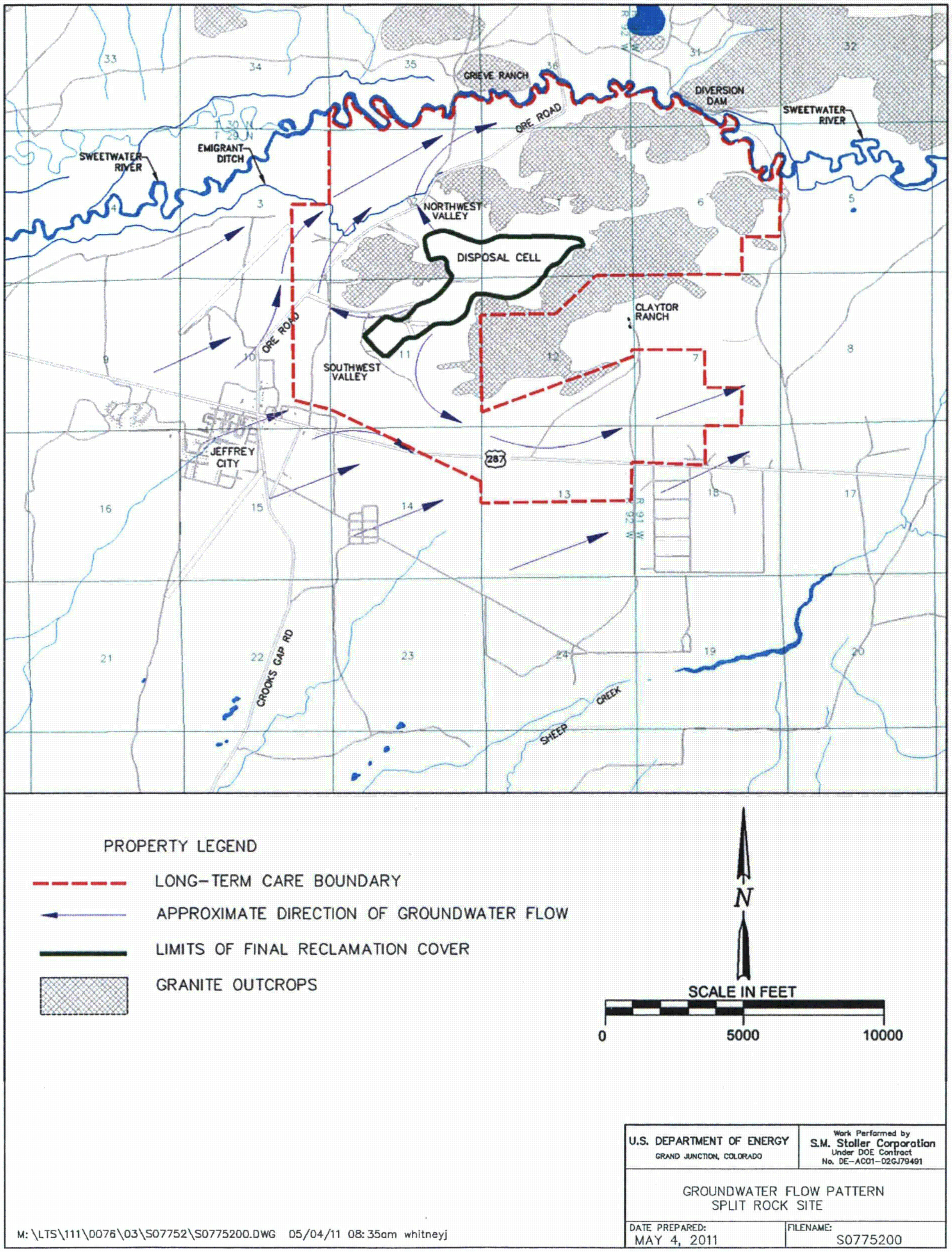

Figure E–2. Groundwater Flow Pattern, Split Rock, Wyoming, Disposal Site

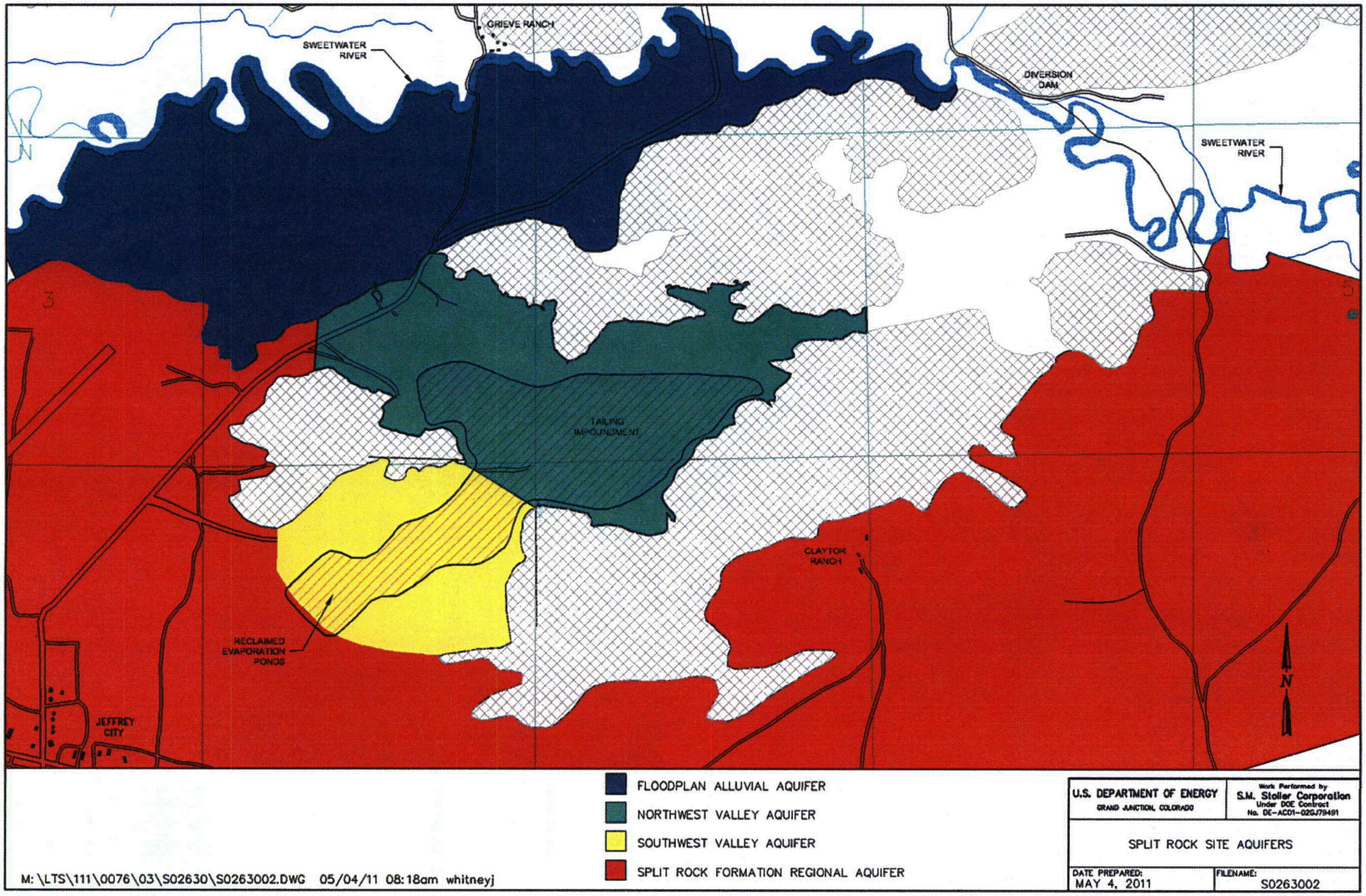

Figure E–3. Split Rock, Wyoming, Disposal Site Aquifers

Groundwater near the site is used for drinking water and livestock watering. Most residents of nearby Jeffrey City derive their water supply from municipal wells, which are completed in the regional Split Rock aquifer west of the site. Therefore, these municipal wells are upgradient of the site and unaffected by site-derived contamination. Groundwater beyond the site's long-term care boundary will likely continue to be used for drinking water and livestock watering (NRC 2006a) and is not expected to be impacted from site-related constituents (Shepherd Miller 1999). The site's long-term care boundary is considered to be the point-of-exposure (POE)

Groundwater within the site long-term care boundary prior to site transition was only used for livestock watering. Although groundwater quality within portions of the site does not meet Wyoming Department of Environmental Quality (WDEQ) Class III livestock standards (i.e., impacted groundwater underlying and directly downgradient of the tailings impoundment), the onsite well used for livestock watering (well WN-24, Figure E-1) is understood to produce water that meets WDEQ Class III standards (NRC 2006a). Following transition, this water well will likely continue to be used for livestock watering under long-term management of the site, provided its water continues to meet WDEQ Class III livestock standards. Any well within the federally-owned portion of the site that is considered for livestock watering under long-term care will be required to meet WDEQ Class III livestock standards. Agriculture conducted within the long-term care boundary prior to site transition was understood to use surface water obtained from the Sweetwater River (or from a groundwater source outside the long-term care boundary); this is expected to continue as such under long-term care. No groundwater obtained within the federally-owned portion of the site will be considered for agricultural use under long-term management unless it first meets WDEQ Class II agriculture standards. Although, groundwater underlying and directly downgradient of the tailings impoundment prior to site transition did not meet WDEQ agricultural or livestock standards, groundwater quality in other areas within the long-term care boundary did comply with WDEQ Class II and Class III standards (NRC 2006a). NRC reviewed the effects of using groundwater from these other areas within the long-term care boundary for agricultural and livestock purposes and concluded it is not likely to impact human health (NRC 2006a).

In 2002, NRC approved the use of ICs within the long-term care boundary to prevent direct human exposure to site-derived contaminants for the duration of the 1,000-year performance period. The ICs control the use of groundwater on privately held lands that lie within the long-term care boundary; three private land owners are impacted. These ICs restrict groundwater from being used for human consumption or any other domestic purpose; although provisions are provided for groundwater to be used for livestock, agriculture, and other ranching purposes on portions of these privately held lands to which the ICs apply. DOE plans to maintain these groundwater ICs under long-term care.

E2.3 Groundwater Corrective Action and Establishment of ACLs

The formal groundwater Corrective Action Program (CAP) at the site began in 1990 when pumping was begun from four collection wells. The primary purpose of the system was to accelerate dewatering of the tailings impoundment. The system was designed to capture from 47.3 million gallons to 66 million gallons of water per year. Beginning in January 1990 the wells operated year round. In February 1992 the pumping duration was reduced to about 6 months per year (April through October), with the required volume of captured water remaining the same as initially specified. Recovered groundwater was piped to an evaporation pond and to an evaporation misting system that sprayed water over the over the unreclaimed portion of the tailings impoundments (Shepherd Miller 1999).

In 1999, WNI concluded that continued corrective action would not be effective in reducing contaminant concentrations in groundwater further and issued a groundwater characterization and evaluation report (Shepherd Miller 1999) to support the selection of a corrective action alternative. This report is also referred to as the site closure plan. While the groundwater CAP was effective in minimizing seepage from the tailings impoundment, based on the performance to date, it was determined that the continued operation of the system was unlikely to achieve the groundwater protection standards specified in the license (SUA-56). Therefore, based on the presumed continued ineffectiveness of the active remediation system, WNI proposed that alternate concentration limits (ACLs) be determined for the site's point of compliance (POC) that are protective of human health and the environment, and which would result in compliance with groundwater protection standards (or established background concentrations) at the long-term care boundary (i.e., POE). The 1999 groundwater characterization and evaluation report submitted to NRC is considered the ACL application.

It was also recognized at the time ACLs were being considered that the groundwater remediation system was having no effect on the pulses of contamination that had migrated beyond the system's extraction wells (Thompson 2005; NRC 2006a). Indeed, it had been established that significant amounts of hazardous constituents from the tailings seepage had become associated with the aquifer solids and would slowly re-mobilize into the groundwater over time, and that at least some of this secondary source term was downgradient of the edge of the reclaimed tailings (Shepherd Miller 1999). This is contradictory to regulations at Criterion 5D of Appendix A in 10 CFR 40 which state that the groundwater CAP "must also address removing or treating in place any hazardous constituents that exceed concentration limits in ground water between the point of compliance and the downgradient facility property boundary".

Criterion 5B(1) of Appendix A of 10 CRF 40 states that the objective of the POC i.e., is to provide "the earliest practicable warning that the impoundment is releasing hazardous constituents to the ground water" and that the POC "must be selected to provide prompt indication of ground-water contamination on the hydraulically downgradient edge of the disposal area". The POC is also the location where regulatory compliance with approved background values, maximum contaminant levels (MCLs), or ACLs is specified under Criterion 5B(5). In this regard the groundwater characterization and evaluation report (Shepherd Miller 1999) stated that "the POC wells for this site under the proposed alternative should be located down gradient of all known source terms and existing peak ground water concentrations".

Information provided in support of the ACL application (Shepherd Miller 1999) included a baseline risk assessment which evaluated the current and future environmental and human health risks associated with the establishment ACLs as required per 10 CFR 40, Appendix A, Criterion 5B[6]. Base on this evaluation a list of constituents of concern (COCs) was determined for which ACLs would be proposed. The COCs determined were natural uranium, combined radium-226 and radium-228, ammonia, manganese, molybdenum, and nitrate. ACLs for these six COCs were proposed for both the Northwest Valley and Southwest Valley flow regimes.

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COCs were established through a process that determined which site-related constituents present in the tailings had migrated beyond the disposal cell at concentrations that exceeded the higher of either background levels, applicable groundwater protection standards (i.e., MCLs), or risk-based concentrations, and that also presented a risk to human health and the environment when considering the existing exposure pathways. Maximum groundwater concentrations from the tailings area from 1996 through 1997 were compared to background concentrations of both the Sweetwater River floodplain alluvial aquifer and the Split Rock Formation regional aquifer. Those constituents that were not detected in concentrations greater than background concentrations were discarded from consideration as a COC. Maximum groundwater concentrations from the tailings area from 1996 through 1997 were considered a conservative representation of the conditions at the time. Pre-1996 concentrations were considered to be non-representative of the current conditions at the time due to the evolution of groundwater flow and geochemical conditions (Shepherd Miller 1999).

E2.4 Groundwater Modeling

Flow and transport modeling of uranium and sulfate was also conducted in support of the ACL application. The flow modeling was done using MODFLOW and the transport modeling was done using RAND3D. In the 2003 supplemental report the flow modeling was again done using MODFLOW, whereas the transport modeling was done using MT3DMS.

Uranium was used in the transport modeling because it was determined to be the most conservative and extensive COC (i.e., its transport would encompass the transport of all other COCs). Sulfate, determined to be another of the more mobile COC, was modeled to confirm the assumptions and predictions made regarding uranium's mobility. In other words, by modeling uranium, and confirming the assumptions and predictions with sulfate, it was assumed that the mobility of these two constituents would represent the furthest extent of mobility of all other site-related hazardous constituents. The transport model used measured uranium and sulfate concentration distributions from 1986 as the initial conditions; the model was then calibrated to measured 1996 concentration distributions (Shepherd Miller 1999).

It is understood that this modeling was conducted in an effort to predict the downgradient behavior of site-related contaminants over time; both those concentrations associated with the legacy plume (which was acknowledged to have migrated some distance beyond the edge of the tailings area and the capture zone of the groundwater CAP) and those concentrations anticipated to be released from the tailings impoundment in the future under long-term surveillance. Modeling predictions were intended (and used) to establish a long-term care boundary that would be protective (i.e., one that assures concentrations of site-related constituents will be compliant with applicable groundwater protection standards or established background concentrations at the POE or site long-term care boundary).

The COCs other than uranium were not modeled explicitly, but were modeled implicitly. The behavior of other constituents were determined or calculated from relationships and observations that the licensee determined relative to uranium. Indeed, the 1999 groundwater characterization and evaluation report states: "Simulation of other constituents which migrate without retardation would transport in identical patterns to uranium. Reactive solutes would tend to lag behind uranium." (Section H.c.3.3, General Chemical Transport). Although NRC had some issues with the modeling, such as simple retardation using an equilibrium K_d approach, their technical evaluation stated: "Although the staff finds that the models for uranium transport are likely oversimplified, all information WNI provided indicates that viable mechanisms exist for uranium retardation and/or removal, at this site." (Section 3.3, Flow and Transport Modeling) (NRC 2006b).

In response to WNI's October 29, 1999 submittal of the site's groundwater characterization and evaluation report, NRC replied (by letter dated December 15, 2000) with a request for additional information regarding the Red Mule subdivision area and the durability of the ICs (i.e., groundwater restrictive covenants) that were planned for this closest downgradient residential area where human consumption of groundwater was occurring. WNI responded with a supplement (WNI 2000) to the report. The supplement discussed "protective levels" in the area of the former Red Mule subdivision (directly east of well SWAB-31; Figure E–1). Predicted future concentrations of three site-related constituents were provided for this area; uranium was estimated to range from 0.3 to 0.8 mg/L, manganese from 0.5 to 1.0 mg/L, and nitrate from 30 to 50 mg/L. Predictive modeling indicated that groundwater in this area could be impacted by site-related constituents in approximately 100 years (Shepherd Miller 1999).

Groundwater modeling also predicted the following: 1) that uranium would mark the maximum extent of site-related contamination in both the Sweetwater River floodplain alluvial aquifer and in the regional Split Rock Formation aquifer; 2) that concentrations would be protective at the POE (i.e., the site's long-term care boundary); 3) that groundwater within the site's long-term care boundary would ultimately discharge into the Sweetwater River; and 4) that if concentrations of site-related constituents at the POC stayed below the maximum concentrations observed they would be protective (Shepherd Miller 1999).

E2.5 Approval of ACLs, Establishment of Trigger Levels, and Discontinuance of the Groundwater Corrective Action Program

In 2006, in response to WNI's ACL application submittal (and supplemental information), NRC prepared an environmental assessment (EA) for amendment of WNI's source materials license (SUA-56) (NRC 2006a). In the EA, NRC recognizes that the ACLs being established must be as low as reasonably achievable (ALARA) in accordance with requirements set forth in regulations at Criterion 5B(6) of Appendix A in 10 CFR 40. NRC also noted in the EA that "current groundwater constituent concentrations are ALARA…" and issued a subsequent finding of no significant impact (FONSI) approving the establishment of ACLs. ACLs were established for ammonia, manganese, molybdenum, nitrate, combined radium -226 and -228, and uranium for both the Northwest Valley and Southwest Valley flow regimes (ACL values are provided below in Section E3.0).

While not explicitly stated in site documentation reviewed for this evaluation, it is assumed that the ACL values to be met at the POCs were set to evaluate future performance of the tailings impoundment (i.e., concentrations of site-related constituents will be compliant with applicable groundwater protection standards or established background concentrations at the long-term care boundary, or POE). As long as ACL values are maintained at the POCs, the impoundment is judged to be performing acceptably.

In approving the ACLs, NRC also established a set of trigger levels for both groundwater and surface water. Trigger levels were established for each constituents with an ACL; ammonia, manganese, molybdenum, nitrate, combined radium -226 and -228, and uranium (values are provided below in Section E3.0). Trigger levels established in NRC's 2006 EA are reported to correspond to background, MCLs, or EPA risk-based concentration where MCLs are not available. It appears that NRC may have established the trigger levels to serve as an early warning for the contaminant pulses that had migrated downgradient of the POCs in order to help ensure protectiveness of areas outside the long-term care boundary (such as the former Red Mule subdivision). It is not clear if the trigger levels were established in lieu of modeling the behavior of the contaminant pulse; although it is indicated in the 1999 groundwater characterization report that the model took into consideration what are referred to as "secondary source terms" (i.e., tailings seepage that had migrated beyond the impoundment and become associated with the aquifer solids, and which would then slowly re-mobilize into the groundwater over time) (Shepherd Miller 1999).

According to WNI's license (SUA-56), compliance with these trigger levels was applicable at the POE. Specific POE wells to which compliance with the groundwater trigger levels would have been required were not designated in the license for either the Split Rock (regional) aquifer or the floodplain (alluvial) aquifer, although it is assumed that they would have been applicable at the well closest to the POE for each flow regime. The Sweetwater River, which serves as the POE for the northern portion of the site (because it defines the site's long-term care boundary), is where the surface water trigger levels are presumed to have been applicable, although WNI's license did not specifically identify a surface water POE. It is also understood that the trigger levels for both groundwater and surface water were established based on maintaining compliance with water quality standards or established background concentrations at the POE. Although these trigger levels were a license condition for WNI, there appears to have been no other regulatory basis for their application. It should be noted that the Split Rock site is the only site that DOE is aware of where trigger levels were established and included as part of the licensee's monitoring program.

Following NRC's approval of ACLs (and the establishment of trigger levels) for the Split Rock site, the groundwater corrective action program was terminated in 2006 after removing a total of 375.3 million gallons of groundwater.

E2.6 Historical Nitrate Concentrations in Excess of the ACL at Non-POC Wells

Concentrations of nitrate in well SWAB-2 were found to have continuously been reported in excess of the ACL value since before the nitrate ACL was proposed in 1999; more recently (since 2009) the nitrate ACL has also been exceeded in replacement well SWAB-1R. Well SWAB-2 is directly downgradient of the Southwest Valley POC (well WN-21) and well SWAB-1R is directly downgradient of well SWAB-2 (Figure E–1). As noted above, it was recognized that an elevated pulse of contamination had moved beyond the POC in the Southwest Valley.

These elevated concentrations of nitrate are believed to be site-related as ammonia used in the uranium milling process degrades to nitrate in the environment. Based on the above statement from NRC's 2006 EA, which indicates that prior to site transition groundwater constituent concentrations were considered to be ALARA, it is assumed that the observed levels of nitrate were determined to be acceptable. It is further assumed that the trigger levels were

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established as a check on the natural attenuation of this remnant plume (that was not addressed during the groundwater CAP).

Additionally, these nitrate concentrations in excess of the ACL appear to have not been considered a regulatory non-compliance event for WNI, presumably because the monitoring requirements in their source material license (SUA-56), specifically Condition 74C, states that compliance with ACLs are applicable at the designated POC wells and these concentrations which exceed the ACL occurred at wells directly downgradient of the Southwest Valley POC (well WN-21). Nevertheless, there is some concern that continued nitrate concentrations in excess of the ACL at these non-POC wells under long-term monitoring could result in an out-of-compliance event, regardless of whether the concentration occurs at a well that is downgradient of the POC. This concern is based on the following statement found in 10 CFR 40, Appendix A, Criterion 5B(1): "Hazardous constituents entering the ground water from a licensed site must not exceed the specified concentration limits in the uppermost aquifer beyond the point of compliance during the compliance period."

However, correspondence between the licensee and NRC indicate that they were aware of the elevated contaminant concentrations downgradient of the POC in the legacy plume. In addition, site groundwater modeling and the associated determination of the long-term care boundary considered these historical nitrate concentrations above the ACL downgradient of the POC. The groundwater model indicates that concentrations of nitrate (and all other hazardous constituents) will not exceed background values at the long-term care boundary and therefore, protection of human health and the environment would be ensured at the POE. Further protection appears to have been provided by the trigger levels established for the site which provide an early warning that a groundwater protection standard could potentially be exceeded at the POE.

Because of this concern, language should be included in the LTSP which states that continued concentrations of nitrate in excess of the ACL at these non-POC wells (SWAB-2 or SWAB-1R) under long-term monitoring will not be considered a regulatory out-of-compliance event. The LTSP should also state that regulatory compliance with established ACLs is required at the designated POC wells, as it was under WNI's source material license SUA-56. However, the LTSP should go on to mention that an exceedance of an applicable standard at the POE (for any hazardous constituent) will be considered a regulatory out-of-compliance event under long-term monitoring.

E2.7 Establishment of Selenium ACL, Other Groundwater Protection Standards, and Revised Uranium Trigger Level

Additional correspondence took place between WNI and NRC to amend the license (SUA-56) with respect to the groundwater and surface water monitoring program for the Split Rock site (i.e., appropriate monitoring wells, analytical parameters, monitoring frequency, and applicable standards). WNI provided additional information to NRC upon request, including supplemental groundwater modeling and analysis. The most recent license amendment request was analyzed in the final EA published by NRC in January 2010 (NRC 2010a); a FONSI was also issued in January 2010 regarding this recent license amendment request. In February 2010, NRC approved the license amendment request, and issued a technical evaluation report and amended license to WNI (NRC 2010b). The amended license (SUA-56, Amendment No. 105, February 24, 2010) contained the current standards and monitoring requirements for the site. The following provides a summary of these most recent license amendment requests.

In 2008, concentrations of selenium at the Northwest Valley POC (Well-5) were noted to exceed the groundwater protection standard of 0.013 mg/L that had been established for the site. As a result, NRC directed WNI to respond to the selenium exceedance. In 2009, WNI responded by submitting a license amendment request proposing the establishment an ACL for selenium at the site equal to the U. S. Environmental Protection Agency (EPA) 40 CFR 141 maximum contaminant level (MCL) for drinking water (0.05 mg/L). As part of the regulatory process, NRC completed an EA for the establishment of the selenium ACL. The EA also addressed WNI's license amendment request to modify the uranium trigger level for groundwater (NRC 2010a). The EA was published in the *Federal Register* on February 5, 2010.

In a concurrent action NRC also approved WNI's license amendment request to establish groundwater protection standards at the site for several other constituents (aluminum 37 mg/L, antimony 0.006 mg/L, arsenic 0.05 mg/L, fluoride 4 mg/L, and thallium 0.002 mg/L), to modify the standard for beryllium (from 0.05 mg/L to 0.01 mg/L), to delete chromium from the list of required monitoring constituents, and to increase the trigger level for uranium in groundwater from 0.03 mg/L to 0.087 mg/L for the Split Rock regional aquifer and to 0.044 mg/L for the Sweetwater River floodplain alluvial aquifer (to reflect established background concentrations) (NRC 2010b).

E2.8 Background and Historical Concentrations of Hazardous Constituents

ACLs and other groundwater protection standards, along with historical concentrations of hazardous constituents (for both background and the tailings area) that were monitored in accordance with WNI's source material license (SUA-56, Amendment No. 105, February 24, 2010) prior to transition of the site to DOE are provided in Table E–1.

E3.0 Monitoring Requirements of Source Materials License SUA-56

Table E–2 through Table E–4 summarize the monitoring requirements and standards (including established ACLs and trigger levels) presented in WNI's source materials license SUA-56, as amended (Amendment No. 105, February 24, 2010). The analytes monitored are considered the COCs for the site (see previous discussion in Section E2.3 on how COCs were determined for the site).

Table E–1. ACLs, Groundwater Protection Standards and Historical Concentrations (Background and Tailings Area) for Hazardous Constituents at the Split Rock, Wyoming, Disposal Site

Constituent	ACL[a] (applicable at the POC)		Groundwater Protection Standard[b]	Maximum Historical Concentrations[c]		Background Concentrations[c]	
	Northwest Valley	Southwest Valley		Tailings Area	Beyond Tailings Area	Floodplain Alluvial Aquifer	Split Rock Formation Aquifer
Aluminum (mg/L)			37	578	2.02	0.1	0.13
Ammonia (mg/L)	0.61	0.84		0.16	2.35	0.011	0.015
Antimony (mg/L)			0.006	0.017	0.01	0.005	0.005
Arsenic (mg/L)			0.05	2.64	0.058	0.024	0.1
Beryllium (mg/L)			0.01	0.084	<0.01	0.004	0.01
Cadmium (mg/L)			0.01	0.188	0.014	0.008	0.014
Fluoride (mg/L)			4	21.7	1.33	1.04	0.517
Lead (mg/L)			0.05	0.11	0.005	0.005	0.050
Manganese (mg/L)	225	35		126	49.1	2.39	0.53
Molybdenum (mg/L)	0.66	0.22		0.55	0.22	0.1	0.1
Nickel (mg/L)			0.05	2.29	0.11	0.05	0.05
Nitrate (mg/L)	317	70.7		362	201	0.88	3.99
$Ra^{226+228}$ (pCi/L)	7.2	19.9		2950	13.5	4.7	5.3
Selenium (mg/L)	0.05[d]	0.05[d]	0.05[d]	0.119	0.061	0.005	0.011
Thallium (mg/L)			0.002	0.075	0.013	0.013	0.003
$Thorium^{230}$ (pCi/L)			0.95	732	5.5	5.5	1.8
Uranium (mg/L)	4.8	3.4		4.055	8.7	0.044	0.087[e]

ACL = alternate concentration limit; POC = point of compliance; mg/L = milligrams per liter;
pCi/L = picocuries per liter; Ra = radium.

[a] ACLs are applicable at the POC (Shepherd Miller 1999).

[b] Groundwater protection standards obtained from WNI's Source Material License (SUA-56), Amendment No. 105, License Condition 74B&C.

[c] Maximum historical concentrations and background concentrations obtained from Volume 1 of the *Site Ground Water Characterization and Evaluation* (i.e. the ACL application), Table 17 (Shepherd Miller 1999).

[d] The ACL for selenium is equivalent to the EPA maximum contaminant level (MCL) for drinking water (NRC 2010b).

[e] The background concentration for uranium was revised subsequent the value included in the *Site Ground Water Characterization and Evaluation* (NRC 2010b).

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Table E–2. Groundwater and Surface Water Monitoring Requirements from WNI's License SUA-56 for the Split Rock, Wyoming, Disposal Site

Groundwater Monitoring Requirements		
Wells	**Analytes**	**Frequency**
NWV: JJ-1R, WN-39B, WN-41B, WN-42A **SWV**: SWAB-1, SWAB-2, SWAB-4, SWAB-12, SWAB-22, SWAB-29, SWAB-31, SWAB-32	Uranium, sulfate	Semi-annually
NWV: JJ-1R, WN-39B, WN-41B, WN-42A **SWV:** SWAB-1, SWAB-2, SWAB-4, SWAB-12, SWAB-22, SWAB-29, SWAB-31, SWAB-32	Aluminum, ammonia, antimony, arsenic, beryllium, cadmium, chloride, fluoride, lead, manganese, molybdenum, nickel, nitrate, pH, combined radium-226 and -228, selenium, sulfate, thallium, thorium-230, TDS, uranium	Annually
NWV: WELL-4R, Well-5 **SWV:** WELL-1, WN-21	Aluminum, ammonia, antimony, arsenic, beryllium, cadmium, chloride, fluoride, lead, manganese, molybdenum, nickel, nitrate, pH, combined radium-226 and -228, selenium, sulfate, thallium, thorium-230, TDS, uranium	Semi-annually
Surface Water Monitoring Requirements		
Location	**Analytes**	**Frequency**
Sweetwater River: SW-1 thru SW-5	Uranium, sulfate	Semi-annually
Sweetwater River: SW-1 thru SW-5	Aluminum, ammonia, antimony, arsenic, beryllium, cadmium, chloride, fluoride, lead, manganese, molybdenum, nickel, nitrate, pH, combined radium-226 and -228, selenium, sulfate, thallium, thorium-230, TDS, uranium	Annually

Information obtained from Conditions 24 and 74 of WNI's source material license SUA-56 (Amendment 105, February 24, 2010).
NWV = Northwest Valley, SWV = Southwest Valley, TDS = total dissolved solids

Table E–3. Alternate Concentration Limits and Groundwater Protection Standards from WNI's License SUA-56 for the Split Rock, Wyoming, Disposal Site

Analyte	ACL Northwest Valley (POC; Well–5)	ACL Southwest Valley (POC; Well WN-21)	Groundwater Protection Standard
Aluminum			37 mg/L
Ammonia	0.61 mg/L	0.84 mg/L	
Antimony			0.006 mg/L
Arsenic			0.05 mg/L
Beryllium			0.01 mg/L
Cadmium			0.01 mg/L
Chloride			2,000 mg/L[b]
Fluoride			4 mg/L
Lead			0.05 mg/L
Manganese	225 mg/L	35.0 mg/L	
Molybdenum	0.66 mg/L	0.22 mg/L	
Nickel			0.05 mg/L
Nitrate	317 mg/L	70.7 mg/L	
pH			
Ra-226 + Ra-228	7.2 pCi/L	19.9 pCi/L	
Selenium	0.05 mg/L[a]	0.05 mg/L [a]	0.05 mg/L[a]
Sulfate			3,000 mg/L[b]
Thallium			0.002 mg/L
Thorium-230			0.95 pCi/L
TDS			5,000 mg/L[b]
Uranium (natural)	4.8 mg/L	3.4 mg/L	NA

Information obtained from Condition 74 of WNI's source material license SUA-56 (Amendment 105, February 24, 2010), except groundwater protection standards for chloride, sulfate, and TDS.
[a] The ACL for selenium is equivalent to the EPA maximum contaminant level (MCL) for drinking water (NRC 2010b).
[b] Indicator constituents only; standards are Wyoming Class III Groundwater Protection Standards for Livestock.
ACL = alternate concentration limit; mg/L = milligrams per liter; pCi/L = picocuries per liter, POC = point of compliance; POE = point of exposure, TDS = total dissolved solids.

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Table E–4. Trigger Levels for Groundwater and Surface Water from WNI's License SUA-56 for the Split Rock, Wyoming, Disposal Site

Analyte	Surface Water Trigger Levels (POE; Long-Term Care Boundary[a])	Split Rock Aquifer Trigger Levels (POE; Long-Term Care Boundary)	Floodplain Aquifer Trigger Levels (POE; Long-Term Care Boundary)
Ammonia	0.5 mg/L[a]	0.5 mg/L	0.5 mg/L
Manganese	0.05 mg/L	0.73 mg/L	2.39 mg/L
Molybdenum	0.18 mg/L	0.18 mg/L	0.18 mg/L
Natural Uranium	0.03 mg/L[b]	0.087 mg/L (0.3 mg/L[c])	0.044 mg/L
Nitrate	10 mg/L	10 mg/L	10 mg/L
Ra-226 + Ra-228	5.0 pCi/L	5.0 pCi/L	5.0 pCi/L

Information obtained from Condition 74 of WNI's source material license SUA-56 (Amendment 105, February 24, 2010).
mg/L = milligrams per liter; pCi/L = picocuries per liter.
[a] EPA groundwater risk-based concentration (RBC).
[b] EPA maximum contaminant level (MCL) for drinking water.
[c] Applicable at well SWAB-32.

Note: WNI's source material license (SUA-56) required compliance with trigger levels at the point of exposure (POE). The POE for groundwater is understood to be the site's long-term care boundary; no specific wells are designated in WNI's source material license SUA-56. The POE for surface water is understood to be the Sweetwater River. Trigger levels appear to have been established to be used as a "trigger" for raising concern should these concentrations be reached at the POE. This approach is presumed to have been taken because of the recognition that a pulse of groundwater contamination had migrated beyond the point of compliance (POC) and beyond the capture zone of WNI's groundwater corrective action program. Therefore, it is understood that trigger levels were established as a safeguard for monitoring the natural attenuation of the legacy plume, whereas the alternate concentration limits (ACLs) were established for monitoring the performance of the disposal cell.

E4.0 Evaluation for Determination of Long-Term Monitoring Requirements

In preparation of DOE's LTSP for the Split Rock disposal site, DOE reviewed historical site documentation, WNI's monitoring requirements (as described in their source materials license SUA-56, Amendment No. 105, February 24, 2010), and historical monitoring data for both groundwater and surface water at the site. This evaluation provided the basis for the long-term monitoring program included in the LTSP. This review was conducted to support two main objectives: 1) the selection of hazardous constituents and indicator parameters and (2) the selection of appropriate groundwater and surface water monitoring locations to include in the long-term monitoring program. Results of this evaluation are discussed below.

Time-concentration plots of historical results for constituents monitored in accordance with WNI's source materials license SUA-56 are provided in Attachment E–1.

E4.1 Selection of Hazardous Constituents and Indicator Parameters

Criterion 5B(3) of Appendix A in 10 CFR 40 allows the NRC, on a site specific basis, to exclude a detected constituent from the set of hazardous constituents required to be monitored "if it finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment." This includes a consideration of a number of factors including site characteristics, land and water uses, and potential effects that groundwater might have on surface water or other media with which it may come in contact.

Table E–3 lists the hazardous constituents required to be monitored in accordance with Condition 24 (surface water) and Condition 74 (groundwater) of WNI's source materials license (SUA-56, Amendment No. 105, February 24, 2010). Of these constituents, all but six were determined in WNI's site groundwater characterization and evaluation report (Shepherd Miller 1999) to not exceed background or protective values (MCLs or risk-based concentrations) beyond the POC at present (as of 1999) or in the future based on modeling predictions (though these values could be exceeded in the tailings area).

A look at data since the site's groundwater characterization and evaluation report was prepared in 1999 confirms this conclusion. Several constituents have never been detected in levels exceeding protective concentrations or background, or have only exceeded these levels in the tailings wells (Well-1 for the Southwest Valley and Well-4R for the Northwest Valley). These constituents include aluminum, antimony, arsenic, beryllium, cadmium, chloride, fluoride, lead, nickel, selenium, thallium, and thorium-230. On the basis of their very limited distribution and low concentrations, DOE believes that these constituents are not capable of posing a substantial present or potential hazard to human health or the environment. In addition, these constituents are unlikely to be good indicators of cell performance or monitoring natural attenuation of the legacy plume, and therefore, DOE proposes that they be eliminated from the long-term monitoring requirements.

The six remaining hazardous constituents—ammonia, manganese, molybdenum, nitrate, combined radium-226 and -228, and uranium—were those previously identified as COCs and for which ACLs were established (Note; although not originally considered a COC, an ACL for selenium was subsequently established, see Section E2.7). Of these remaining COCs, WNI estimated that only manganese, uranium, and nitrate had the potential to be transported as far as the former Red Mule subdivision area (WNI 2000). The Red Mule subdivision had been located in an area that is now within the southeastern portion of the long-term care boundary and protected by institutional controls (i.e., a groundwater restrictive covenant).

Each of these six remaining hazardous constituents (COCs) with ACLs—ammonia, manganese, molybdenum, nitrate, combined radium-226 and -228, and uranium—is discussed separately below and evaluated for inclusion in the long-term monitoring network (including selenium for which an ACL was also established).

Ammonia. Ammonia data have been difficult to interpret based on the various ways it can be reported (total as nitrate, "unionized ammonia," "free ammonia"). According to the licensee, the ACL for ammonia is based on "unionized" or "free" ammonia. At the time of the ACL application, aquatic standards for ammonia were commonly based on only the unionized fraction (EPA 1998). Since that time, the federal EPA ambient water quality criterion (AWQC) for protection of aquatic life was changed to reflect "total ammonia (as N)" (EPA 1999). Groundwater trigger levels established in NRC's 2006 EA are reported to correspond to established background values, MCLs, or EPA risk-based concentrations (where MCLs are not available). The ammonia trigger level of 0.5 mg/L apparently corresponds to the State of Wyoming's groundwater standard for domestic use (most of these State standards correspond to EPA's drinking water MCLs). However, the Wyoming standards are reported as total ammonia as N (Chapter 8, Quality Standards for Wyoming Groundwaters). EPA has a lifetime health advisory for ammonia in drinking water of 30 mg/L (presumably total as N; EPA 2009).

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Although ammonia was used in the processing of uranium, it has mainly been detected in the tailings wells (Well-1 and Well-4R) at the Split Rock site. Concentrations in the Southwest Valley have declined appreciably, while those in the Northwest Valley have fluctuated within a relatively consistent range. There have been only occasional exceedences of the ACL and the EPA benchmark, most notably in the tailings wells. Well SWAB-2 has also displayed elevated levels of ammonia, but from the onset has continued to decline until reaching concentrations in recent years that are below both the ACL and the EPA benchmark. Because this decline is accompanied by a corresponding increase in nitrate, it is likely the result of degradation of ammonia to nitrate. Because ammonia degrades to nitrate and also because of the confusion over the ammonia standards, DOE proposes that ammonia be excluded as an analyte in the long-term monitoring program and that nitrate be used as a surrogate.

Manganese. High levels of manganese have been observed historically in tailings wells (Well-1 in Southwest Valley and Well-4R in Northwest Valley); concentrations also reached the ACL in Well-1 as recently as the spring of 2010. Predicted future concentrations are close to identified "protective" concentrations that were determined for the area of the former Red Mule subdivision directly east of SWAB-31 (WNI 2000). DOE therefore proposes to retain manganese as an analyte in the long-term monitoring program.

Molybdenum. Molybdenum has rarely been detected over the last decade and only at levels close to the detection limit, though the detection limit used was often the same as the molybdenum standard in 40 CFR 192. However, based on the lack of significant detections, it is unlikely that molybdenum is capable of posing a substantial present or potential hazards to human health or the environment. DOE therefore proposes to exclude molybdenum as an analyte in the long-term monitoring program.

Nitrate. Nitrate concentrations have been reported in excess of the ACL in wells SWAB-2 and SWAB-1R since their installation in 1996 and 2009, respectively (see Sections D2.6). Ammonia also degrades to nitrate (see above recommendation to exclude ammonia from the long-term monitoring program). DOE therefore proposes to retain nitrate as an analyte in the long-term monitoring program.

Combined Radium-226 and -228. The combined radium-226 and -228 standard has occasionally been exceeded in the past, but radium levels have appeared to be rather stable over the last several years. Radium does not appear to be capable of posing a substantial present or potential hazard to human health or the environment and is not a good indicator of cell performance. However, because radium is the primary radioactive hazardous constituent which remains in the impounded tailings waste material (as identified on the site marker), DOE therefore proposes to retain the analysis of combined radium-226 and -228 in the long-term monitoring program.

Selenium. An ACL of 0.05 mg/L was established for selenium in 2010 after the site-specific standard of 0.013 mg/L was exceeded at the Northwest Valley POC (Well-5) and the downgradient well WN-42A. The NRC approved selenium ACL is the same as EPA's primary drinking water standard (MCL) under the safe drinking water act (0.05 mg/L, see Section D2.7). That standard has not been exceeded in any site well except in the two tailings wells (in 1995 at the Northwest Valley Well-4R and in 1984 at the Southwest Valley Well-1). Selenium is also not considered to be a good indicator of site-related contamination.

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In addition, proposed revisions to EPA's groundwater protection standards at 40 CFR 192 (that are adopted by reference into the general license at 10 CFR 40.28) are anticipated to become more in line with EPA's drinking water MCLs. The UMTRCA groundwater protection standard for selenium (as listed in Appendix A, Table 1 of the general license) is 0.01 mg/L and the EPA MCL is 0.05 mg/L. The UMTRCA standard for selenium is therefore anticipated to be revised to 0.05 mg/L, consistent with EPA's MCL which has never been exceeded at the POC wells or any well downgradient of the POC and concentrations appear relatively stable.

DOE therefore, proposes to exclude selenium as an analyte in the long-term monitoring program.

Uranium. Uranium was used in flow and transport modeling conducted in support of the ACL application. Because uranium is a good indicator of cell performance and will be useful in monitoring the natural attenuation of the legacy plume (i.e., model validation), DOE proposes to retain uranium as an analyte in the long-term monitoring program.

Other Indicator Constituents (Sulfate and TDS). DOE also proposes to retain sulfate and total dissolved solids (TDS) as indicator constituents in the long-term monitoring program. Sulfate was used in the flow and transport modeling conducted in support of the ACL application (to confirm the assumptions and predictions made regarding uranium's mobility). Both sulfate and TDS are good indicators of cell performance and will be useful in monitoring the natural attenuation of the legacy plume (i.e., model validation). DOE therefore proposes to retain sulfate and TDS as an analytes in the long-term monitoring program.

E4.2 Selection of Groundwater and Surface Water Monitoring Locations

Each monitoring location specified in WNI's source material license SUA-56 (Amendment No. 105, February 24, 2010) (Figure E–1) was evaluated to determine whether it would add value to the proposed long-term groundwater monitoring program presented in the LTSP. The evaluation took into account the requirement for establishment of POC and POE locations (as discussed in NRC's guidance and standard review plan for Title II uranium mill ACL applications [NRC 1996]) as well as the need to monitor both future cell performance and attenuation of the legacy contaminate plume.

E4.2.1 Northwest Valley Groundwater Flow

The majority (90%) of the groundwater underlying the tailings impoundment flows out the Northwest Valley (Figure E–2). Groundwater flow exiting the Northwest Valley combines with the east northeast trending regional groundwater flow of the Split Rock aquifer that is merging with the east flowing groundwater of the Sweetwater River floodplain alluvial aquifer. Groundwater exiting the Northwest Valley discharges to the Sweetwater River.

- Well-5 was designated the POC well for the Northwest Valley because it is downgradient of the tailings impoundment (approximately 1,200 feet [ft]) and peak concentrations. Well-5 was also determined to be downgradient of any so-called secondary source terms (i.e., tailings seepage that had migrated beyond the impoundment and become associated with the aquifer solids, and which would slowly re-mobilize into the groundwater over time [Shepherd Miller 1999]). Well-5 still contained concentrations greater than average concentrations for the valley; however, it was also recognized that elevated concentrations of site-related constituents occurred further downgradient. Well-5 is screened over a broad portion of the aquifer and was located in the center of the existing and predicted future flow path for this flow regime. Well-5 is recommended for retention in the long-term monitoring network as the POC for the Northwest Valley.

- Well-4R is located approximately 1,200 ft upgradient of the designated POC (Well-5) on the edge of the portion of the tailing impoundment that extends into the Northwest Valley. Well-4R is labeled in the 1999 groundwater characterization and evaluation report as a "tailings and source area well (above POC)" (Shepherd Miller 1999, Figure 7). The depth, completion interval, formation information, etc., is unknown for Well-4R because no construction or lithologic logs were available from the licensee. The concentration for many of the site-related hazardous constituents at Well-4R is higher than any of the other wells in this flow regime and the pH is also lower. This data is not surprising considering the proximity of the well to the tailings impoundment. It appears that Well-4R is strongly influenced by the seepage from the tailings impoundment. Well-4R is recommended for elimination from the long-term monitoring network as the interpretation of monitoring data from this location is ambiguous.
- Well WN-41B is the farthest downgradient location for monitoring site-related constituents in groundwater exiting the Northwest Valley (i.e., the monitoring point closest to the POE for this groundwater flow regime). The POE for this flow regime is understood to be the Sweetwater River; although the POE is not specifically designated in WNI's license. Well WN-41B is located approximately 1,000 ft upgradient of the Sweetwater River. Well WN-41B is recommended for retention in the long-term monitoring network because it is the farthest downgradient groundwater monitoring point for the Northwest Valley flow regime, and is the well best suited for demonstrating that site-related contamination exiting the Northwest Valley has not reached the POE at concentrations above applicable standards.
- Wells WN-42A and WN-39B both monitor natural attenuation between the Northwest Valley POC (Well-5) and the farthest downgradient monitoring point (Well-41B), and as such, are somewhat redundant. Well WN-42A is located approximately 1,000 ft downgradient of the POC. WN-39B is located approximately 1,000 ft downgradient of Well WN-42A. It is recommended that well WN-42A—the more upgradient and closer to the POC of the two wells—be retained to provide an earlier signal of potential changes in trend or concentration. Well WN-39B is recommended for elimination from the long-term monitoring network.
- Well JJ-1R is located directly north of the Sweetwater River and historical groundwater monitoring data shows no indication of site-related contamination at this location. The Split Rock tailings impoundment lies approximately 4,000 ft south of the Sweetwater River. Contaminated groundwater in the area of the impoundment flows out of the Northwest Valley and into the floodplain alluvial aquifer which discharges to the Sweetwater River. As demonstrated by the fifteen years historical data, there is no indication that site-related contamination will migrate north of the river, and therefore, continued monitoring of Well JJ-1R will not provide any additional benefit. Concentrations at well WN-41B (just south of the river) can also be used to assess whether there is any cause for concern for areas further to the north. Well JJ-1R is therefore recommended for elimination from the long-term monitoring network.
- *Surface Water Monitoring:* Concentrations of site-related constituents in groundwater exiting the Northwest Valley discharge to the Sweetwater River (Shepherd Miller 1999, Figure 3), although no evidence of concentrations above applicable standards have ever been reported in surface water samples collected from the river; likely because of dilution (i.e., at

minimum low flow, groundwater discharge is only estimated to account for approximately 20 percent of river flow). Surface water monitoring was conducted by WNI for five years at five locations across the site; an upstream and downstream location and three locations in between within the site. This monitoring provides adequate baseline data. However, because concentrations of site-related constituents do discharge to the Sweetwater River (the designated POE) it is recommended that monitoring of location SW-3 be continued under the long-term monitoring program in order to demonstrate that site-related constituents continue to not negatively impact the river. SW-3 is the surface water sampling location on the Sweetwater River that is directly in line with the groundwater flow path exiting the Northwest Valley and downgradient of well WN-41B. Long-term monitoring results will be compared against any applicable surface water standards.

E4.2.2 Southwest Valley Groundwater Flow

The remaining portion (10 percent) of the groundwater underlying the tailings impoundment that doesn't flow out of the Northwest Valley flows out the Southwest Valley (Figure E–2). Approximately 80 percent of the groundwater exiting the Southwest Valley (or 8 percent of the total underlying the impoundment) flows to the south and east around the granite outcrops where it combines with the east northeast trending regional groundwater flow of the Split Rock aquifer. This flow continues along the southern edge of the granite outcrops south of the impoundment and then beyond the site's eastern boundary where it ultimately enters the Sweetwater River floodplain alluvial aquifer. The balance (20 percent) of the groundwater exiting the Southwest Valley (or 2 percent of the total underlying the impoundment) is diverted to the north around the granite outcrops west of the impoundment where it joins the east northeast trending regional groundwater flow of the Split Rock aquifer that is merging with the east flowing groundwater of the Sweetwater River floodplain alluvial aquifer. All groundwater exiting the Southwest Valley eventually discharges to the Sweetwater River.

Southwest Valley Flow to the South

- Well WN-21 was designated the POC well for the Southwest Valley also because it was directly downgradient of the tailings impoundment (approximately 1,500 ft) and peak concentrations. The Southwest Valley POC was also determined to be downgradient of any so-called secondary source terms (i.e., tailings seepage that had migrated beyond the impoundment and become associated with the aquifer solids, and which would then slowly re-mobilize into the groundwater over time [Shepherd Miller 1999]). The Southwest Valley POC also still contained concentrations greater than average concentrations for the valley; however, it was again recognized that elevated concentrations of site-related constituents occurred further downgradient. POC well WN-21 is also located in the center of the existing and predicted future groundwater flow path for this flow regime. Well WN-21 is recommended for retention in the long-term monitoring network as the POC for the Southwest Valley.
- As with Well-4R in the Northwest Valley, Well-1 is located upgradient of the designated POC (approximately 1,500 ft) on the edge of the portion of the tailing impoundment that extends into the Southwest Valley. Well-1 is also directly upgradient of the remediated groundwater corrective action evaporation ponds. Again, no construction or lithologic logs are available for this well so the depth, completion interval, formation information, etc., is unknown. The concentration for some of the site-related hazardous constituents is also higher at this well than any of the other wells in this flow regime and the pH is again lower.

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This data is also not surprising considering the proximity of this well to the tailings impoundment, and it again appears that this location is strongly influence by the seepage from the tailings impoundment; however, the influence is not as strongly as Well-4R in the Northwest Valley (likely a result of the lower volume of tailings impoundment impacted groundwater that exits the Southwest Valley as compared to the Northwest Valley). Interpretation of monitoring results from Well-1 is ambiguous (as it is with Well-4R in the Northwest Valley). It is therefore recommended that Well-1 be eliminated from the long-term monitoring network.

- Wells SWAB-31 and SWAB-32 are the farthest downgradient locations for monitoring site-related constituents in groundwater exiting the Southwest Valley. These wells lie approximately 4000 feet upgradient of the POE (i.e., the long-term care boundary) and 8,000 feet downgradient of the POC (i.e., well WN-21) for this groundwater flow regime. However, because the regional groundwater flow will likely keep any flow exiting the Southwest Valley further to the north and nearer to the granite outcrops, site-related constituents would be more likely first detected at well SWAB-29 (and then at SWAB-31, the next downgradient well) before any indication would be reported at well SWAB-32. Additionally, because well SWAB-32 is located in a known (or suspected) area of higher uranium concentrations that are reported to be naturally-occurring, it would be difficult to attribute any observed increase in uranium concentrations to contamination migration or mobilization that is associated with the tailings impoundment. Therefore because of the ambiguity in interpreting results from well SWAB-32, it is recommended that this well be eliminated from the long-term monitoring network and that wells SWAB-29 and SWAB-31 be retained. It is further recommended that because well SWAB-31 is the farthest downgradient groundwater monitoring point for the Northwest Valley flow regime, it is the well best suited for demonstrating that site-related constituents exiting the Northwest Valley has not reached the POE at concentrations above applicable standards. It should also be noted that wells SWAB-29 and SWAB-31 are located in an area already protected by groundwater restrictive covenants.

- Well SWAB-2 is located approximately 1,000 ft downgradient of the Southwest Valley POC (well WN-21), midway between the POC and well SWAB-1R. Analyte concentrations at well SWAB-2 are higher (and for some much higher) than for the POC well WN-21 and well SWAB-1/1R. As discussed above, a pulse of site-related contamination likely migrated beyond the POC that could be passing through the well SWAB-2 area. It is therefore recommended that SWAB-2 be retained in the long-term monitoring network until data confirm that contaminants are clearly attenuating as predicted in this area.

- Well SWAB-1 was located approximately 1,000 ft downgradient of well SWAB-2. As a response action to NRC, well SWAB-1R was installed in May 2009 as a replacement well for well SWAB-1 which had been found to be dry at the time of sampling for several of the previous years. Well SWAB-1R was installed at the same location as the original well SWAB-1 but was completed 15 feet deeper in depth (well screen depths; SWAB-1 was 17.5 to 27.5 ft whereas SWAB-1R is from 17.4 to 42.8 ft). Initial monitoring results from the replacement well reported an increase in the uranium concentration (from 0.62 mg/L in SWAB-1 to 1.91 mg/L in SWAB-1R) and the sulfate concentration (from 428 mg/L in SWAB-1 to 1,000 mg/L in SWAB-1R). The concentration of uranium in replacement well SWAB-1R reached a maximum of 2.46 mg/L in September 2009 before returning to a pre-replacement level of 0.74 mg/L in September 2010. Correspondingly, the concentration of sulfate in replacement well SWAB-1R increased to its maximum of 1,200 mg/L in

September 2009 before returning to a pre-replacement level of 563 mg/L in September 2010. This situation initially raised question regarding the concentration of site-related hazardous constituents at increased depth in this location, as data suggests that a pulse of contamination could be passing through the area (see Sections E2.3 thru E2.5 above). Well SWAB-1R should therefore be retained to determine how future analyte concentrations correspond to past concentrations in the original shallower well SWAB-1.

Southwest Valley Divergent Flow to the North

- Well SWAB-4 is located approximately 3,000 ft downgradient of the tailings impoundment and provides an early detection point for monitoring any site-related contamination exiting the Southwest Valley that is diverted north to merge with the east northeast trending regional flow entering the Sweetwater River alluvial floodplain. For most of the contaminants that have an ACL or other groundwater protection standard, the concentration in well SWAB-4 is consistently higher than at the next downgradient well (SWAB-22, located near the western edge of the long-term care boundary). Although monitoring data from well SWAB-4 are somewhat limited, it appears that concentrations have been relatively stable over the last several years. The higher concentrations at SWAB-4 are likely the result of two processes. First, regional flow from the west should keep contamination near the granite outcrop (Note; an upward vertical gradient occurs in the groundwater of the regional aquifer due to the presence of the granite formations which results in seepage from the tailings impoundments occurring primarily in the upper portion of the aquifer in this area). Second, the contamination has likely decreased due to natural attenuation if it were to reach as far west as well SWAB-22. Monitoring and modeling have demonstrated that any contamination in the vicinity of well SWAB-4 will remain within the western edge of the long-term care boundary. Contamination that persists beyond SWAB-4 would also be detected at downgradient monitoring points in the Sweetwater River alluvial floodplain; although, natural attenuation may occur first. Additional data from well SWAB-4 would provide little useful information and therefore this well is recommended for elimination from the long-term monitoring network.

- Well SWAB-22 has been used historically to monitor the west northwest edge of the long-term care boundary. The monitoring data to date have shown no evidence of site-related contamination; however, the monitoring history of this well is not extensive. SWAB-22 is located approximately 400 ft inside the long-term care boundary, 2,000 ft downgradient of well SWAB-4, and approximately 5,000 ft downgradient of the tailings impoundment. Well SWAB-22 demonstrates that any site-related hazardous constituents exiting the Southwest Valley have not reached the POE (long-term care boundary) and the McIntosh property (where groundwater restrictive covenants have been instituted as a precaution). Data from well SWAB-22 also demonstrates that groundwater exiting the Northwest Valley that is diverted north around the granite outcrop and mergers with groundwater in the regional Split Rock aquifer (and then with the Sweetwater River floodplain aquifer) continues its east northeast flow and thereby assures continued containment of any site-related contamination within the long-term care boundary. Well SWAB-22 therefore is recommended for retention in the long-term monitoring network.

- Well SWAB-12 was used historically to monitor the west southwest edge of the long-term care boundary. The monitoring data to date have shown no evidence of site-related contamination; however, the monitoring history of this well is also not extensive. SWAB-12 was located approximately 300 ft inside the long-term care boundary. As with well

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SWAB-1R, well SWAB-12R was installed a response action to NRC in May 2009 as a replacement well for well SWAB-12 which had been found to be dry at the time of sampling for several of the previous years. Well SWAB-12R was also installed at the same location as the original well SWAB-12 but was again completed 15 feet deeper in depth (well screen depths; SWAB-12 was 9.0 to 19.4 ft whereas SWAB-12R is from 8.7 to 34.1 ft). Monitoring results from the replacement well have reported a slight decrease in both uranium and sulfate concentrations. Well SWAB-12R is also located approximately 2,500 ft from POC well WN-21. Data from this monitoring location demonstrates that any site-related hazardous constituents exiting the Southwest Valley have not reached the POE (long-term care boundary) and Jeffrey City. Well SWAB-12R also demonstrates that groundwater in the regional Split Rock aquifer continues its east northeast flow and thereby assures continued containment of any site-related contamination within the long-term care boundary. Well SWAB-12R therefore is recommended for retention in the long-term monitoring network.

E4.2.3 Summary of Recommended Long-term Monitoring Requirements

Based on conclusions reached from the evaluation of WNI's pre-transition groundwater and surface water monitoring program (and its historical results), the review of site documents, and the information provided above, a recommended long-term monitoring program is proposed for incorporation into the site LTSP. Table E–5 and Table E–6 summarize DOE's proposed long-term monitoring requirements for the Split Rock disposal site.

It is understood that ACLs were established to monitor long-term performance of the disposal cell. Therefore, it is recommended that these ACLs be incorporated into the long-term monitoring program and be applicable at the designated POC well for each groundwater flow regime (i.e., Well-5 for flow exiting the Northwest Valley and well WN-21 for flow exiting the Southwest Valley), as specified under Criterion 5B(5) of 10 CFR 40, Appendix A.

However, because there is no basis for trigger levels found within the regulations, it is recommended that the trigger levels established at the site for manganese, nitrate, combined radium -226 and -228, and uranium (Table E–4) should not be incorporated into the long-term monitoring program. Instead, it is recommended that DOE compare monitoring results in the wells closest to the POE (i.e., site long-term care boundary) to groundwater protection standards applicable offsite to ensure compliance continues to be maintained. Surface water monitoring results are recommended to be compared to water quality standards applicable to the Sweetwater River to ensure compliance continues to be maintained.

As discussed in Section E2.6, historic nitrate concentrations in excess of the ACL at wells downgradient of the POC appear to have not been considered a regulatory non-compliance event for WNI, presumably because the monitoring requirements in their source material license (SUA-56) explicitly states that compliance with ACLs are applicable at the designated POC wells, and these concentrations occurred at wells directly downgradient of the Southwest Valley POC (well WN-21)—i.e., in wells SWAB-2 and SWAB-1R. Therefore, it is recommended that DOE includes language in the LTSP which states that continued nitrate concentrations in excess of the nitrate ACL at these non-POC wells under long-term monitoring will not be considered a regulatory out-of-compliance event. As stated above, DOE considers compliance with established ACLs to be applicable at the designated POC wells, as it was for WNI under license SUA-56 prior to site transition.

The frequency of monitoring is recommended to be reduced from semi-annual to annual for the first year of long-term monitoring. Annual monitoring is then recommended to continue at all locations in the long-term monitoring network except at wells SWAB-22, SWAB-29, and SWAB-31 in the Southwest Valley flow regime, well WN-41B in the Northwest Valley flow regime, and surface water location SW-3, where monitoring is recommended to be reduced to once every five years. The technical basis for recommending reducing the frequency to once every five year at these farthest downgradient locations is based on groundwater flow and transport modeling which determined that site-related constituents would not reach these locations for many years (i.e., in the Southwest Valley flow regime) or because stability below groundwater protection standards has been demonstrated and upgradient locations being sampled annually provide protection.

It is recommended that the long-term monitoring program be reevaluated after 5 years (and periodically thereafter based on site conditions) to determine if there are any modifications to the monitoring program that are technically warranted—i.e., to include modifications in composition (e.g., constituents and locations), frequency, and duration. The evaluation should also include an assessment as to the need for continuing long-term monitoring at the site. Monitoring evaluations and recommended modifications to the long-term program should be submitted to the NRC for concurrence prior to implementation.

Table E–5. Proposed Long-Term Monitoring Plan for the Split Rock, Wyoming, Disposal Site

Groundwater Monitoring		
Wells*	**Analytes**	**Frequency**
NWV Flow Regime: Well-5 (POC well), WN-41B (furthest downgradient well), WN-42A **SWV Flow Regime:** WN-21 (POC well), SWAB-1R, SWAB-2, SWAB-12R, SWAB-22, SWAB-29, SWAB-31 (furthest downgradient well)	manganese, nitrate, combined radium-226 and -228, sulfate, TDS, uranium (and standard field measurements; pH, temperature, conductivity, alkalinity, dissolved oxygen, and turbidity)	Annually for all wells except well WN-41B in the NWV flow regime and wells SWAB-22, SWAB-29, and SWAB-31 in the SWV flow regime where monitoring should be reduced to once every five years following the first annual long-term monitoring event.
Surface Water Monitoring[a]		
Location	**Analytes**	**Frequency**
Sweetwater River: SW-3	manganese, nitrate, combined radium-226 and -228, sulfate, TDS, uranium (and standard field measurements; pH, temperature, conductivity, alkalinity, dissolved oxygen, and turbidity)	Annually for the first long-term monitoring event, once every five years thereafter.

NWV = Northwest Valley; SWV = Southwest Valley; TDS = total dissolved solids.

[a] Site-related constituents being monitored in surface water should be compared to the Human Health Values for Fish and Drinking Water that are applicable to Wyoming Class 2AB waters (Section 18, Chapter 1 of the Wyoming Department of Environmental Quality's Water Quality Rules and Regulations).

* Note: Water level measurements will be taken at each well prior to sampling. Wells not otherwise designated are considered trend wells for their respective flow regime. The designations for both the groundwater monitoring wells and the surface water monitoring location were adopted from WNI's historical names used for these monitoring locations to maintain continuity.

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Table E–6. Alternate Concentration Limits and Groundwater Protection Standards for Long-Term Monitoring Constituents at the Split Rock, Wyoming, Disposal Site

Analyte	ACL* Northwest Valley (POC; Well-5)	ACL* Southwest Valley (POC; Well WN-21)	Groundwater Protection Standard
Manganese	225 mg/L	35.0 mg/L	
Nitrate	317 mg/L	70.7 mg/L	100 mg/L[b]
Combined Radium-226 and -228	7.2 pCi/L	19.9 pCi/L	5.0 pCi/L[b]
Sulfate[a]			3,000 mg/L[b]
TDS[a]			5,000 mg/L[b]
Uranium (natural)	4.8 mg/L	3.4 mg/L	

ACL = alternate concentration limit; mg/L = milligrams per liter; pCi/L = picocuries per liter; POC = point of compliance; POE = point of exposure; TDS = total dissolved solids.
[a] Indicator constituents only.
[b] Standards are Wyoming Class III Groundwater Protection Standards for Livestock and applicable at the POE.
* Note: ACLs are applicable at the designated POC wells, as they were prior to transition under WNI's source material license SUA-56 (Amendment 105, February 24, 2010) and as specified under Criterion 5B(5) of 10 CFR 40, Appendix A. Nitrate concentrations in excess of the ACL in well SWAB-2 (directly downgradient of the POC) and well SWAB-1R have been reported since their installation in 1996 and 2009, respectively. Therefore, continued concentrations in excess of the nitrate ACL in these wells under long-term monitoring will not be considered an out-of-compliance event.

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Appendix E–1

Trend Graphs

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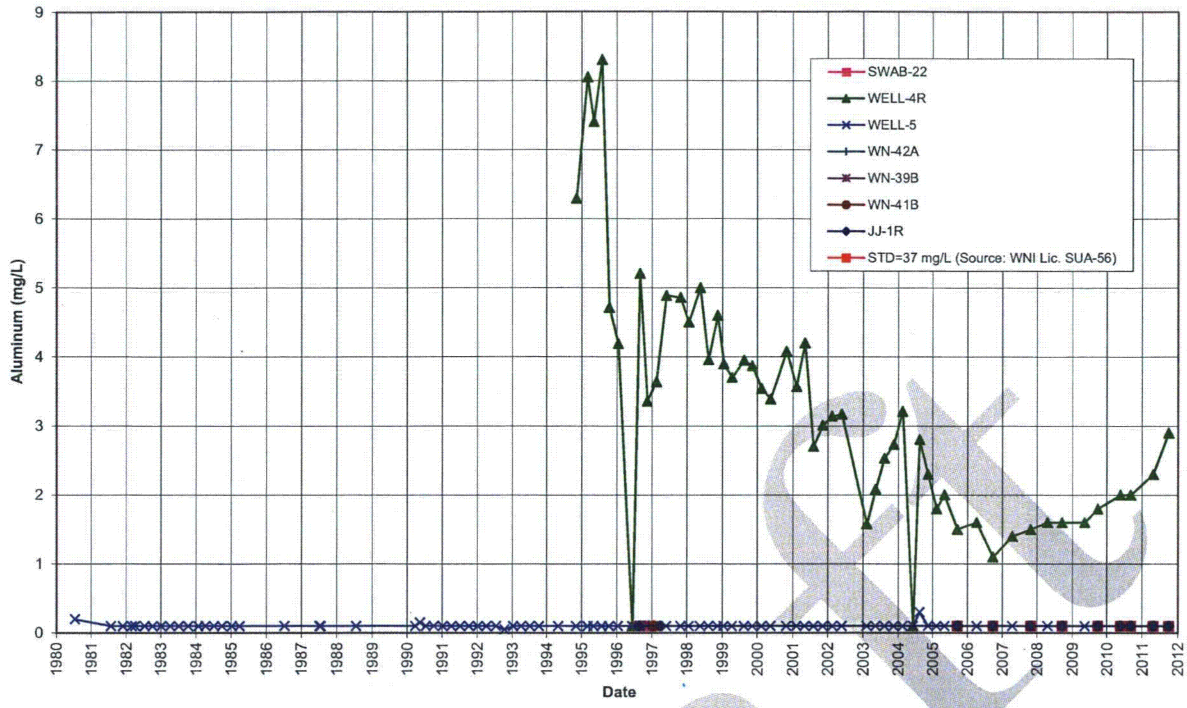
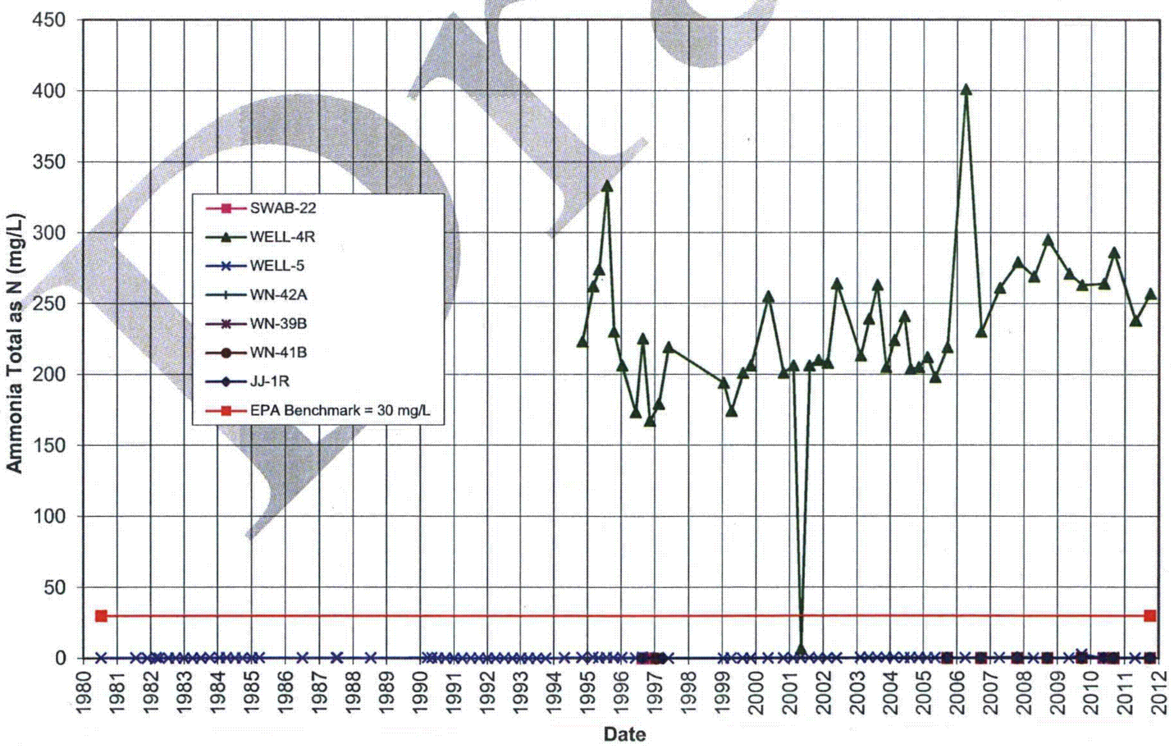
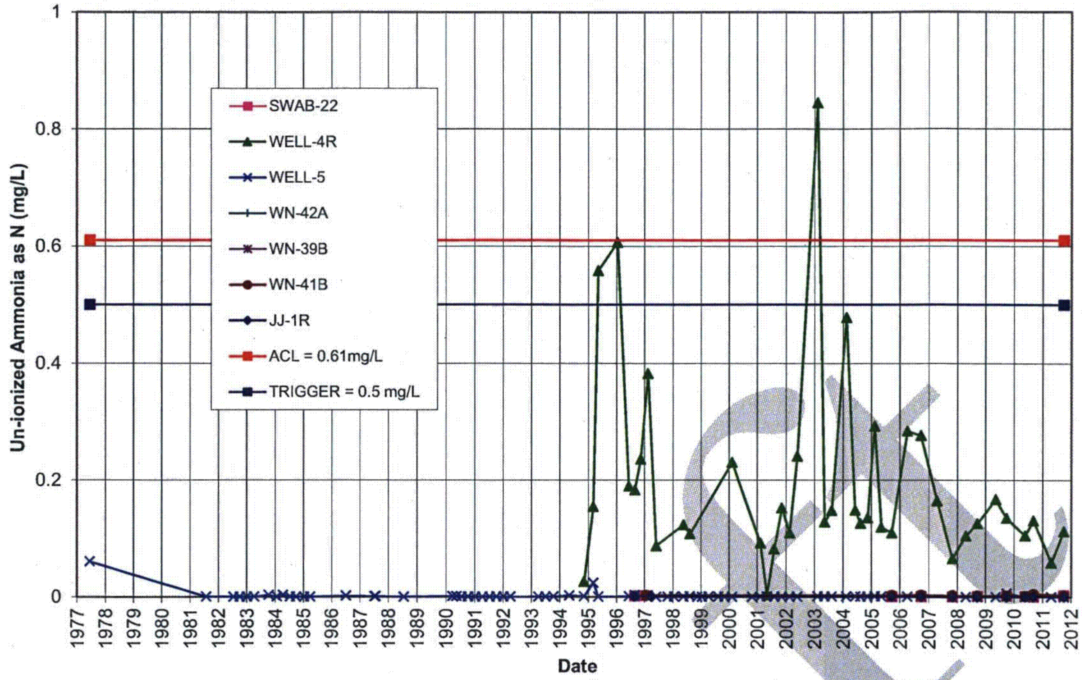


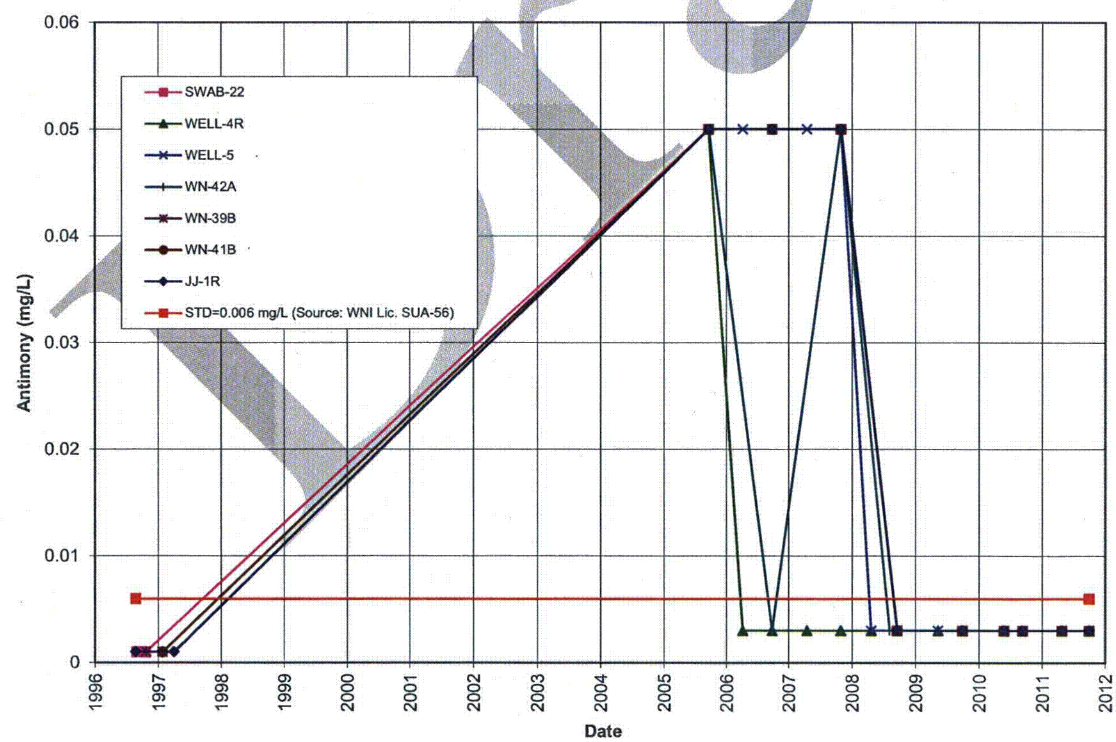
Time-Concentration Plots of Aluminum Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Ammonia (Total as N) Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Un-ionized Ammonia Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



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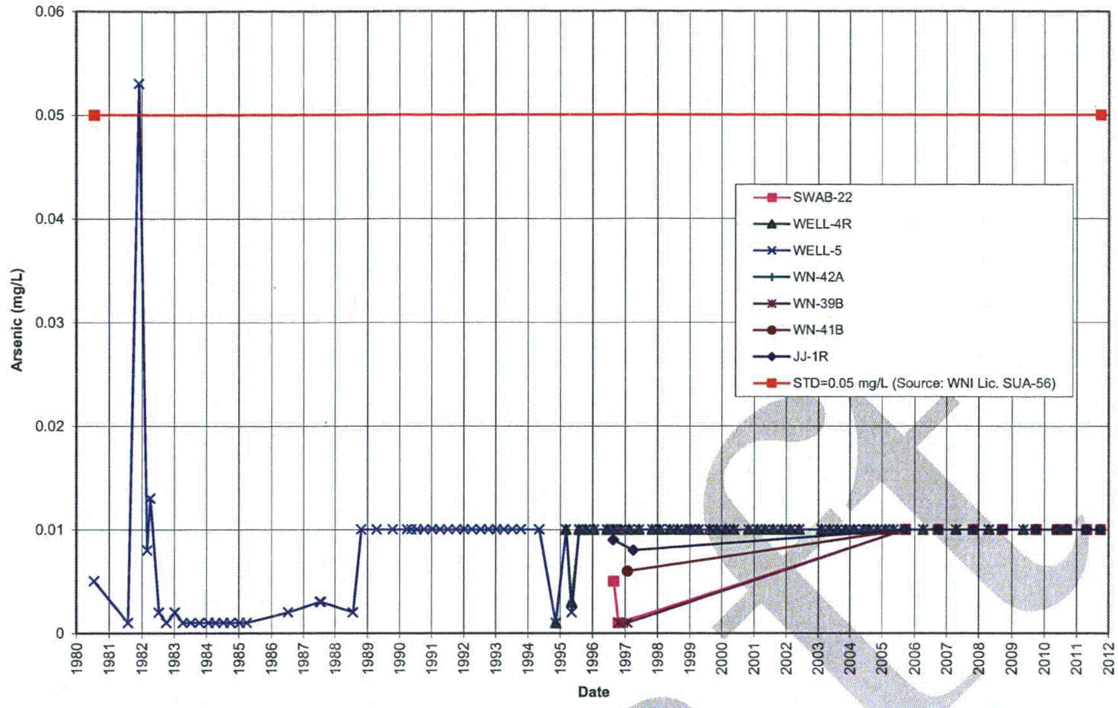
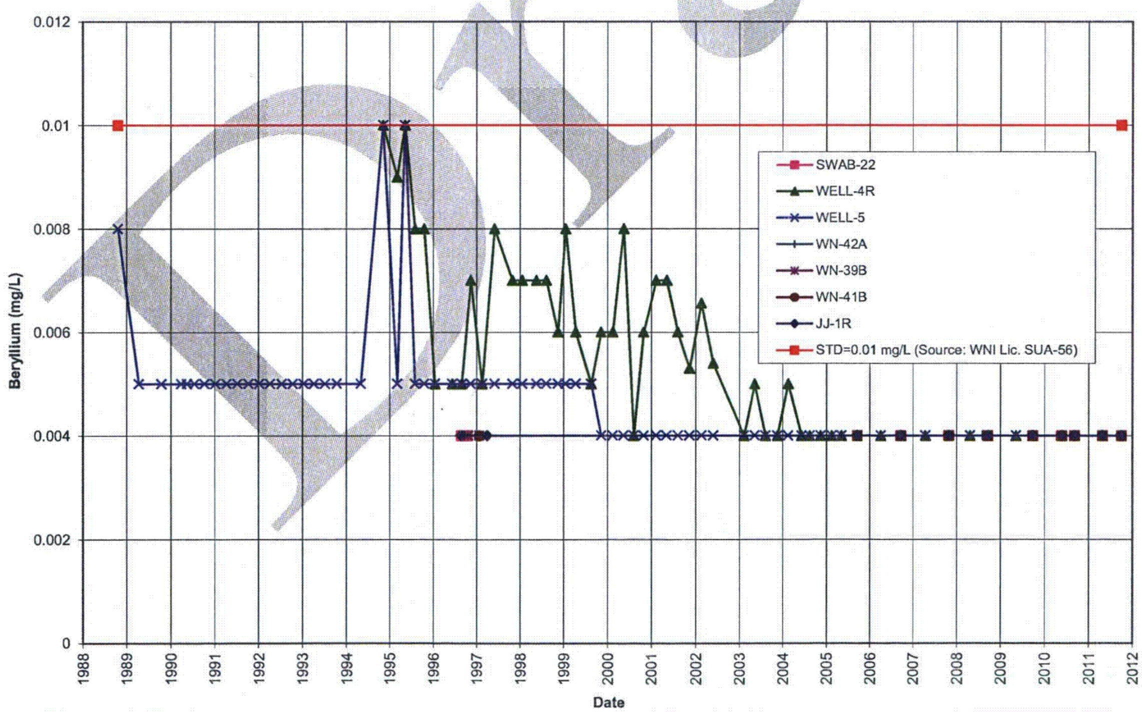


Time-Concentration Plots of Arsenic Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



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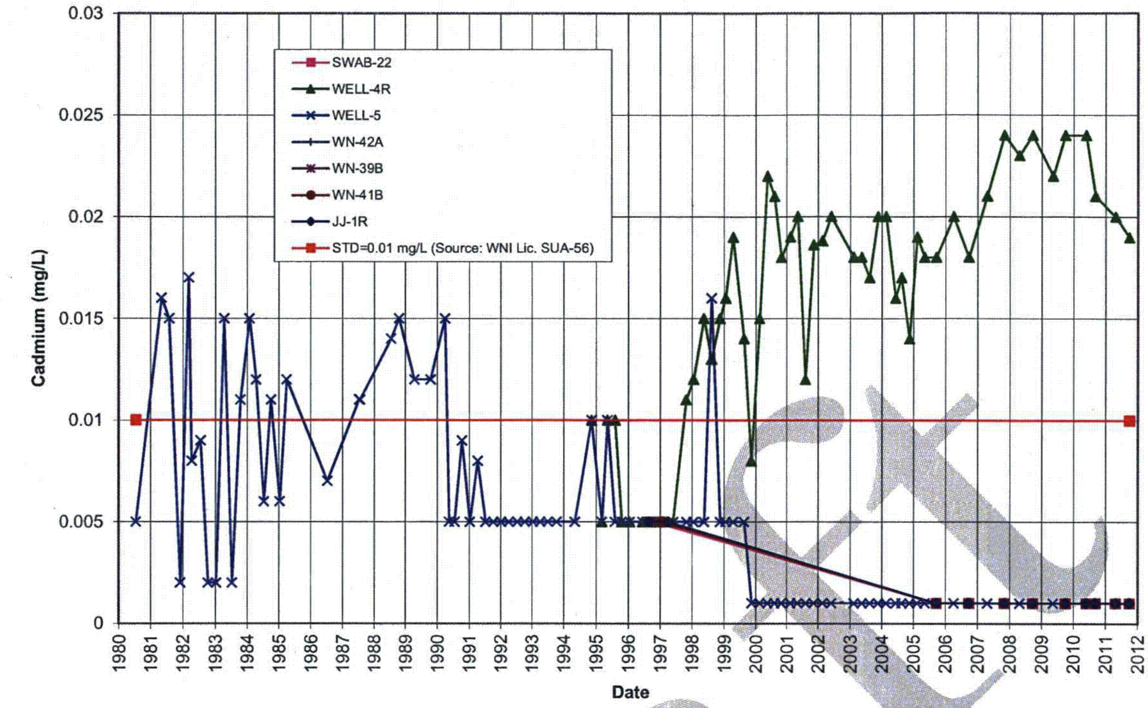

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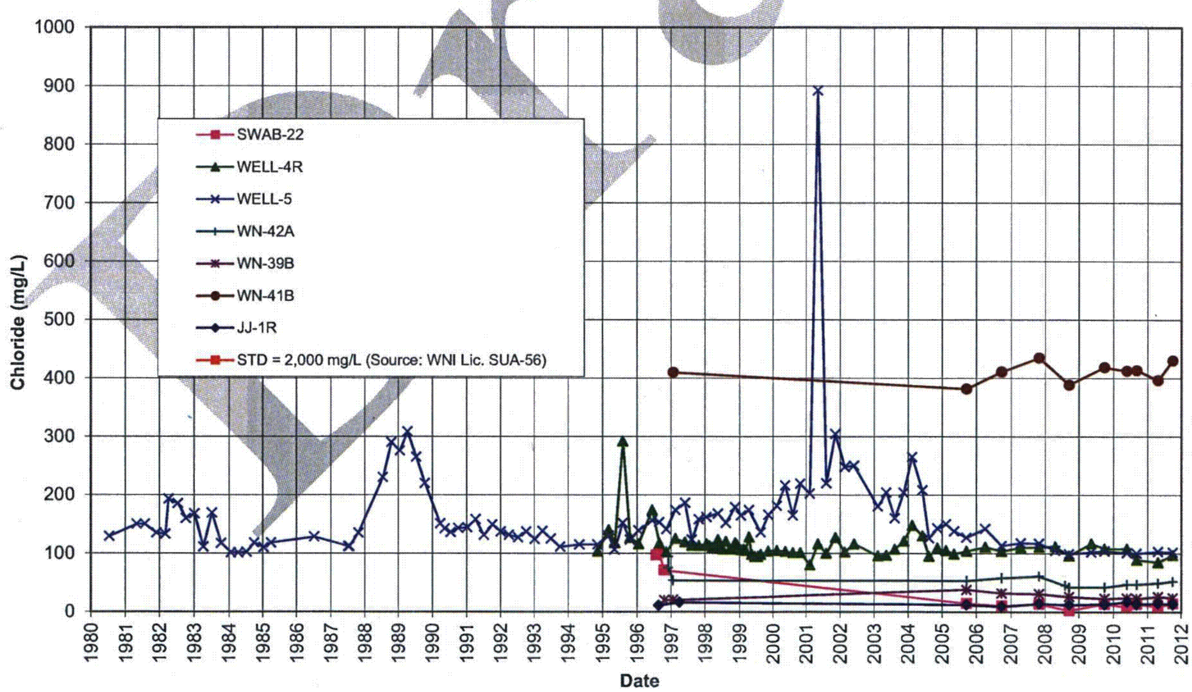

Time-Concentration Plots of Chloride Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site

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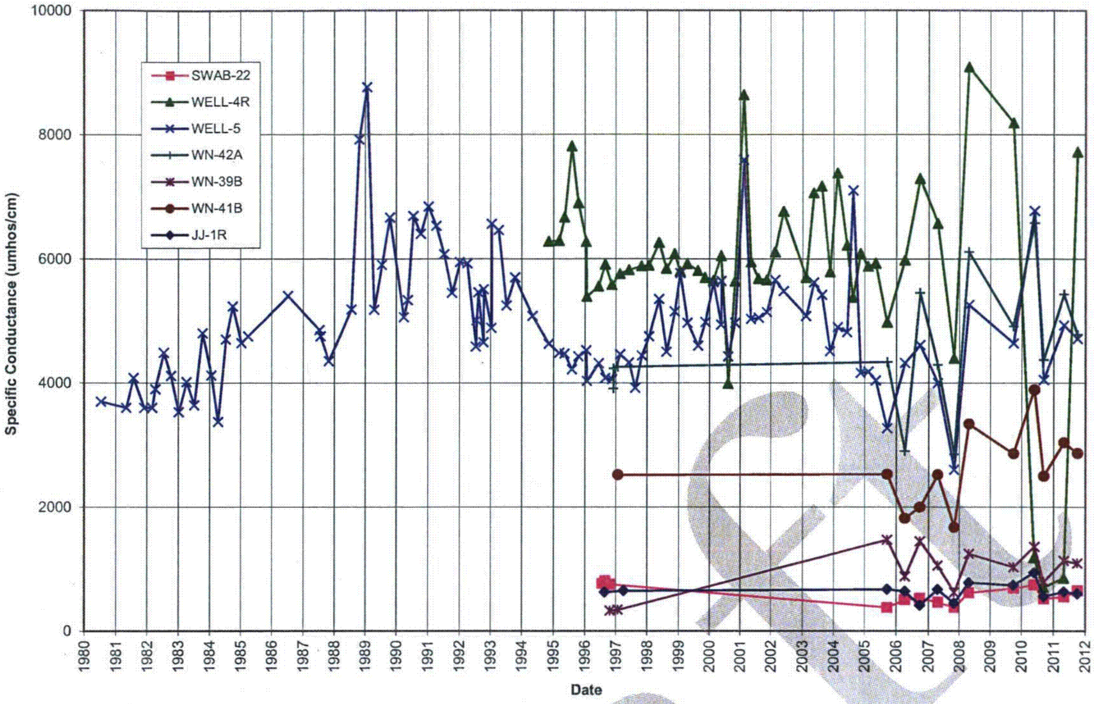

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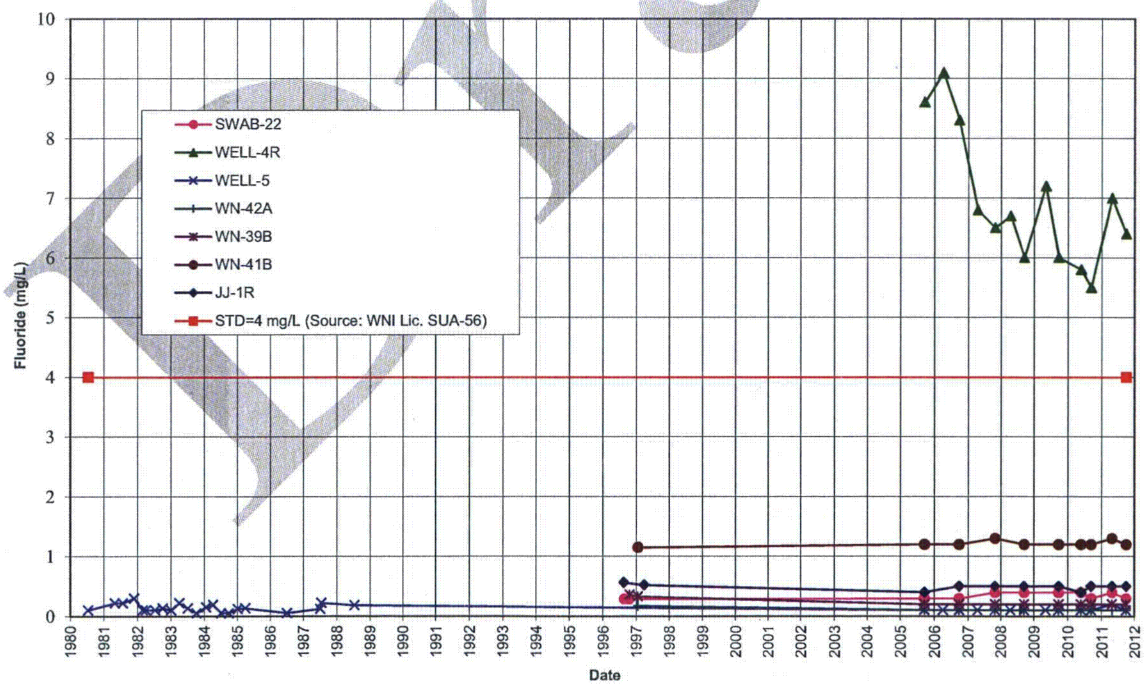

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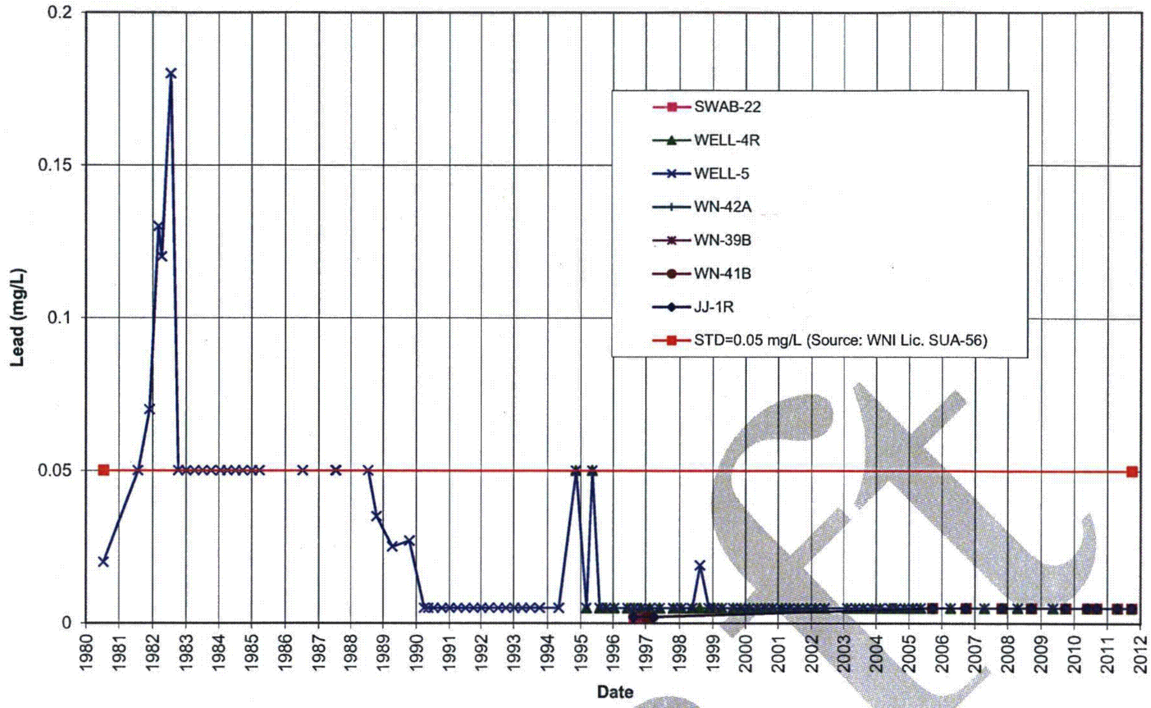

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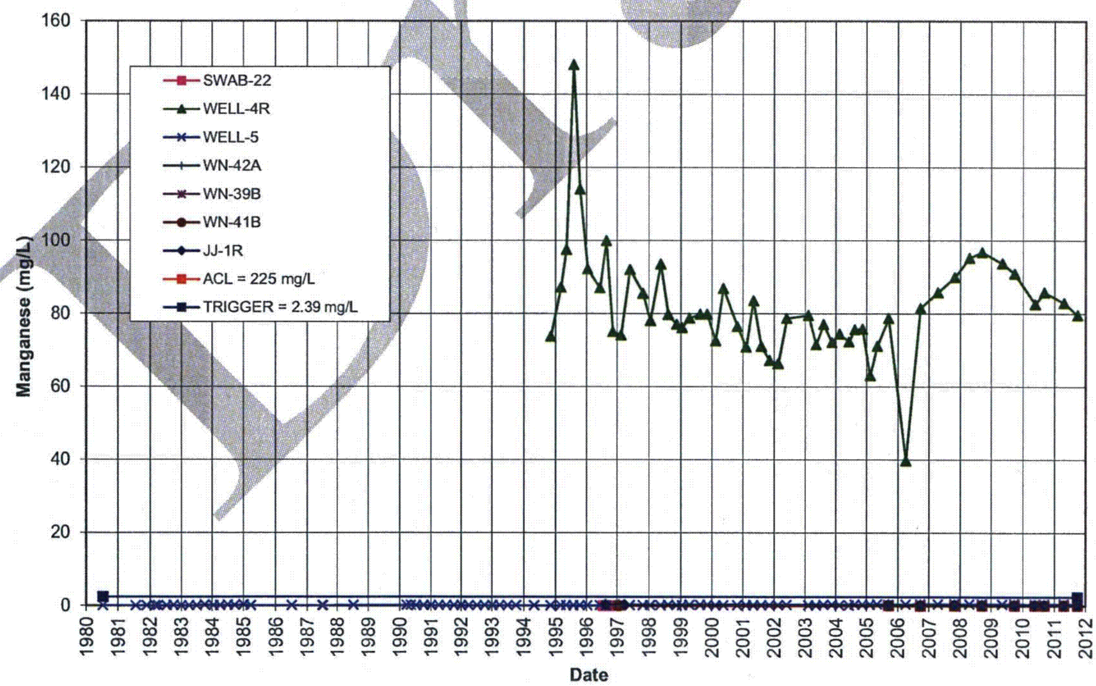

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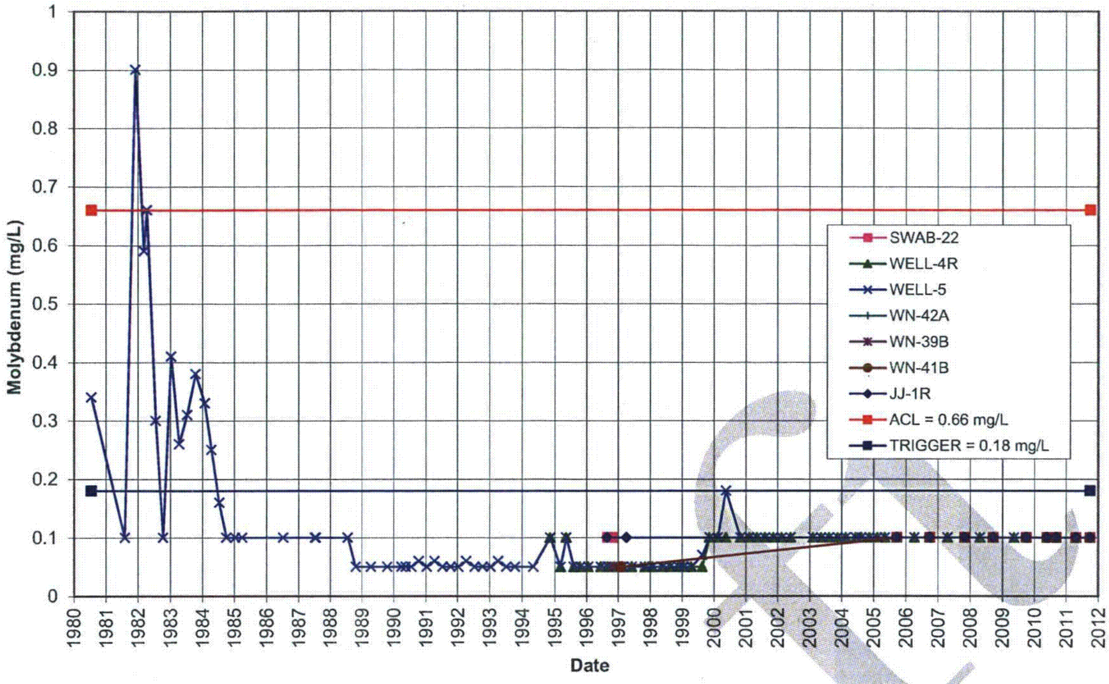

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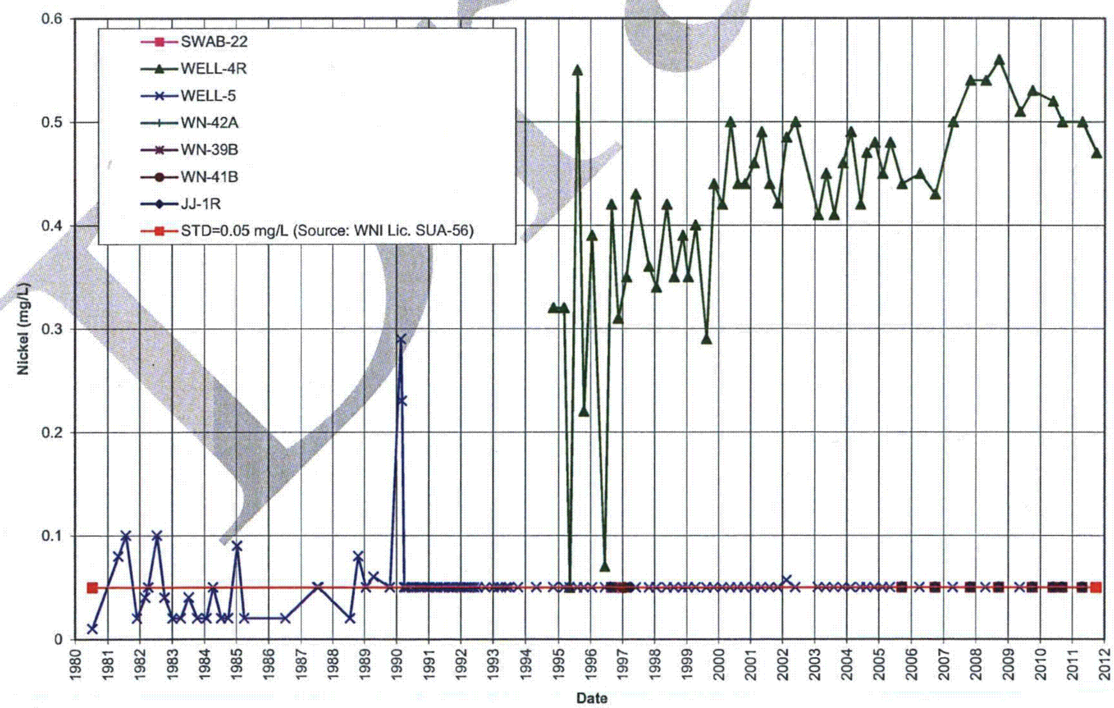

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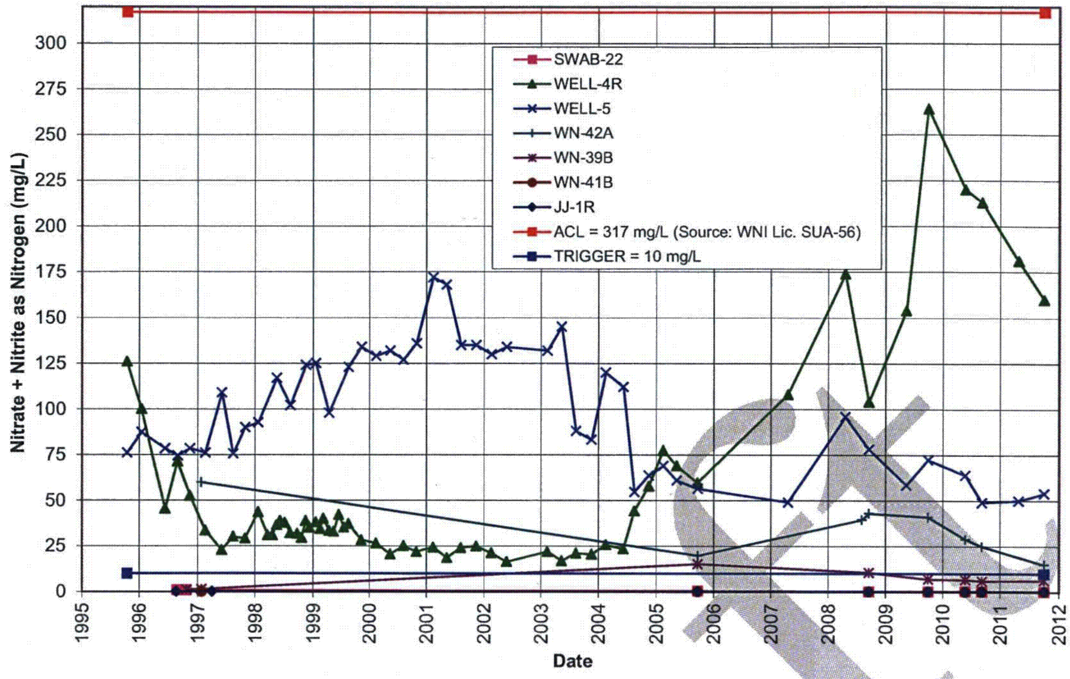
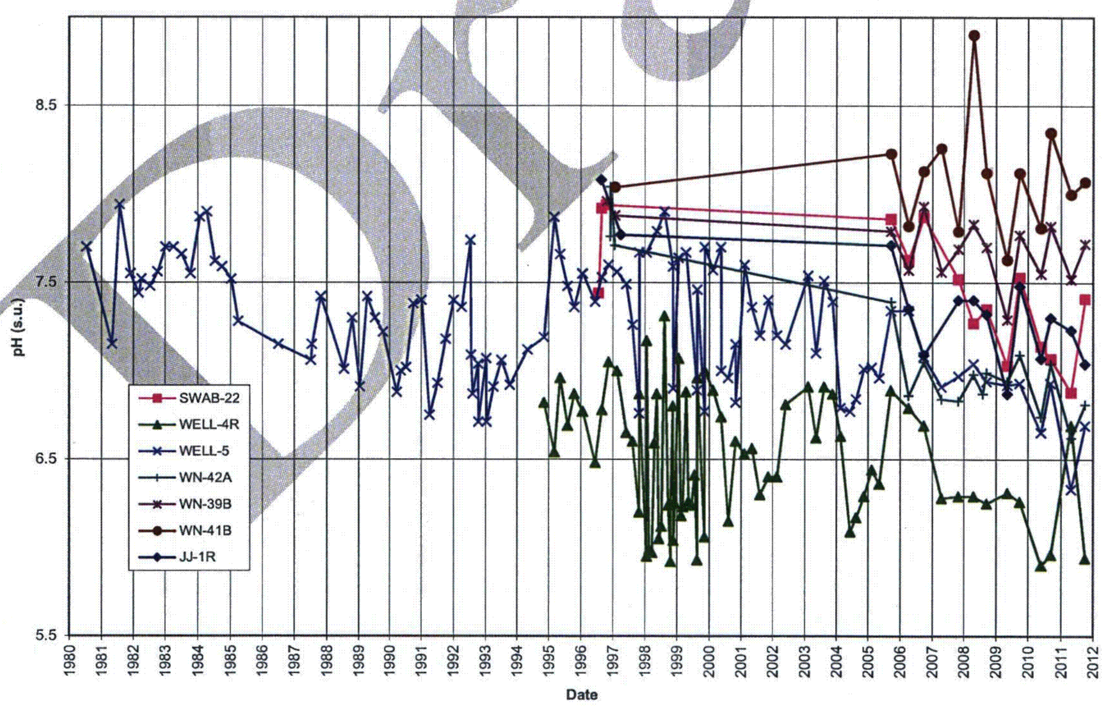
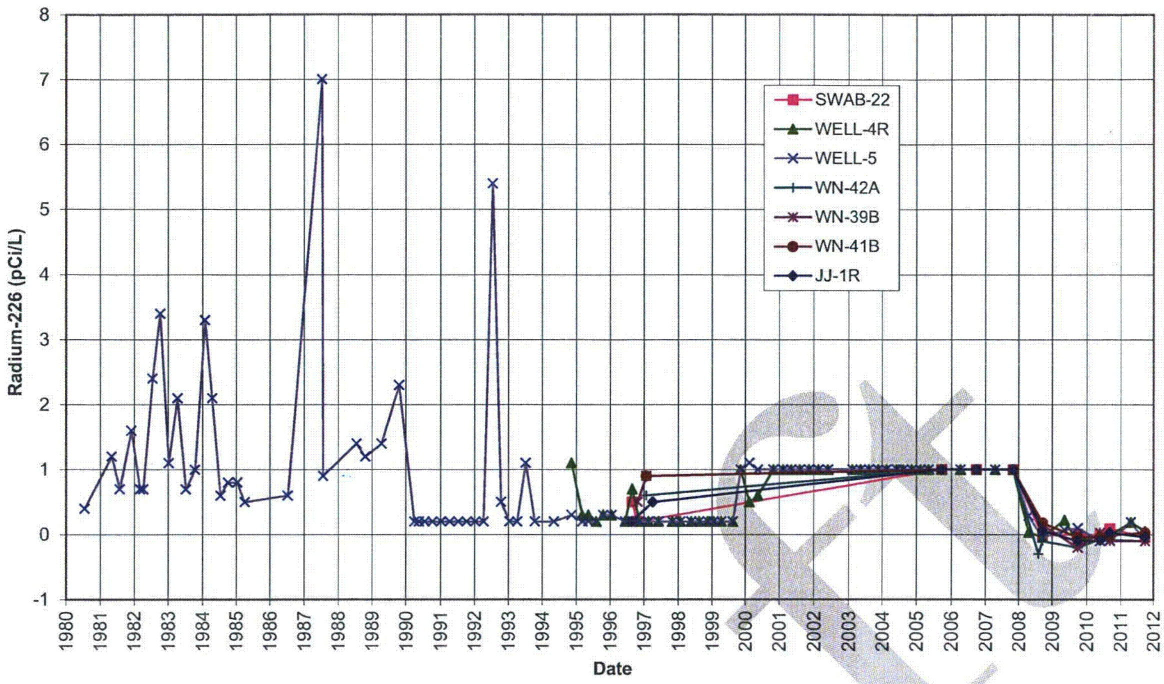


Time-Concentration Plots of Nitrate + Nitrite as Nitrogen Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of pH Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



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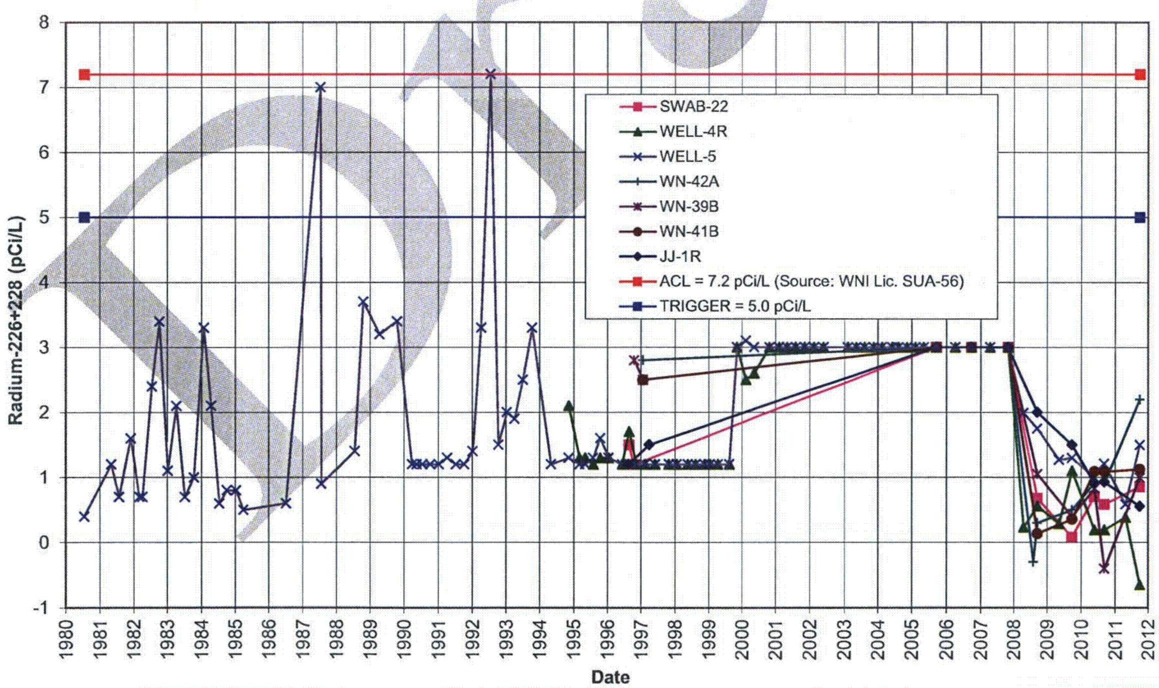

Time-Concentration Plots of Radium-226+228 Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site

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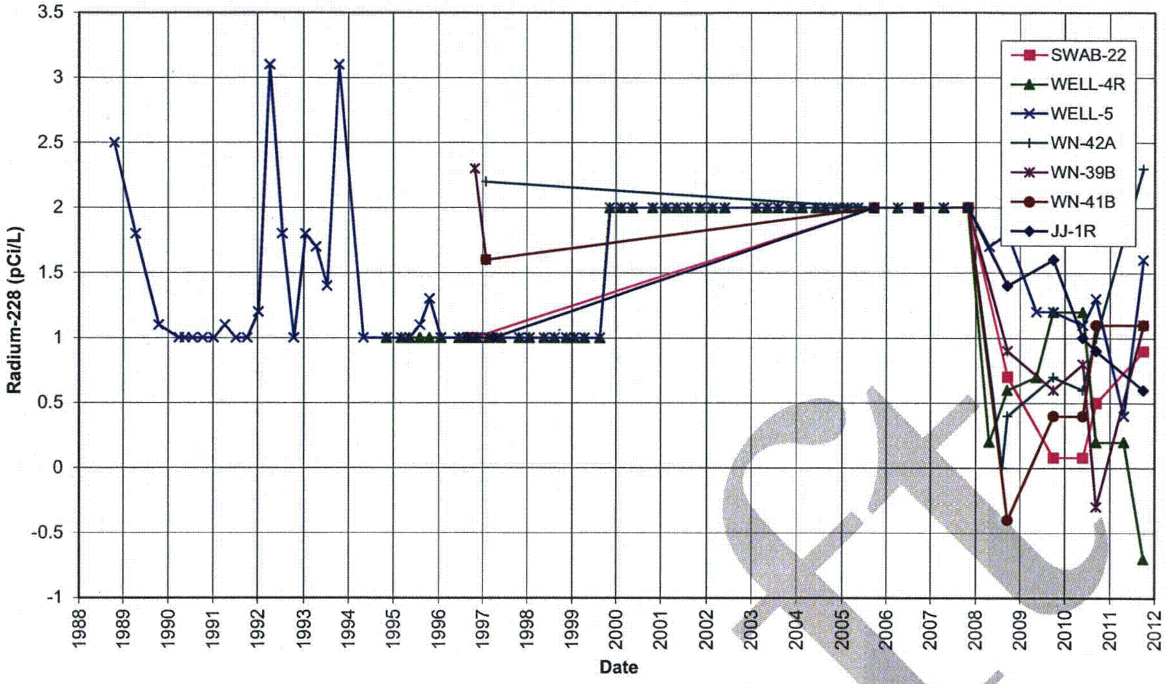

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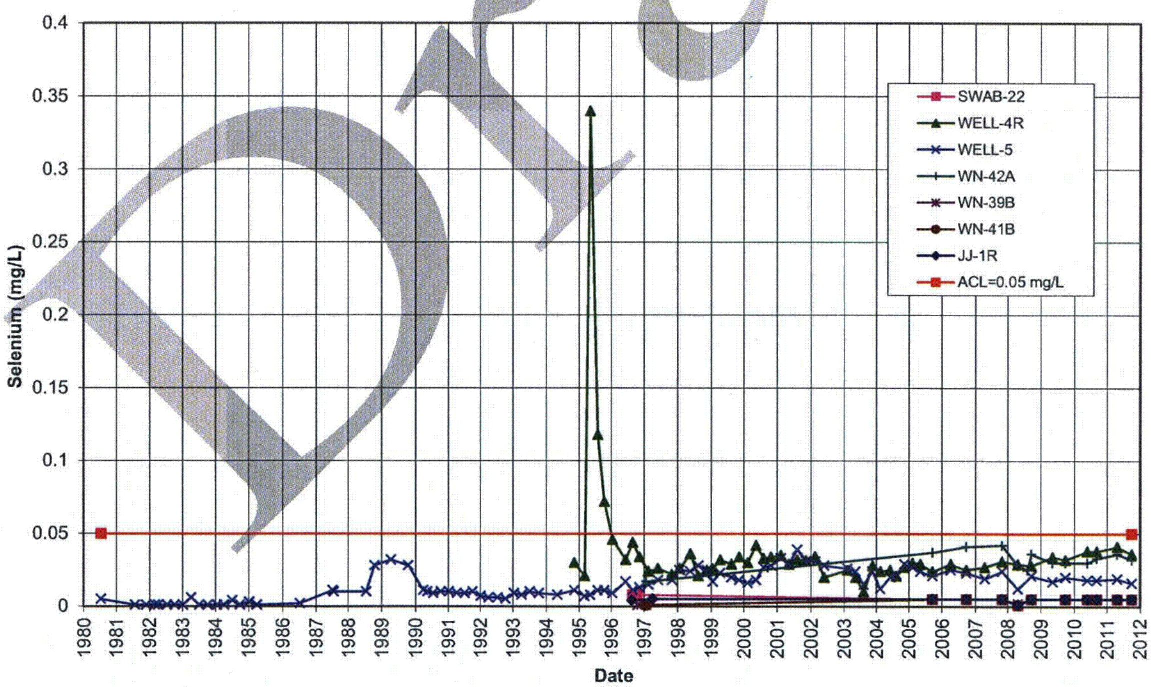
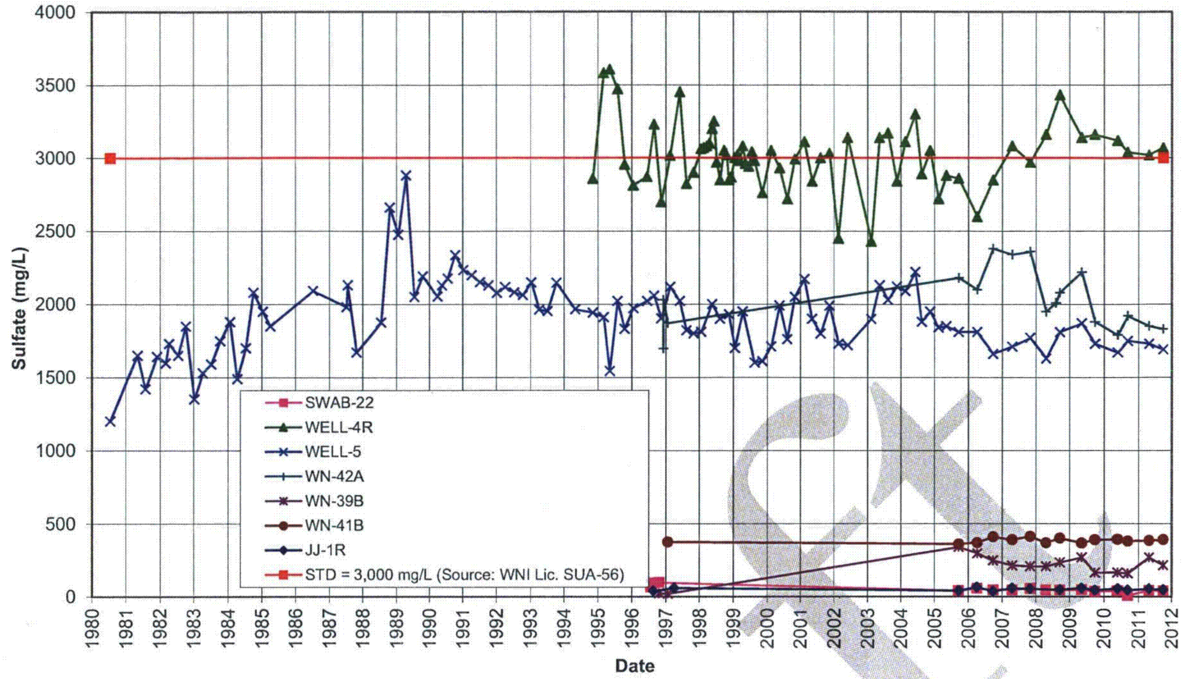
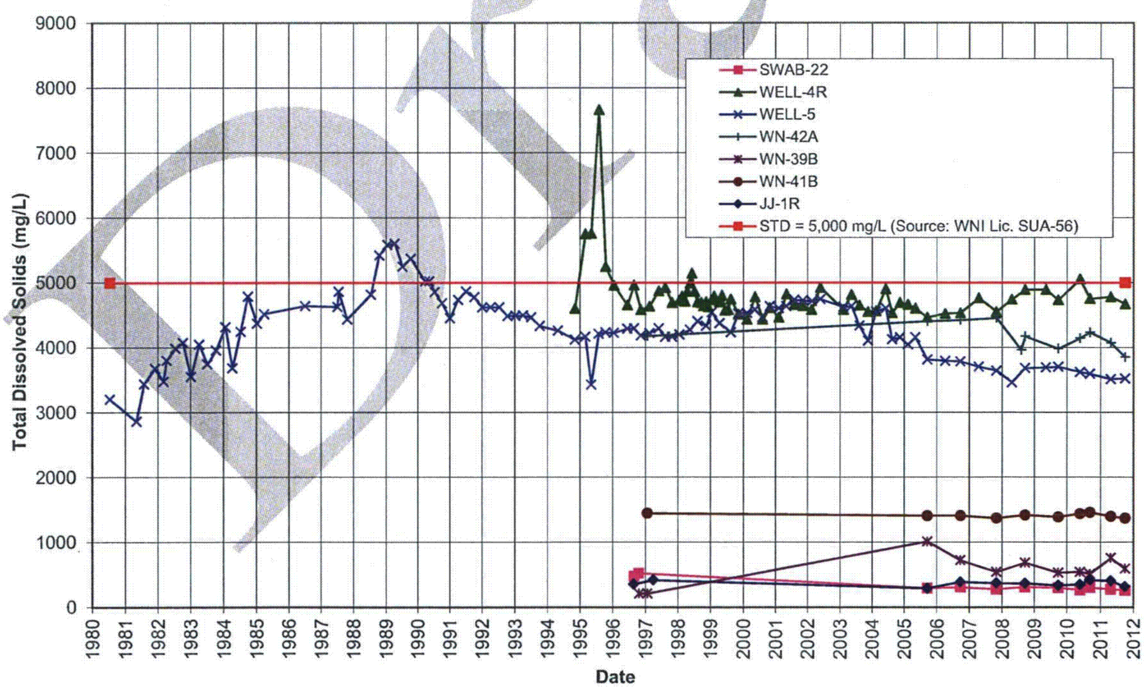


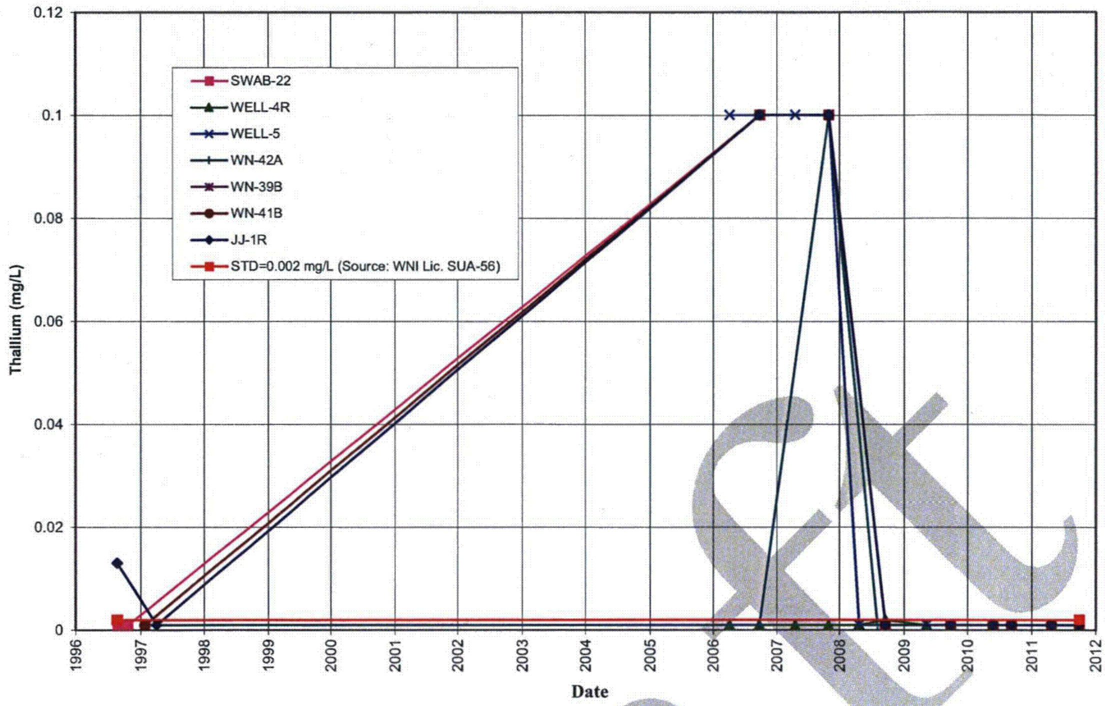
Time-Concentration Plots of Selenium Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



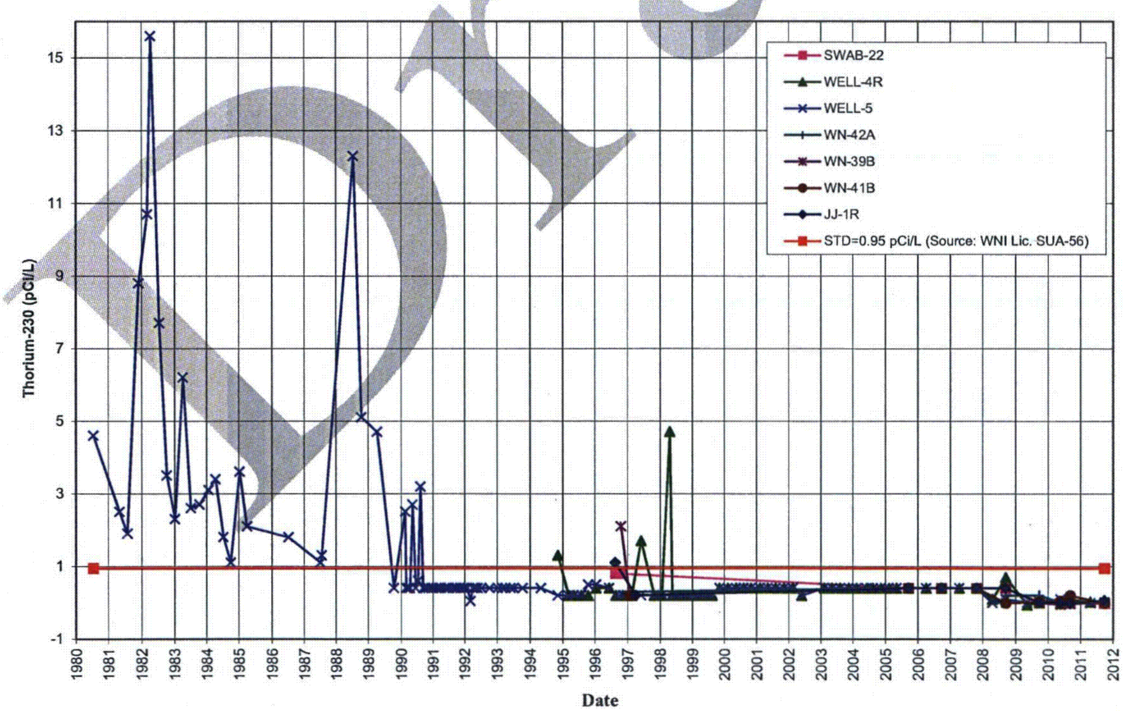
Time-Concentration Plots of Sulfate Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Total Dissolved Solids Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Thallium Concentration in Groundwater in the Northwest Valley (Alluvial Floodplain Aquifer), Split Rock, Wyoming, Disposal Site



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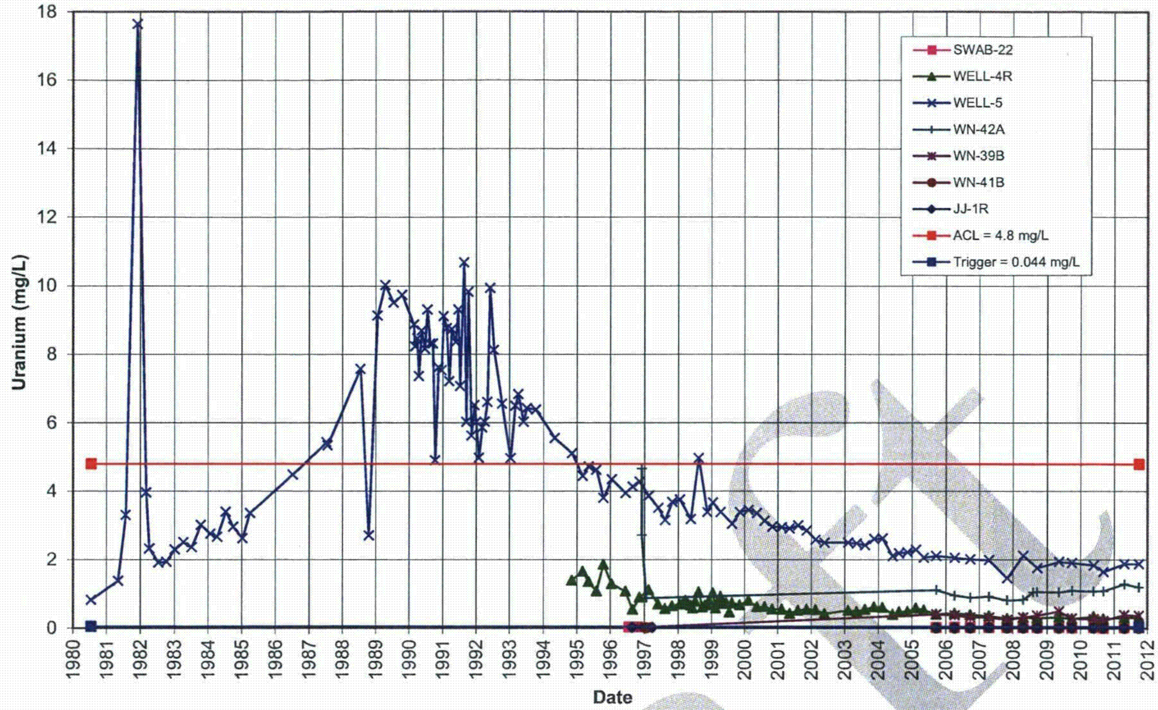

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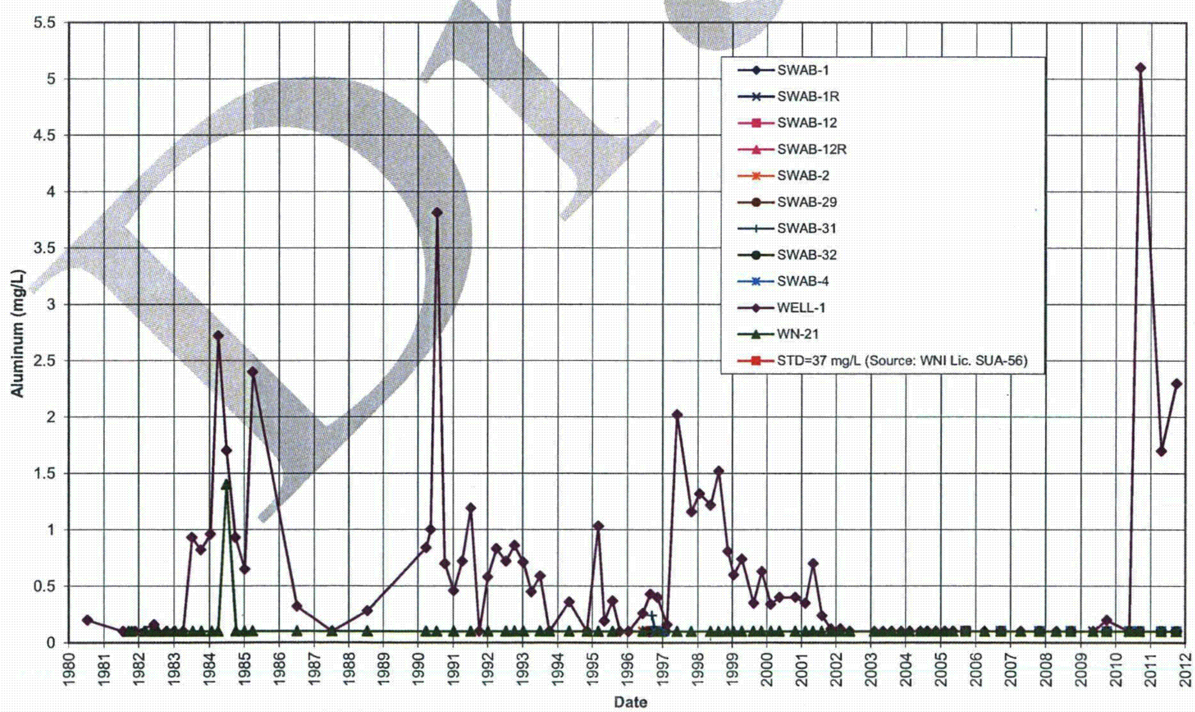

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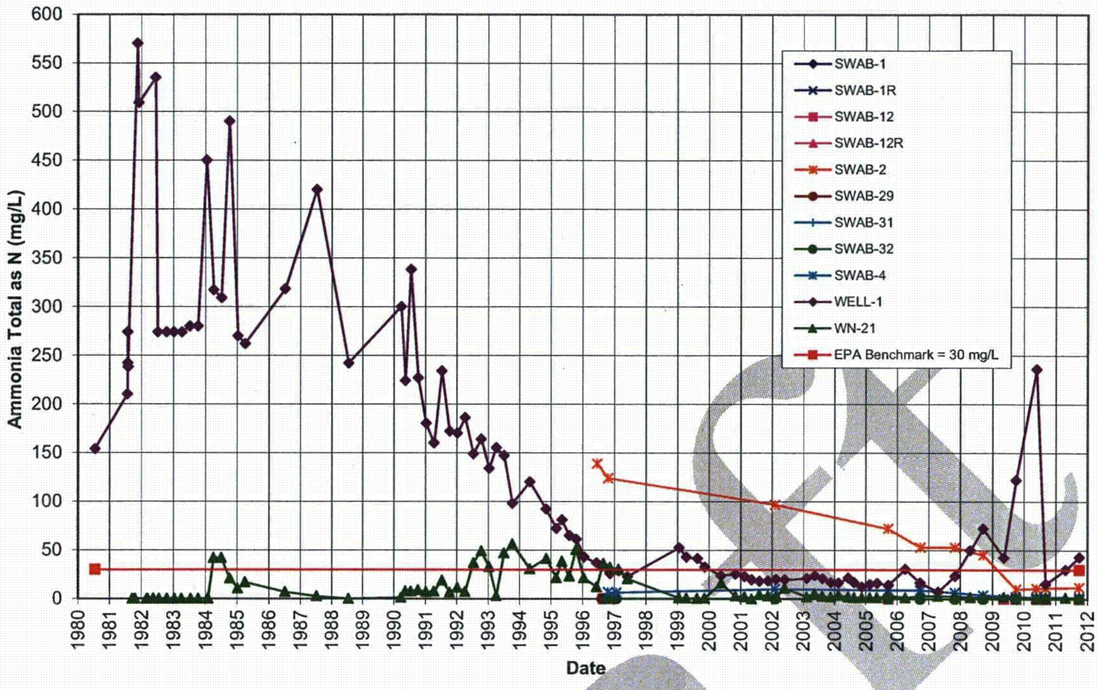
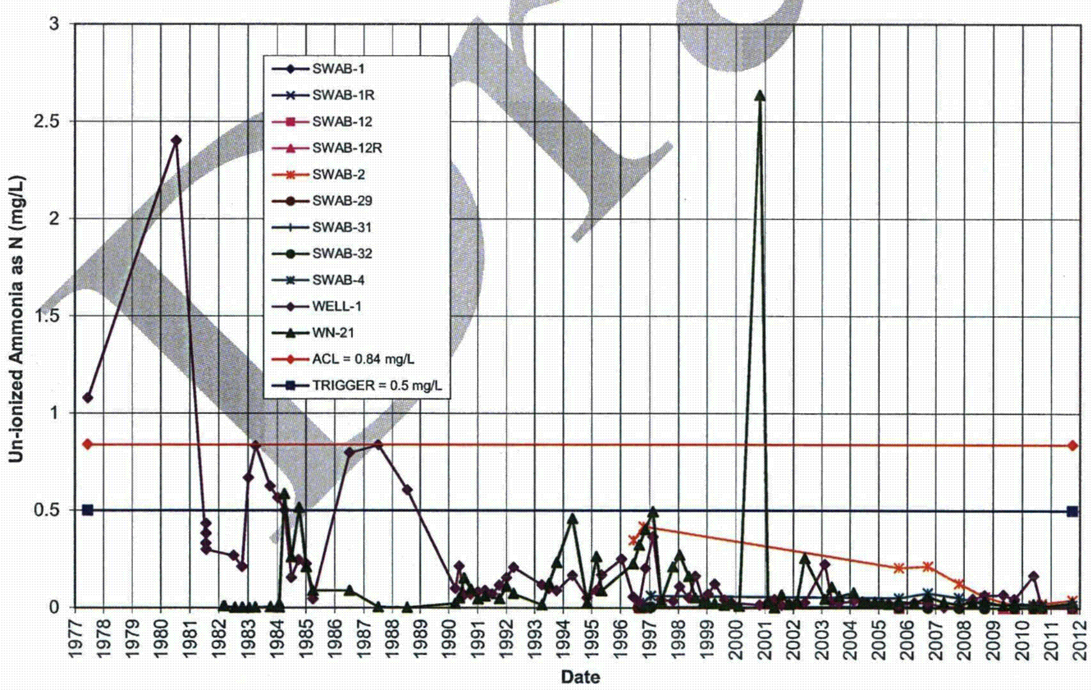


Time-Concentration Plots of Ammonia (Total as N) Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



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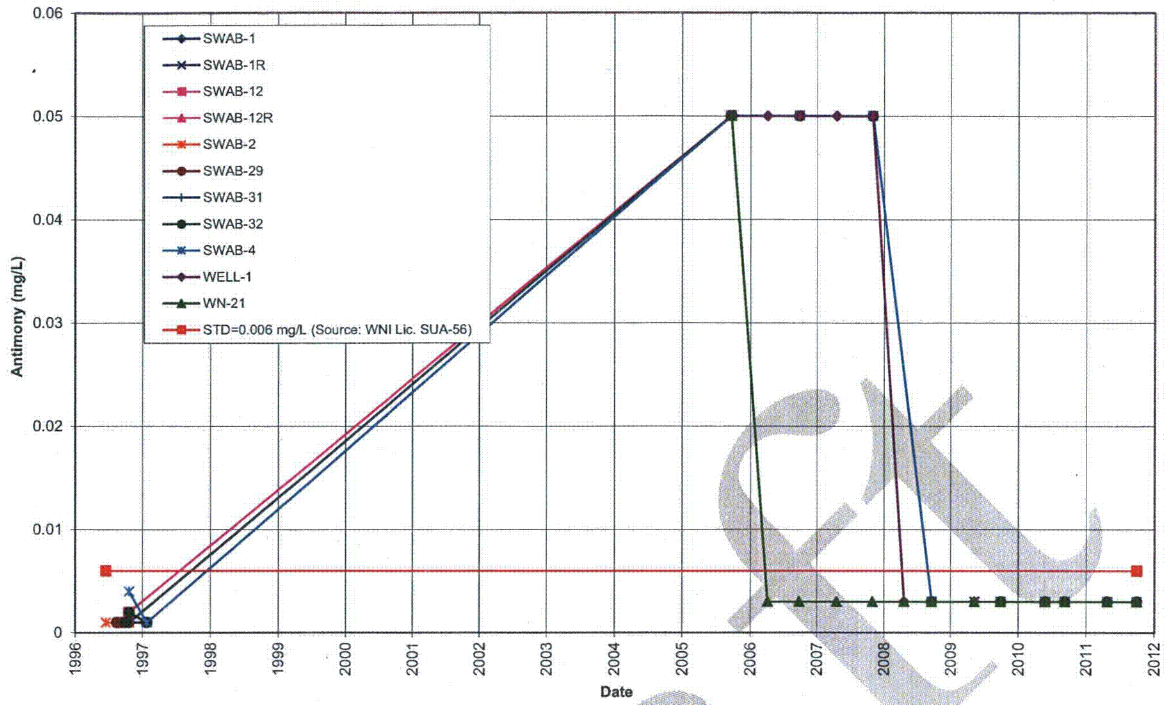

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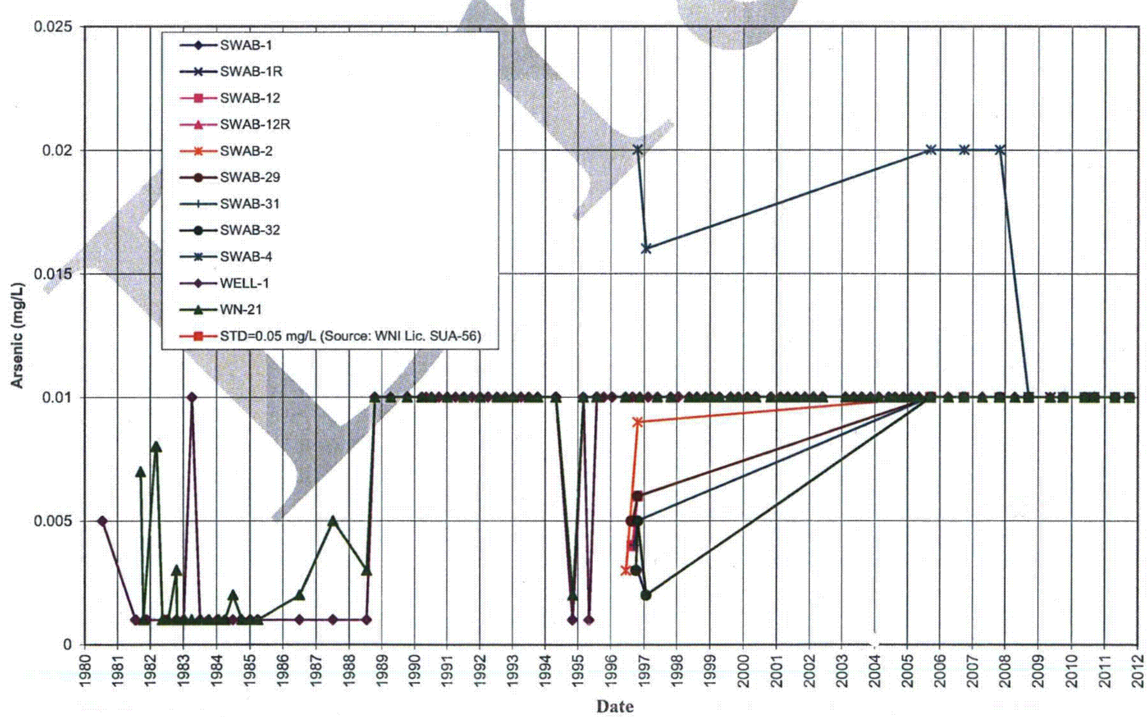

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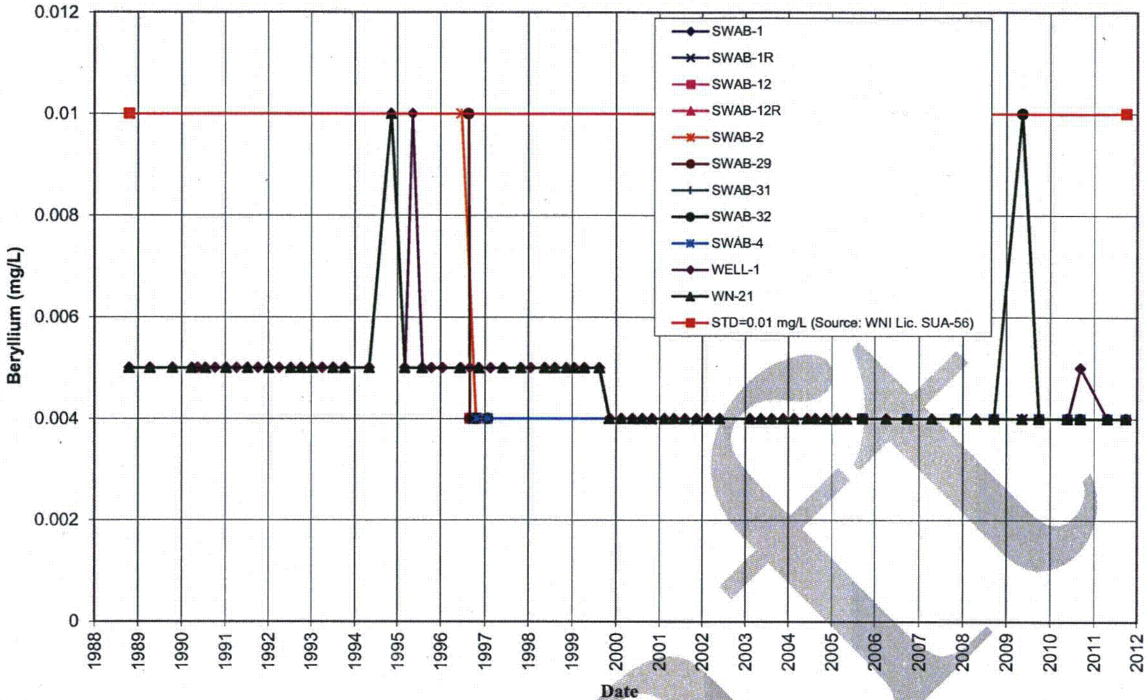

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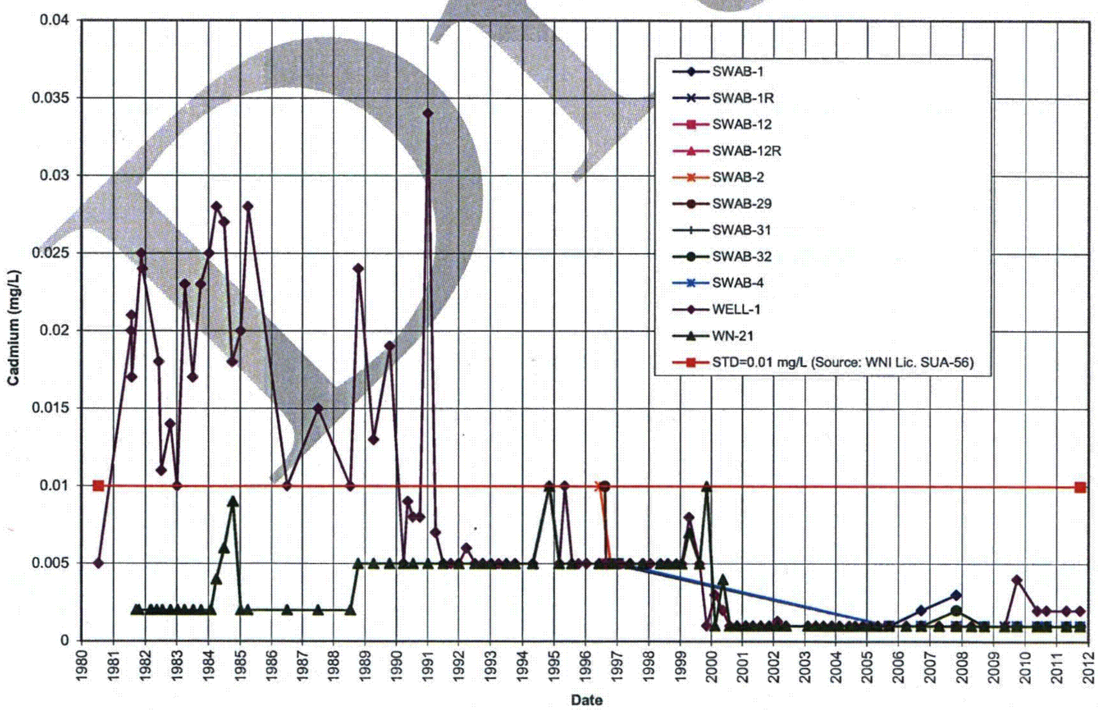

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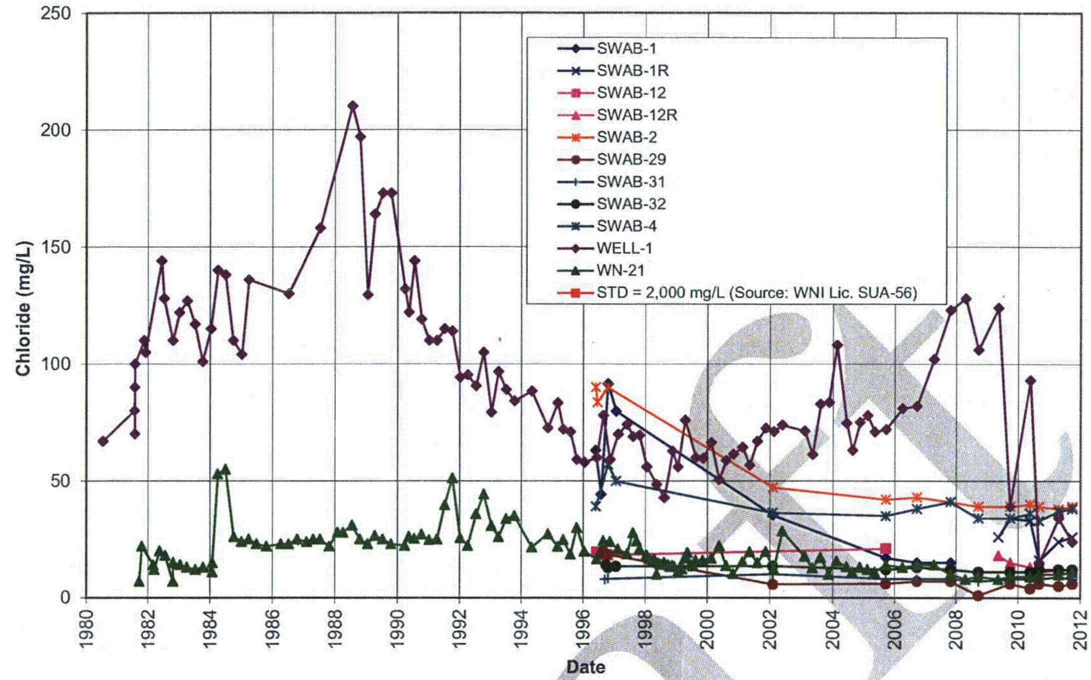

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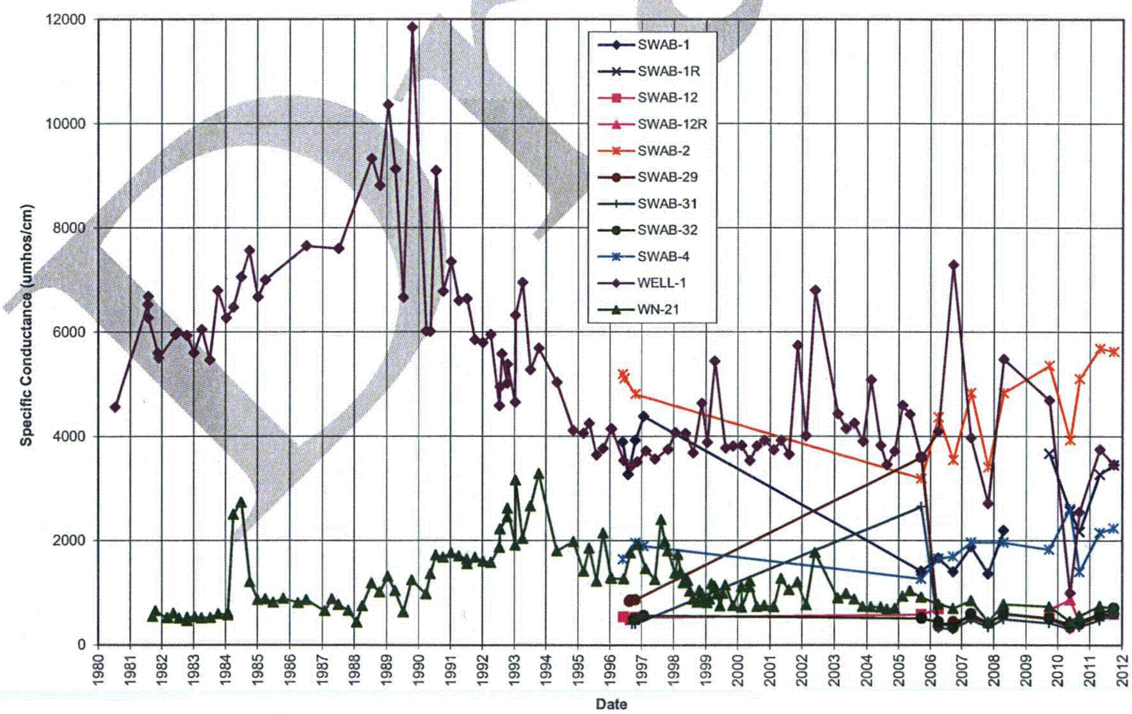
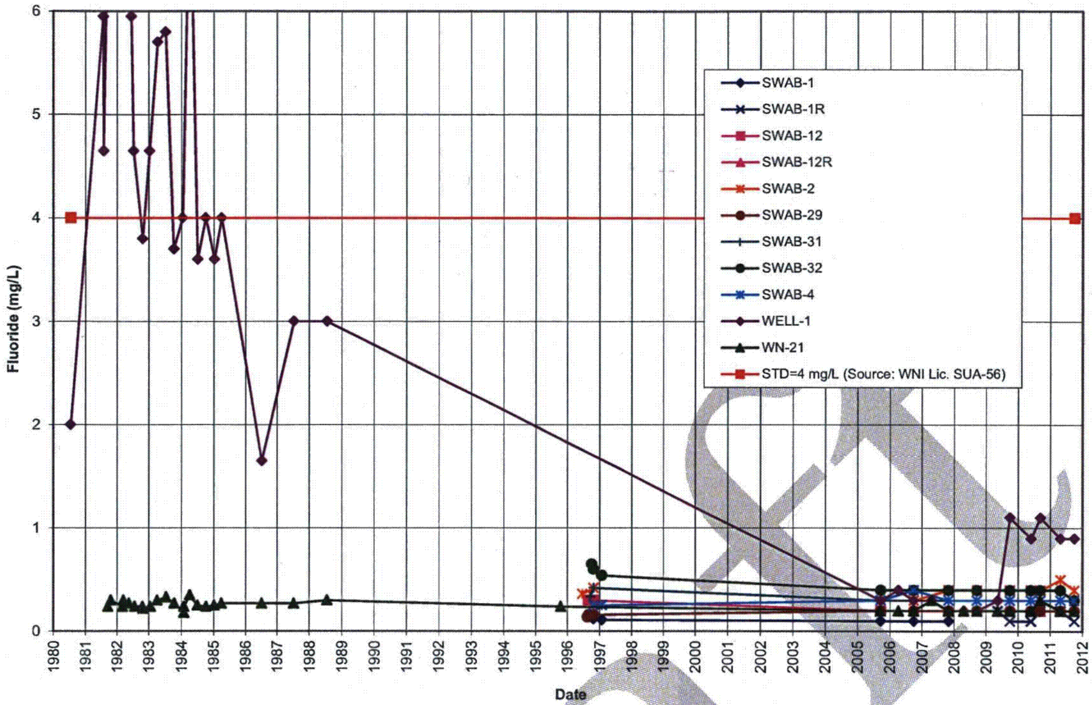


Time-Concentration Plots of Specific Conductance Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



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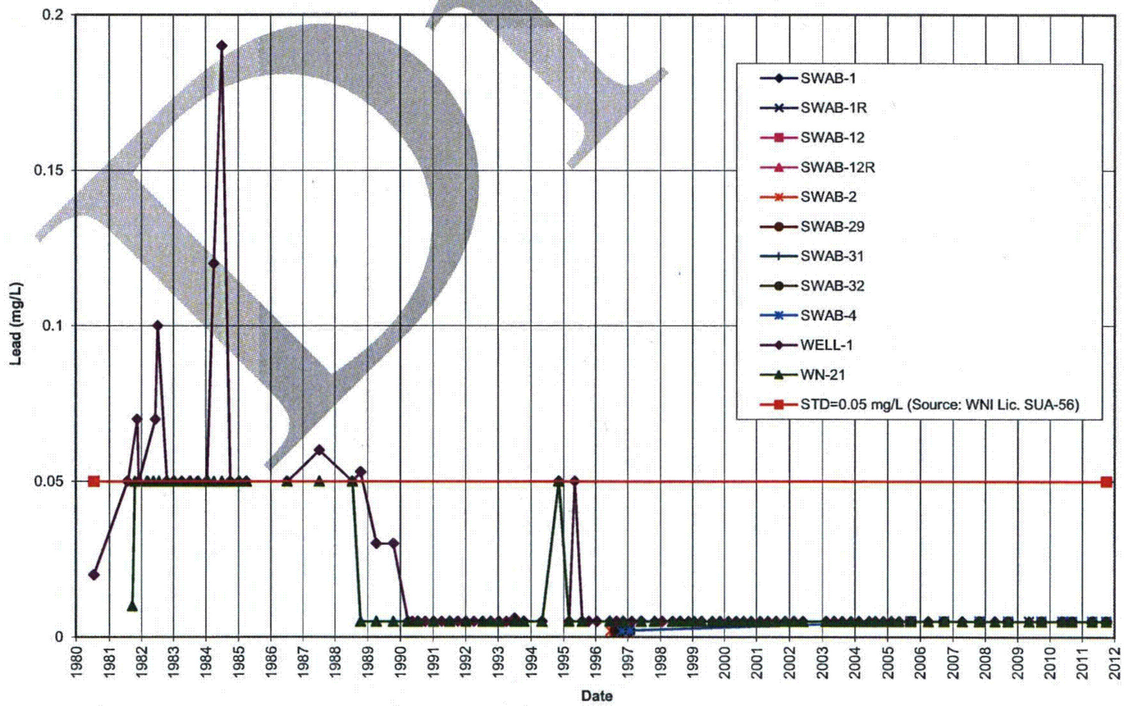

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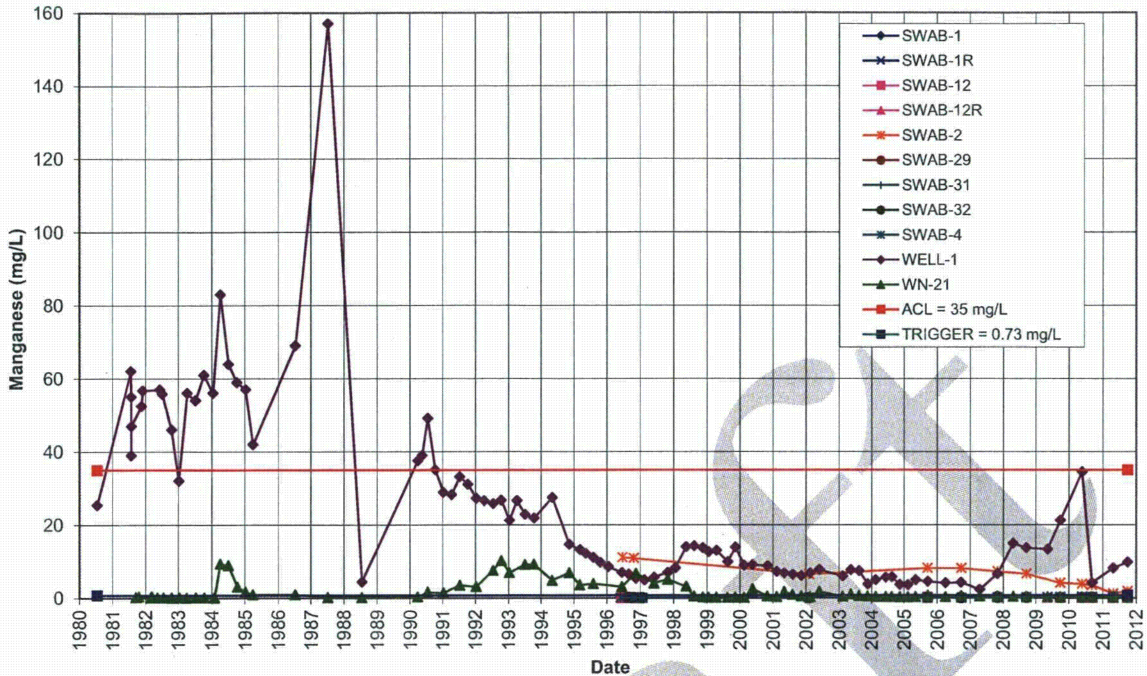

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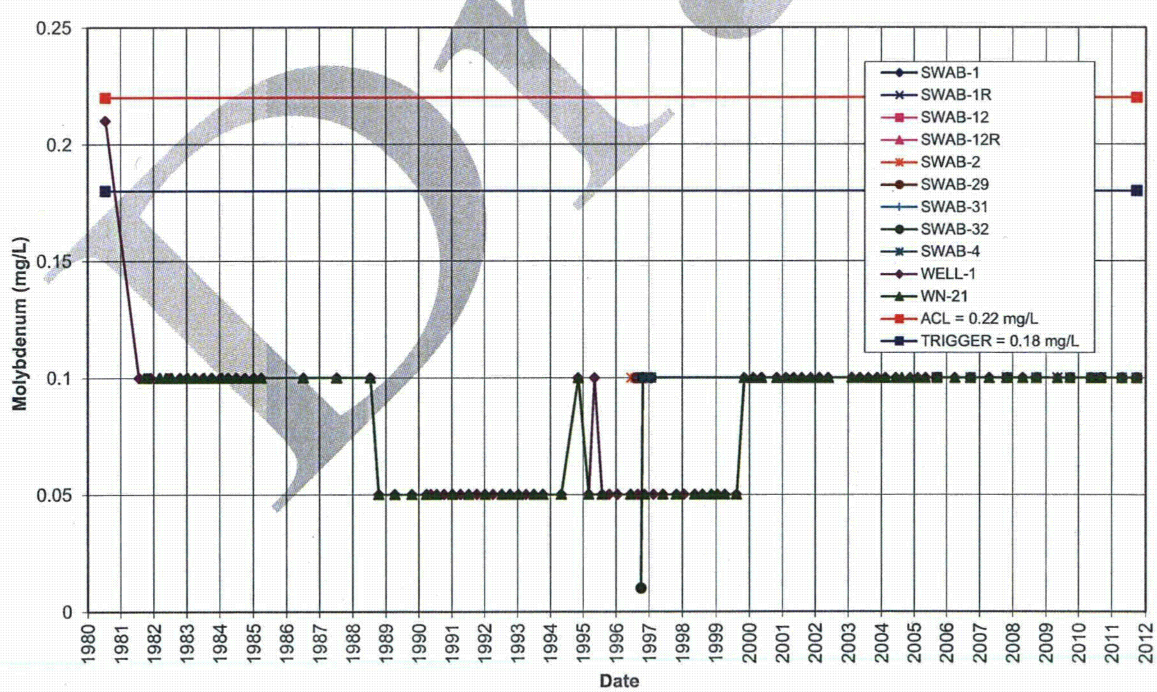

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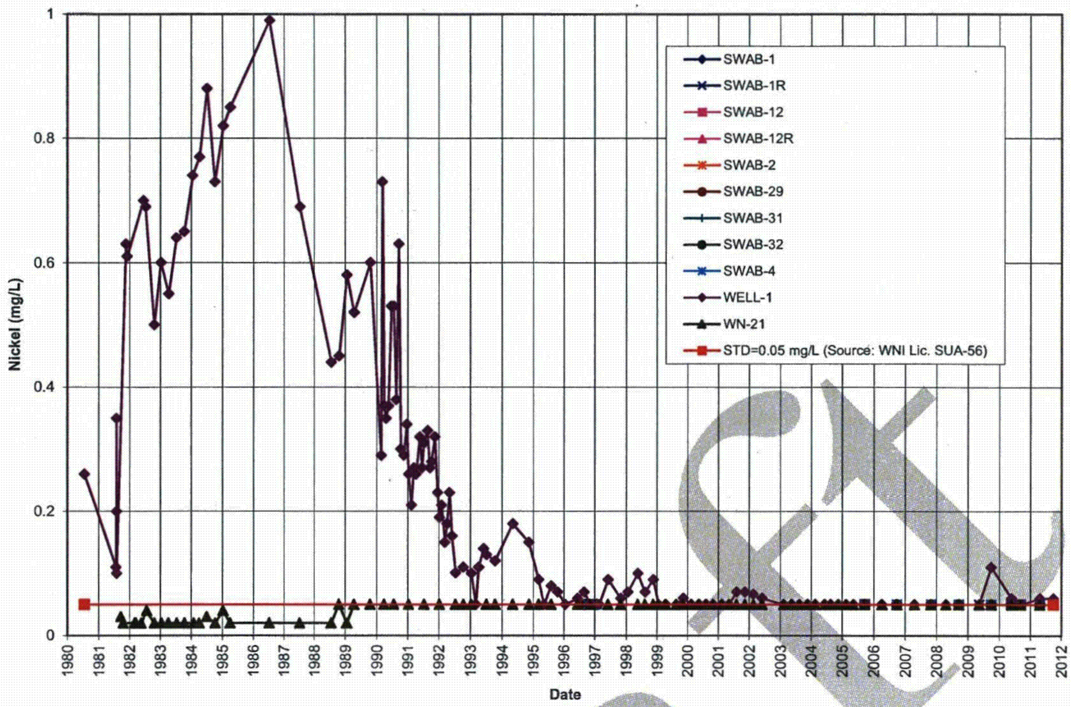

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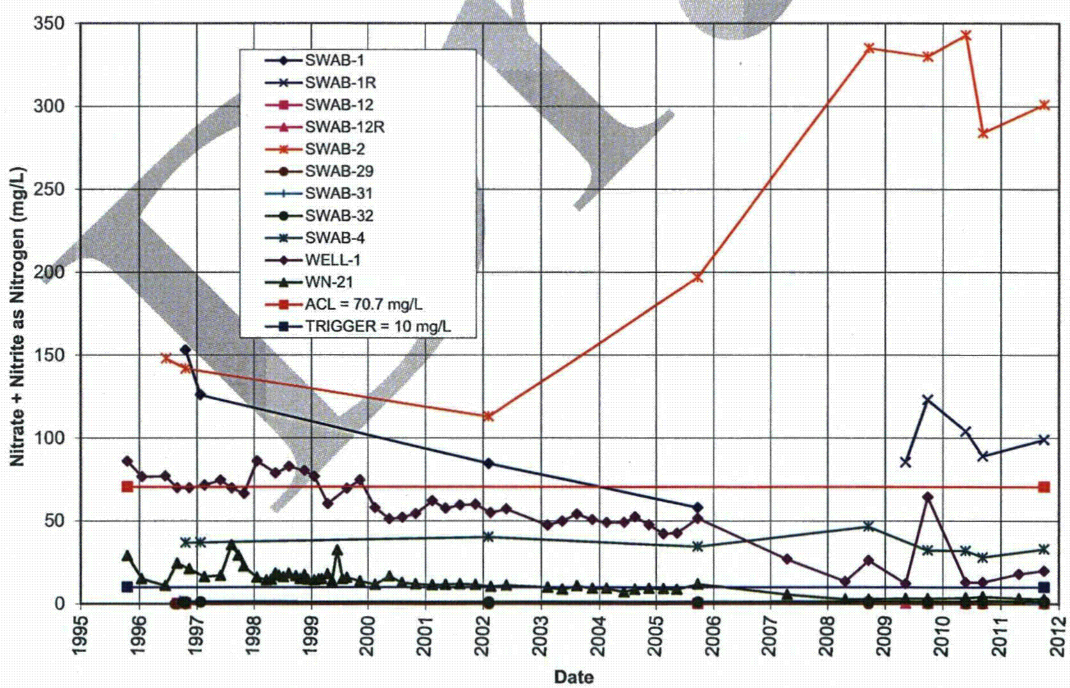
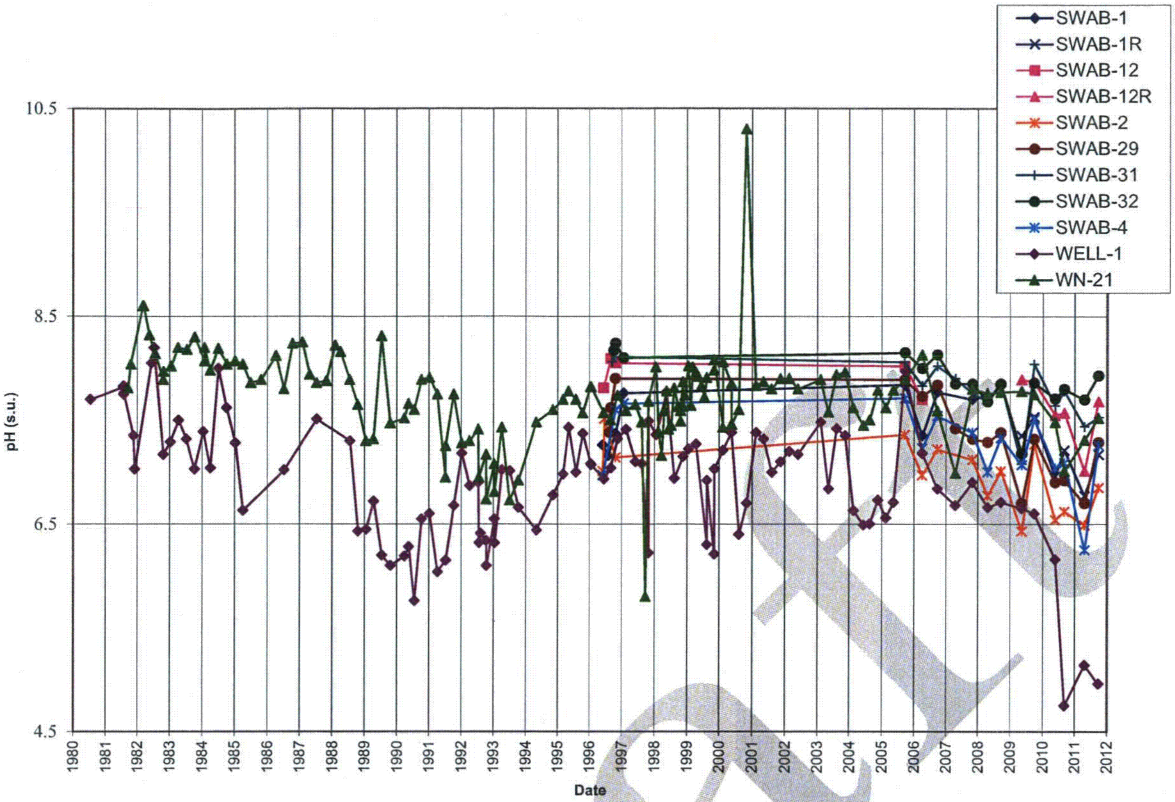


Time-Concentration Plots of Nitrate + Nitrite as Nitrogen Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



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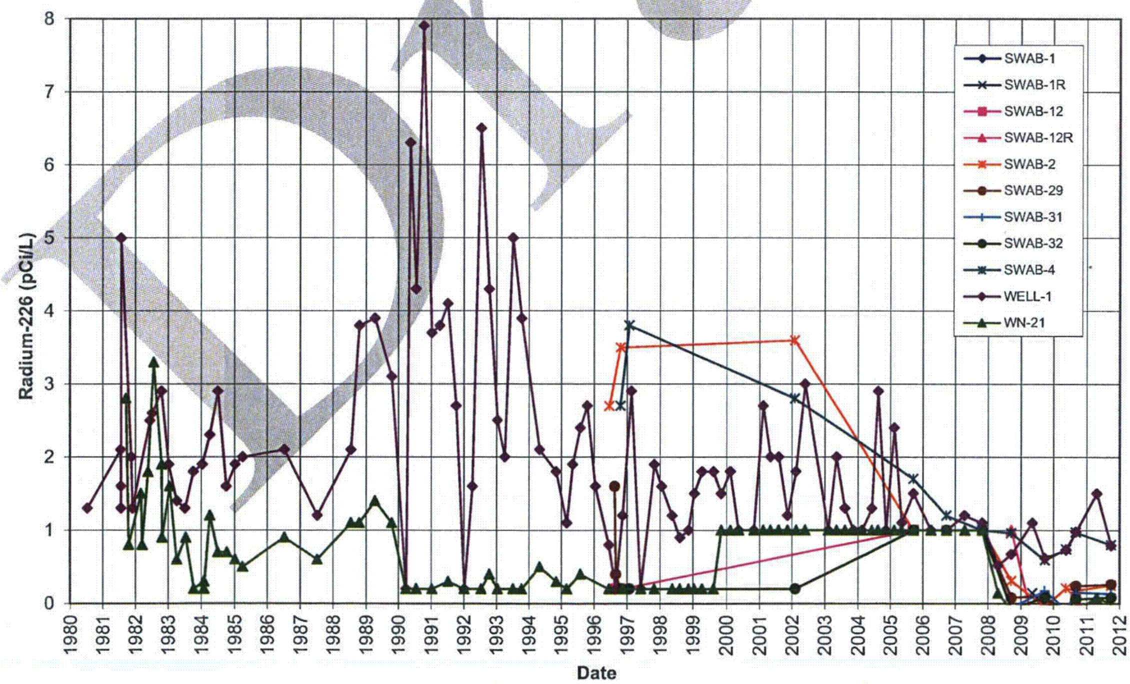

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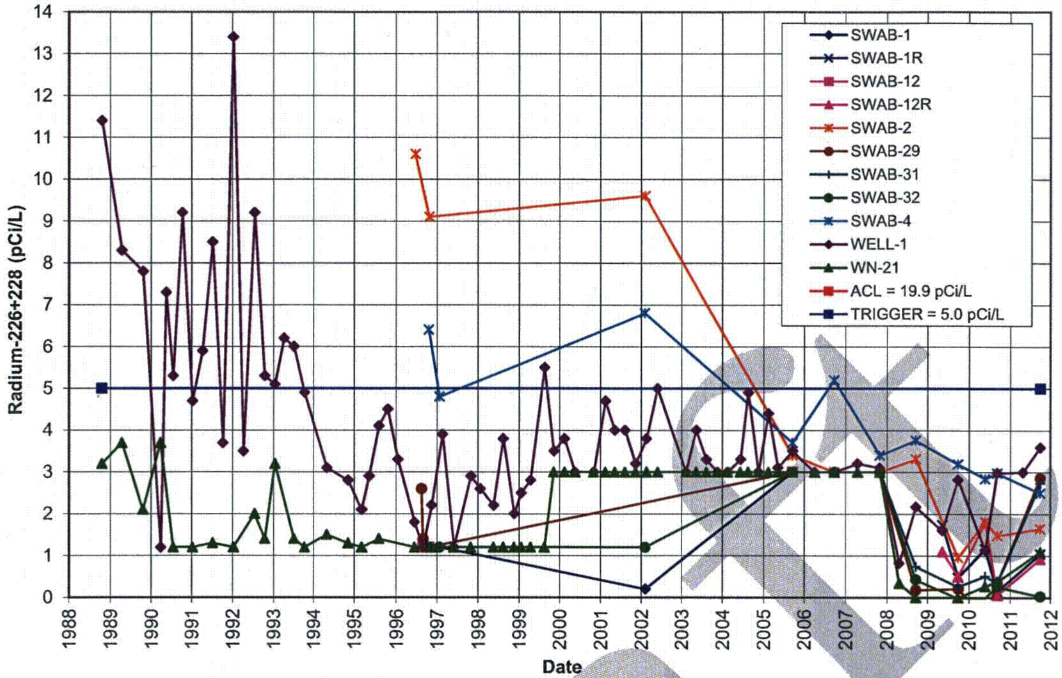

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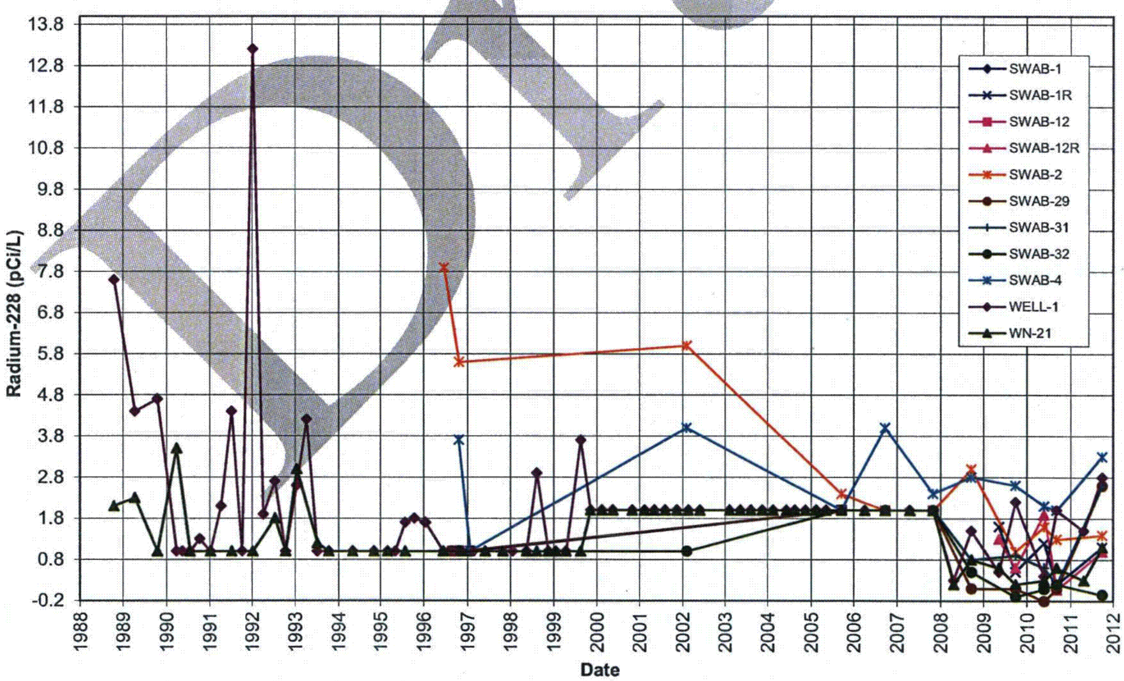

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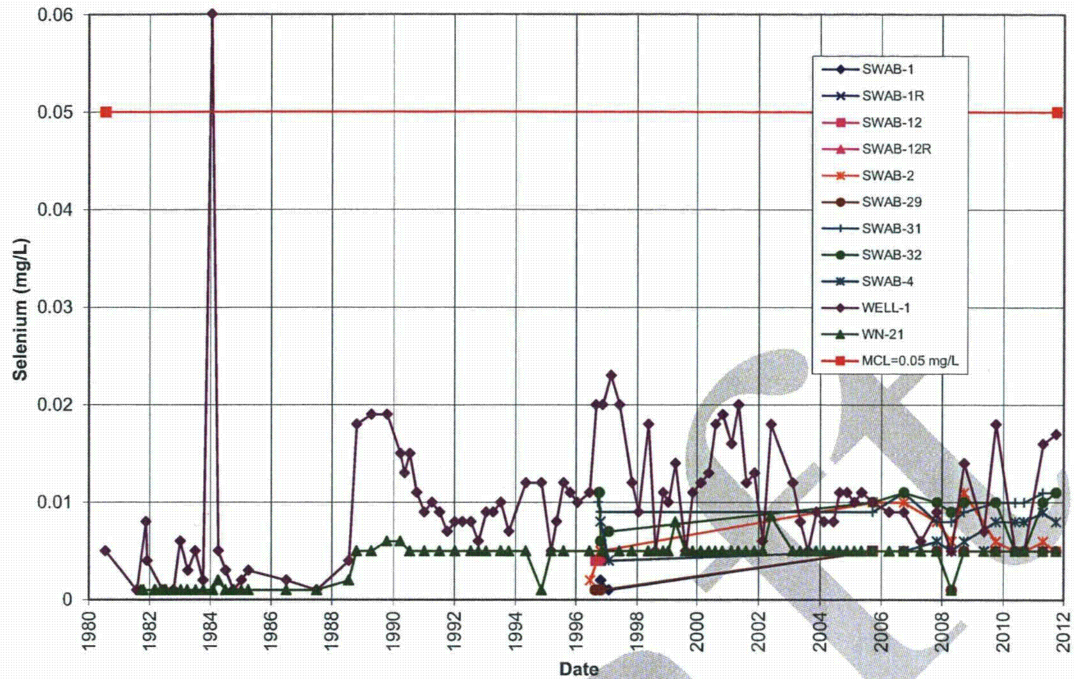
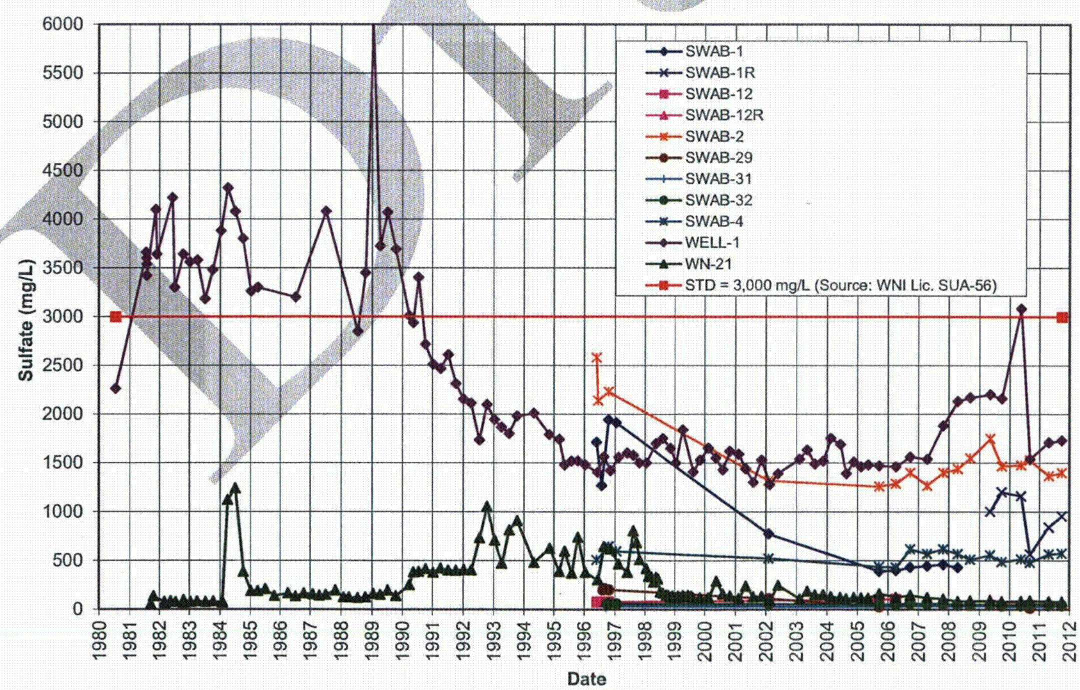
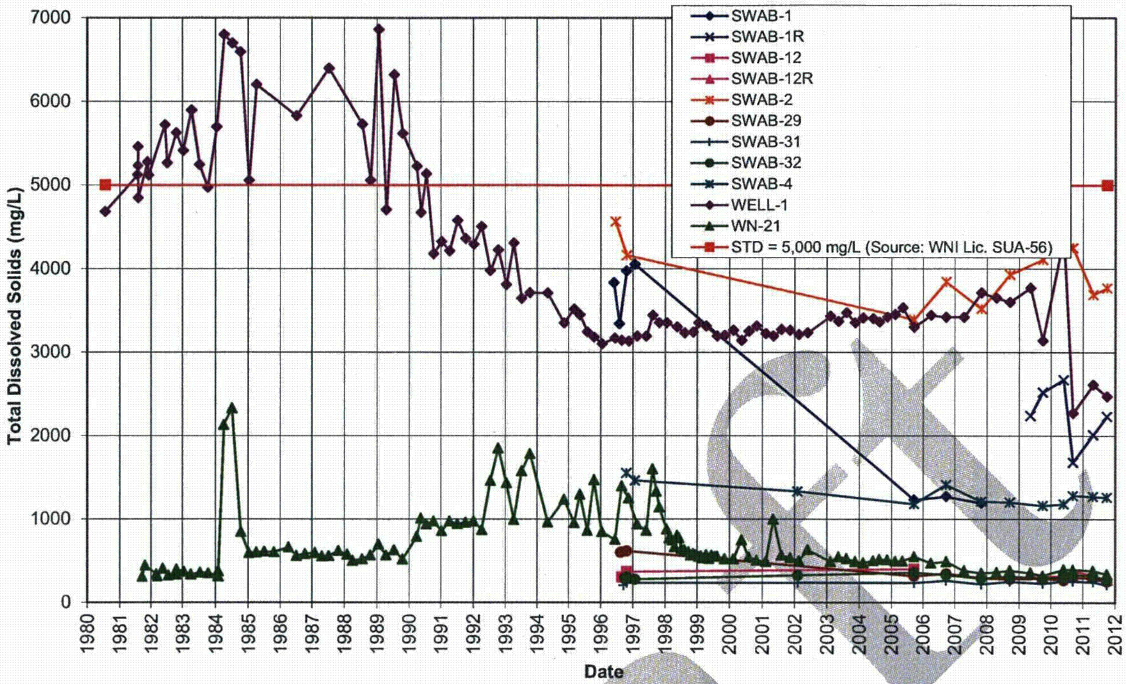


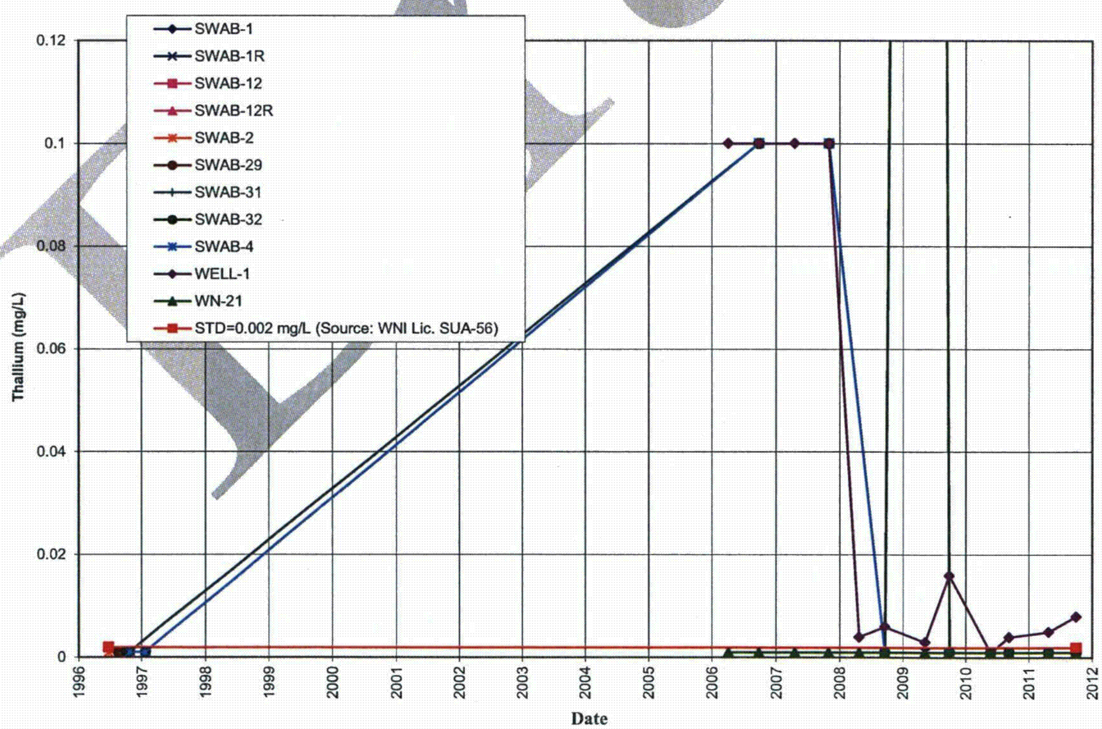
Time-Concentration Plots of Selenium Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Sulfate Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Total Dissolved Solids Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



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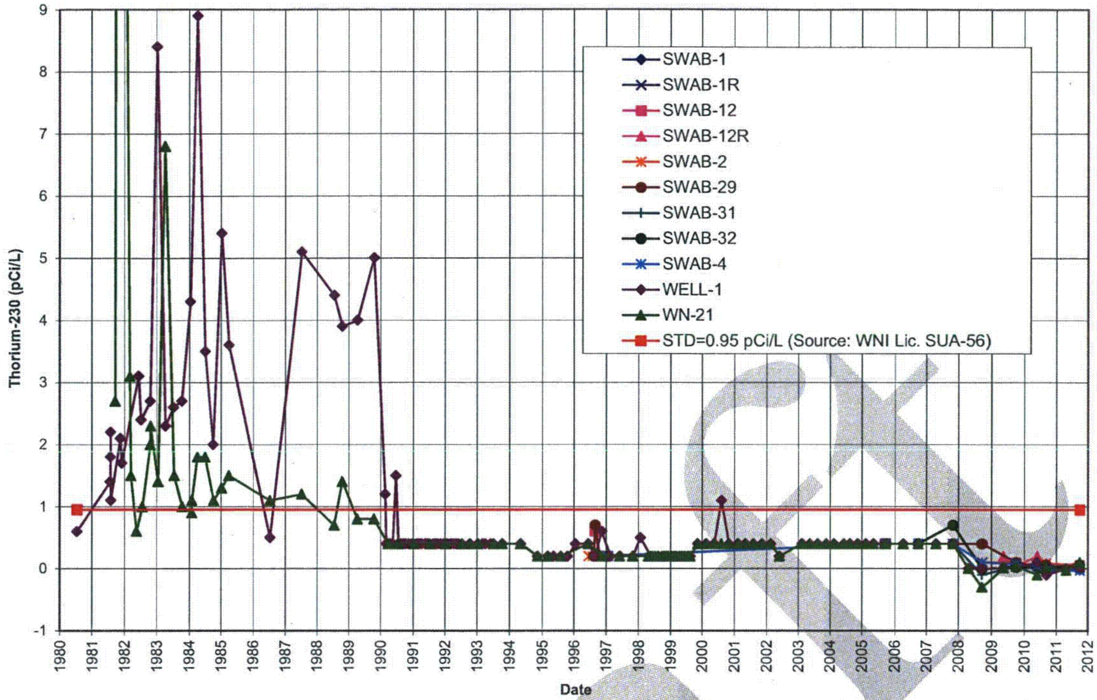

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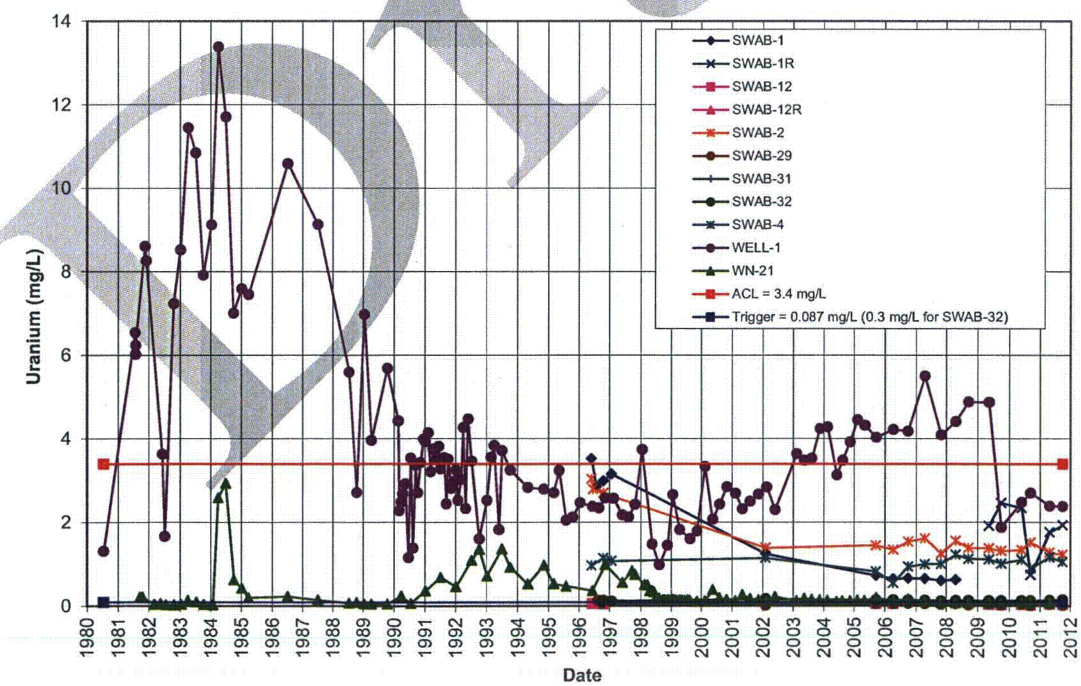
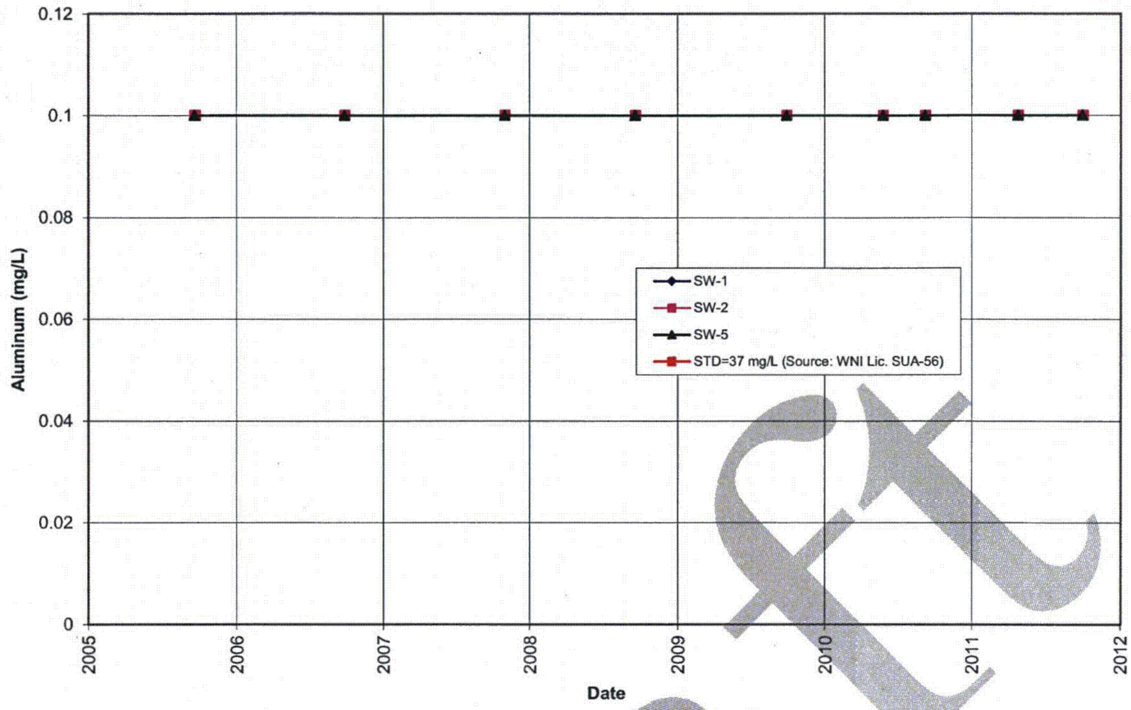
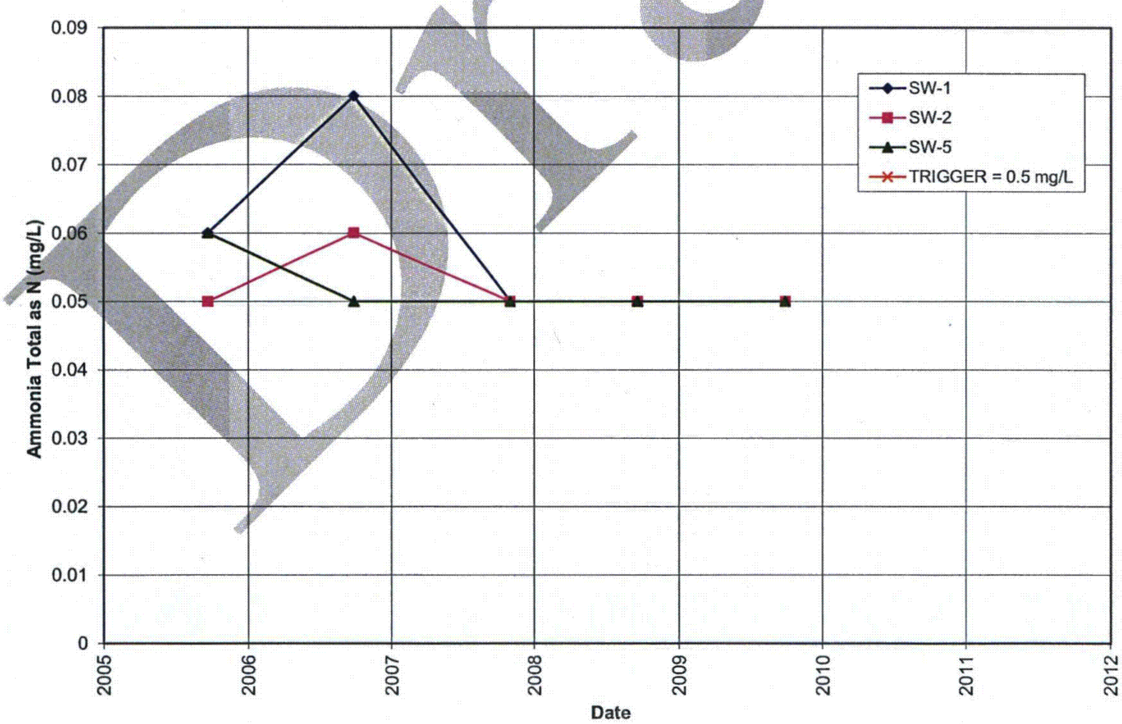


Time-Concentration Plots of Uranium Concentration in Groundwater in the Southwest Valley (Regional Aquifer), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Aluminum Concentration in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Ammonia (Total as N) Concentration in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

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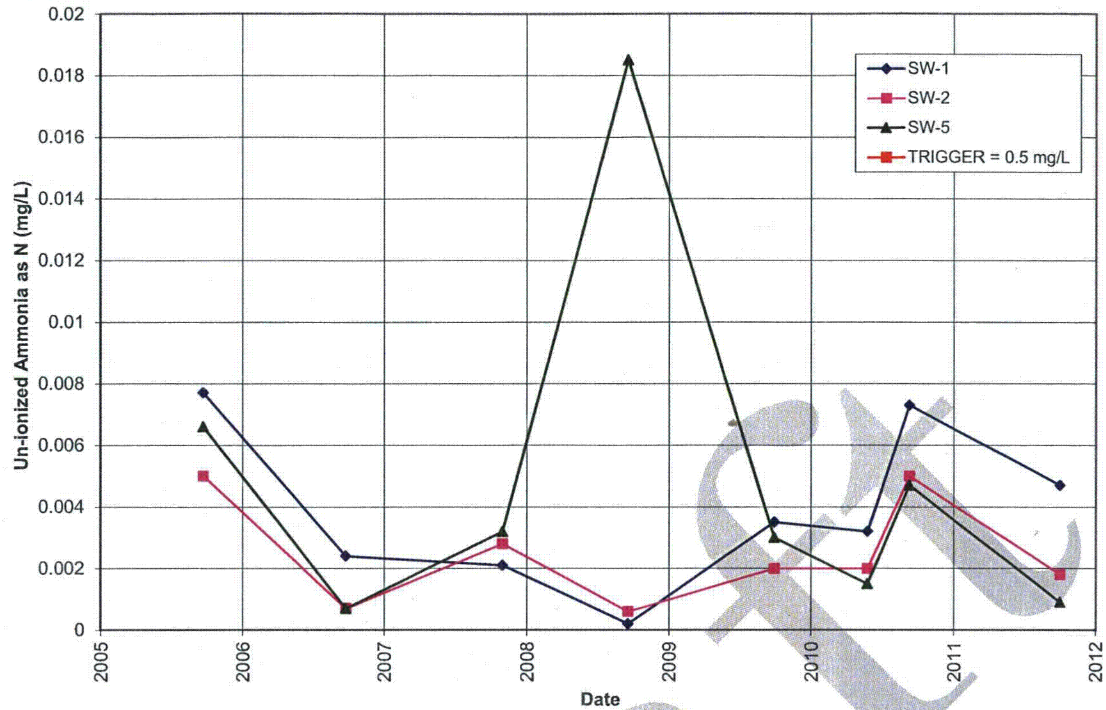
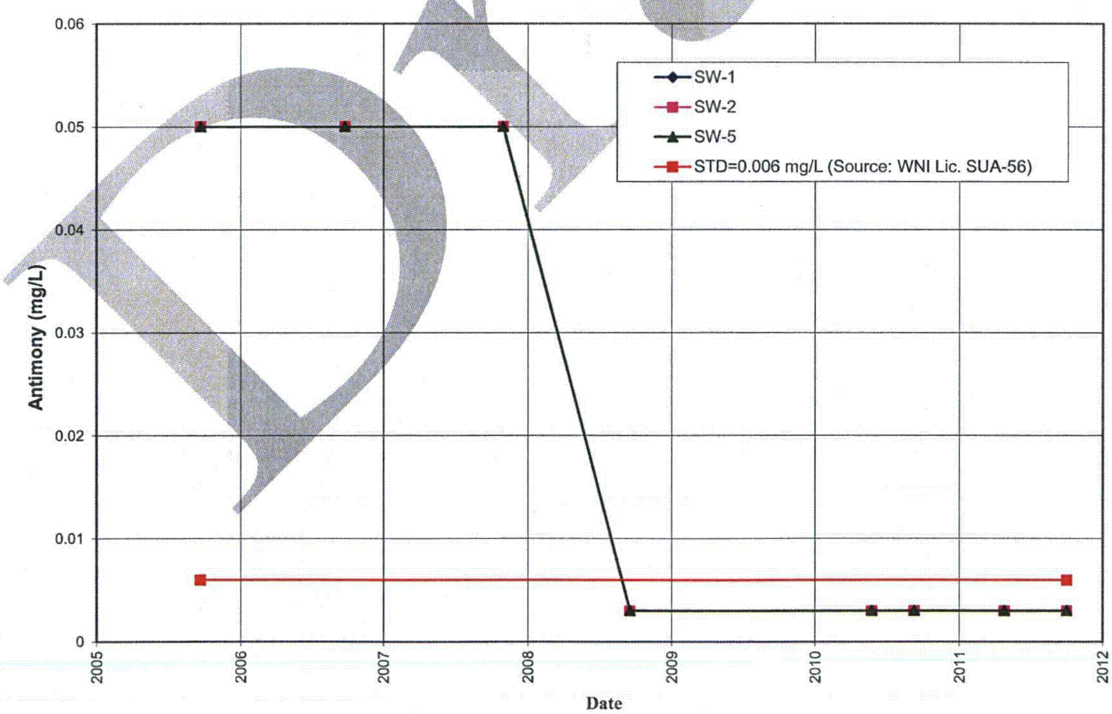
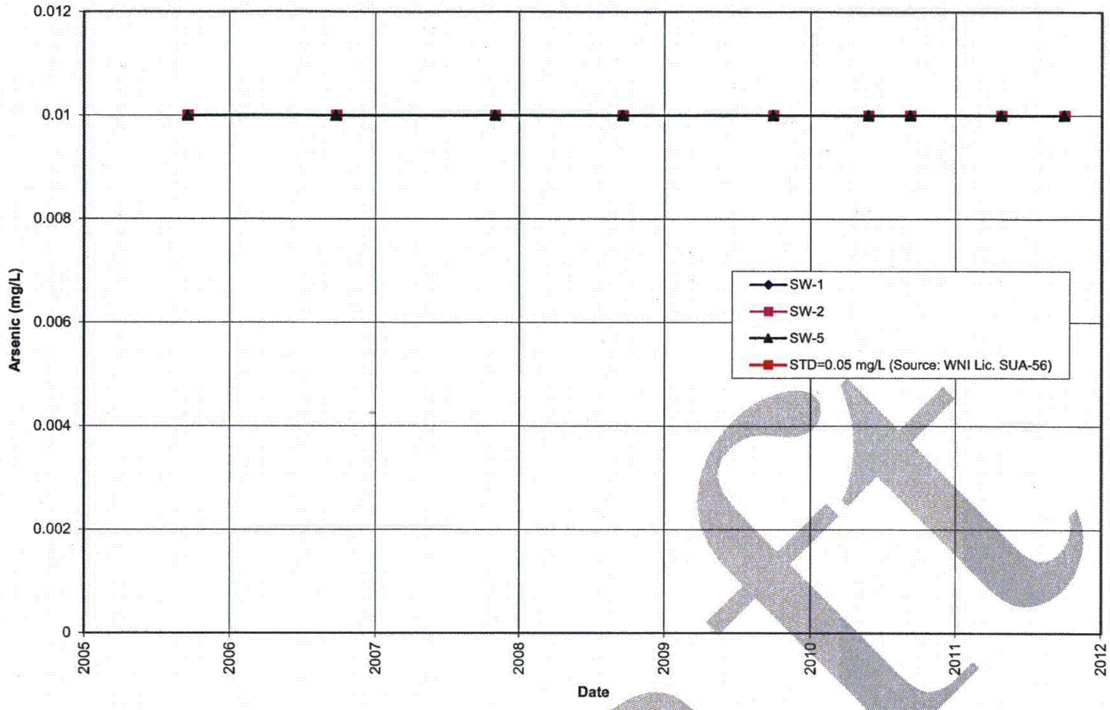


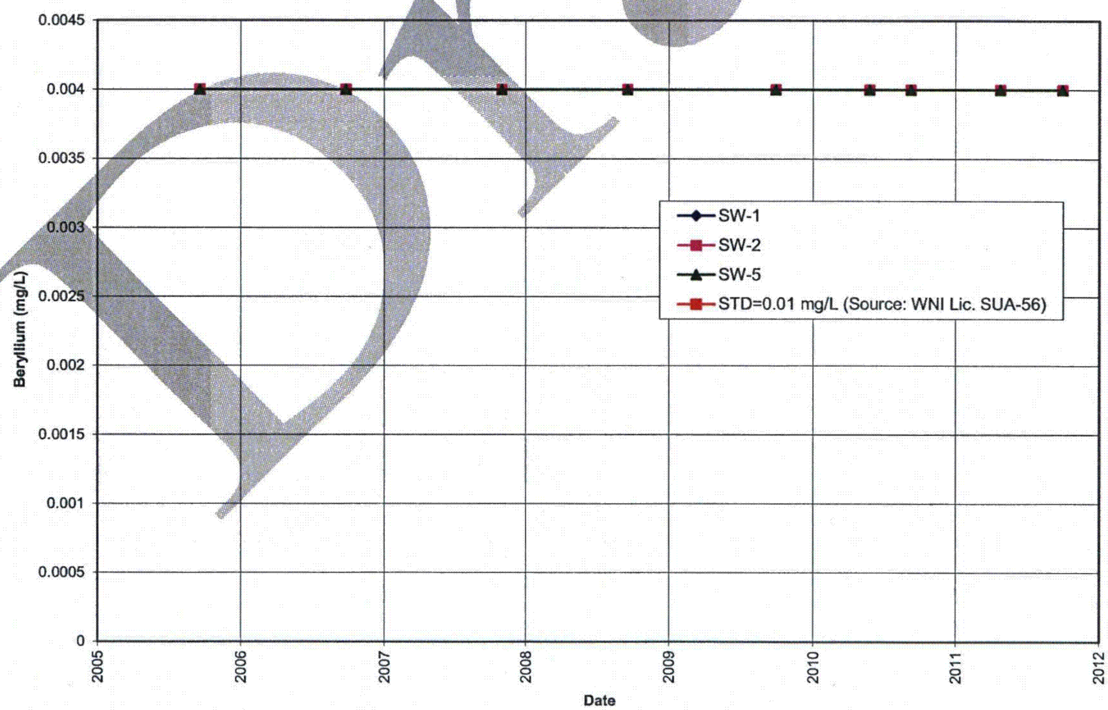
Time-Concentration Plots of Un-ionized Ammonia Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Antimony Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

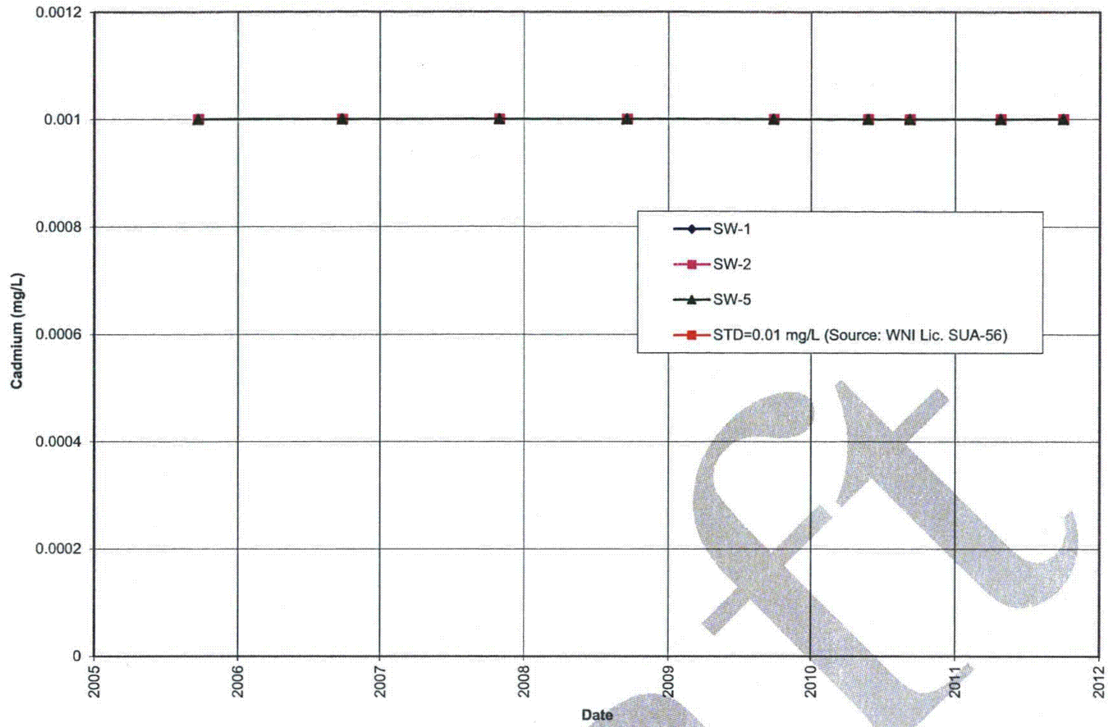


Time-Concentration Plots of Arsenic Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

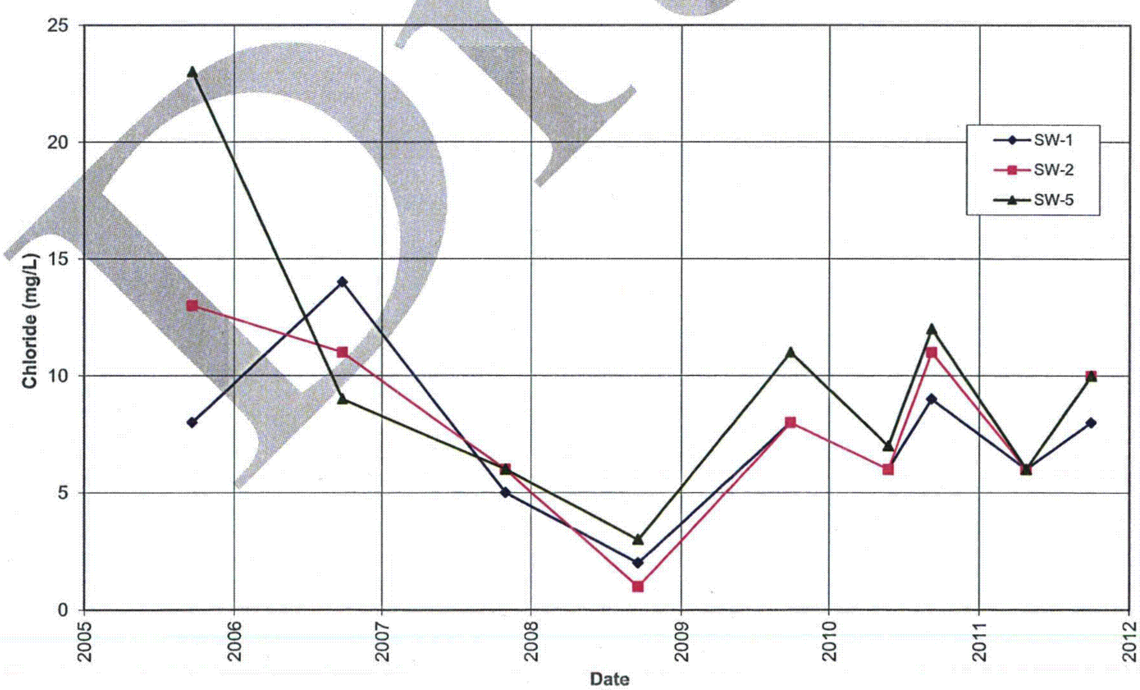


Time-Concentration Plots of Beryllium Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

Draft

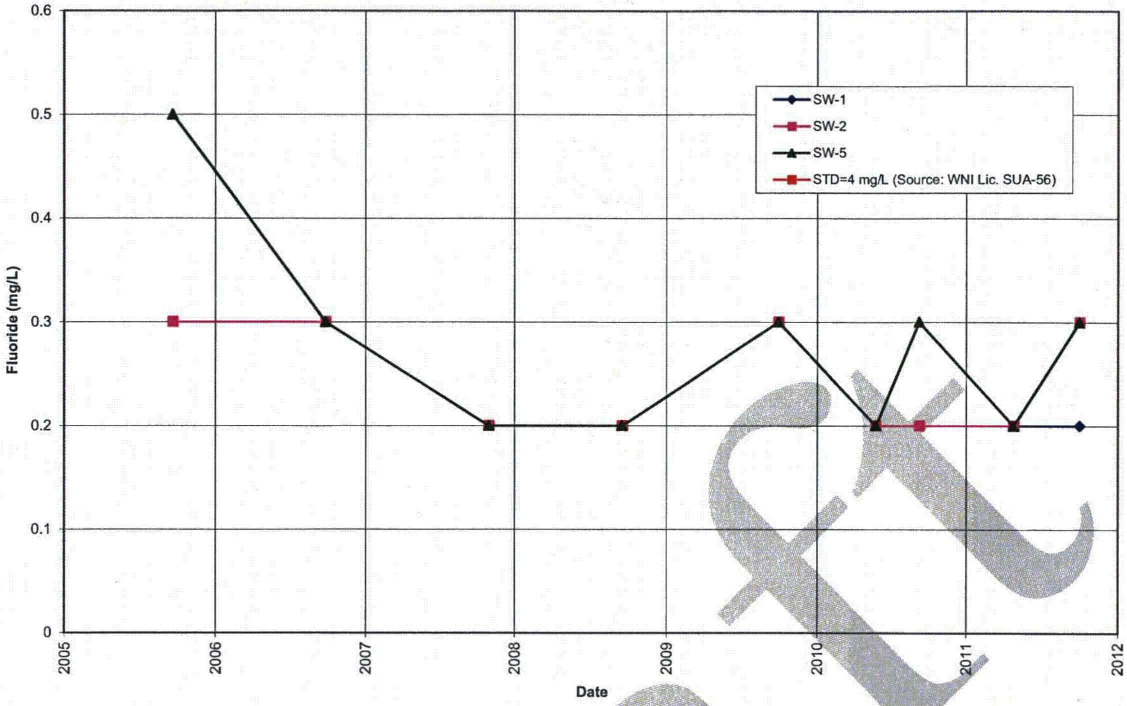


Time-Concentration Plots of Cadmium Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

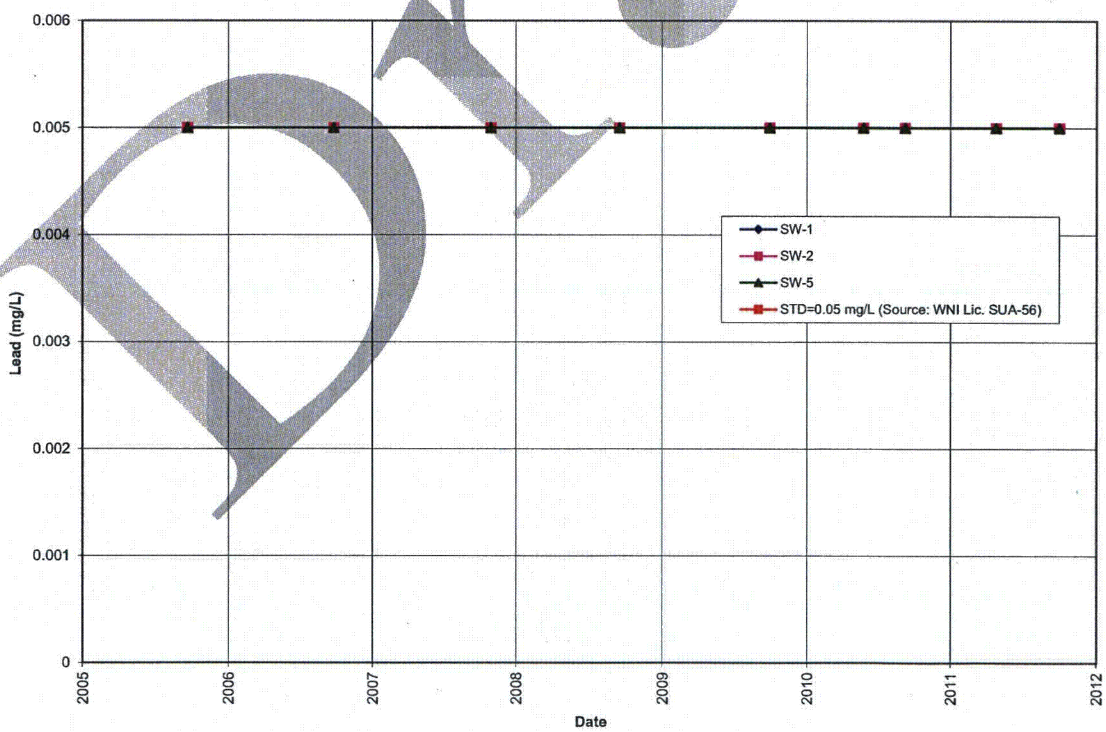


Time-Concentration Plots of Chloride Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

Draft

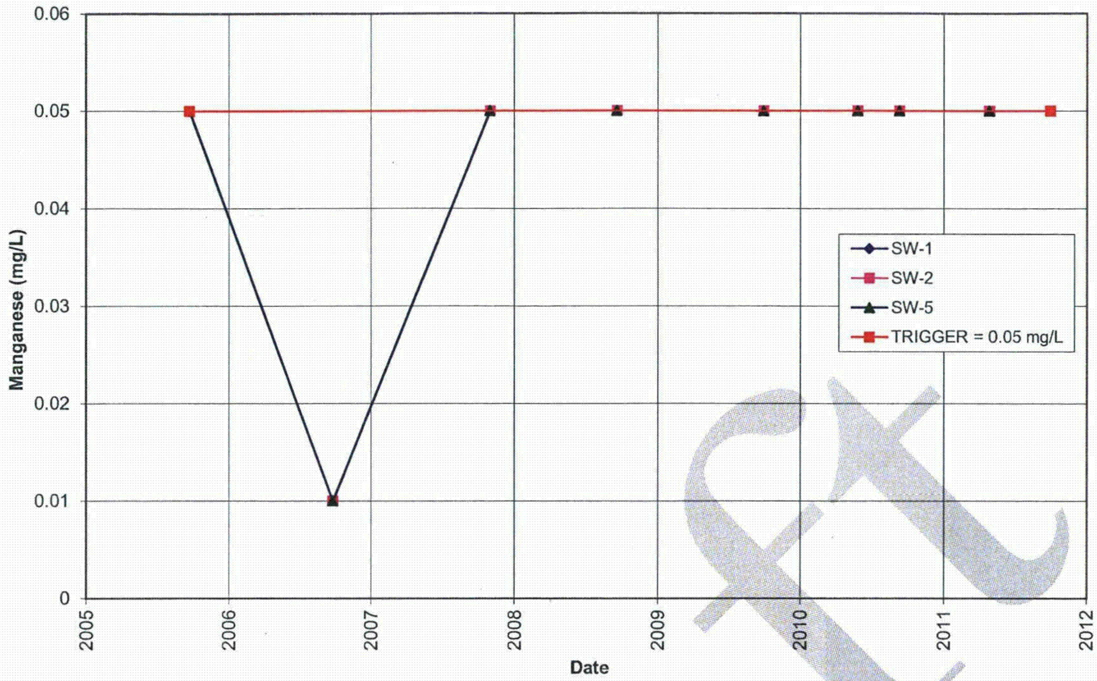


Time-Concentration Plots of Fluoride Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

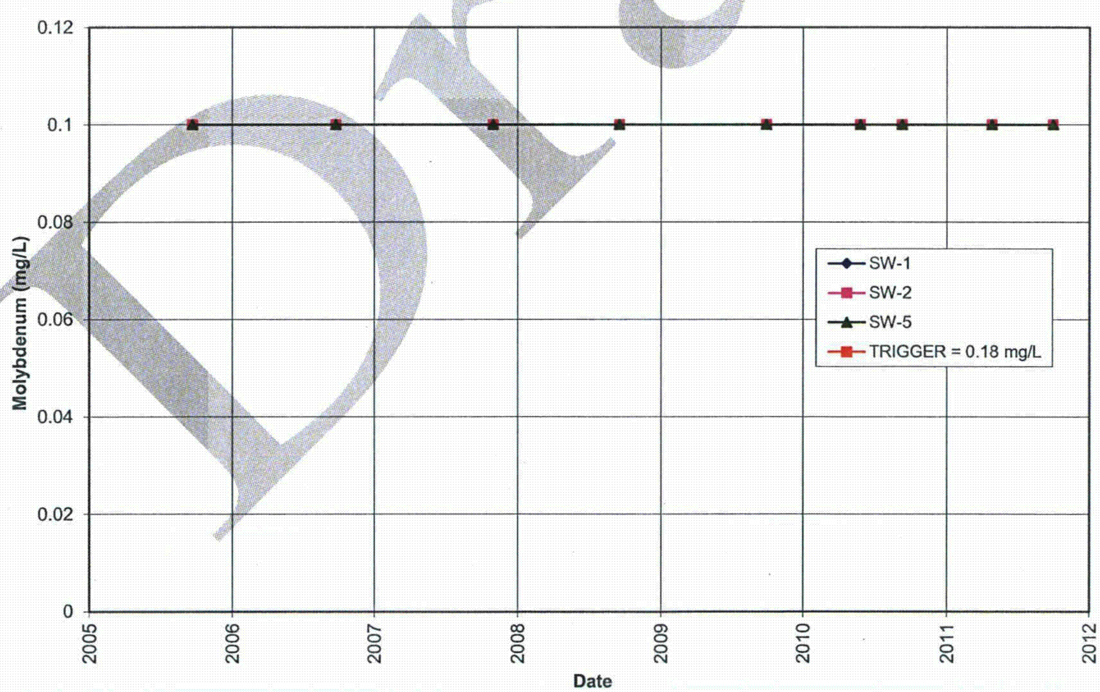


Time-Concentration Plots of Lead Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

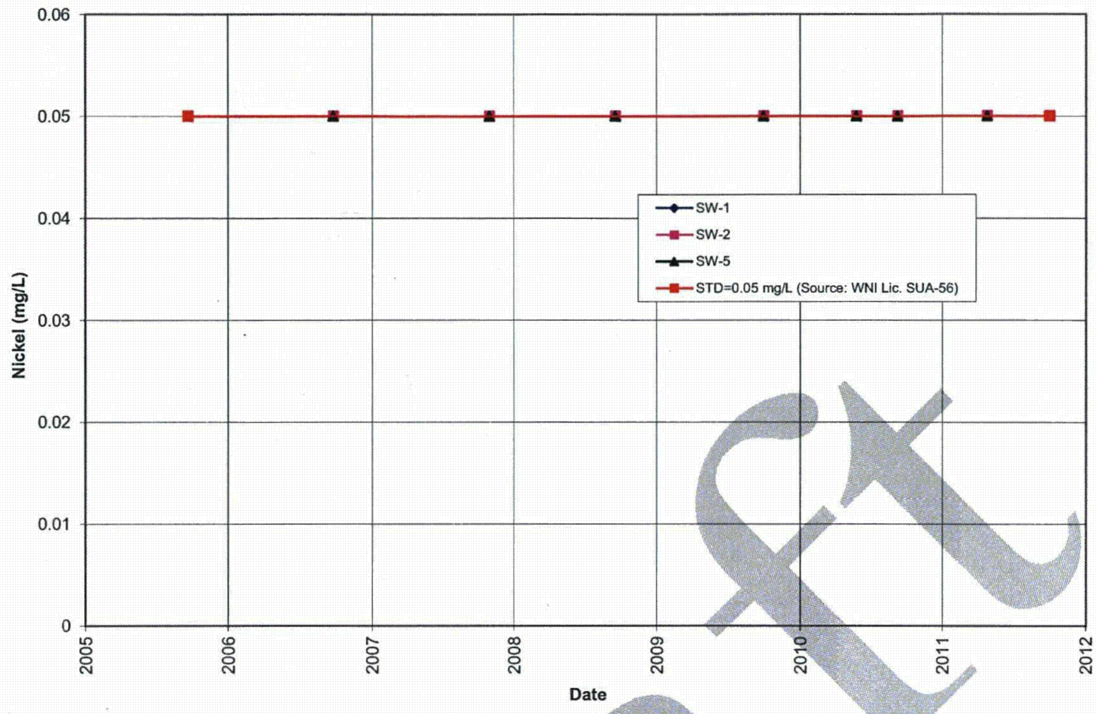
Draft



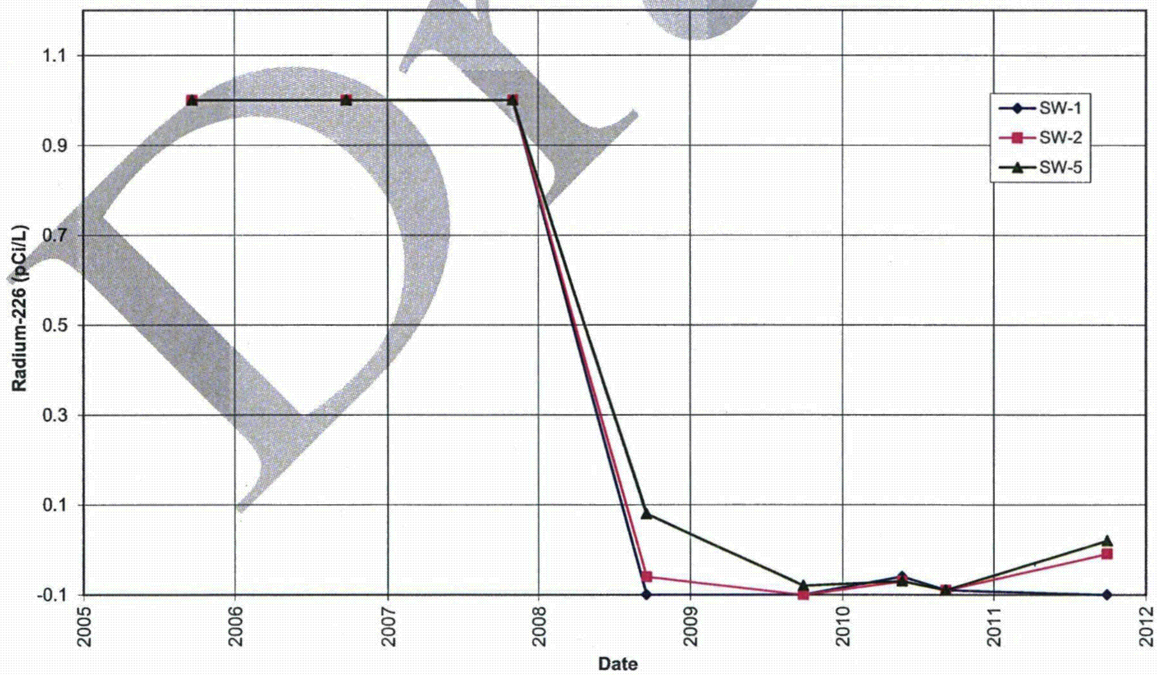
Time-Concentration Plots of Manganese Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



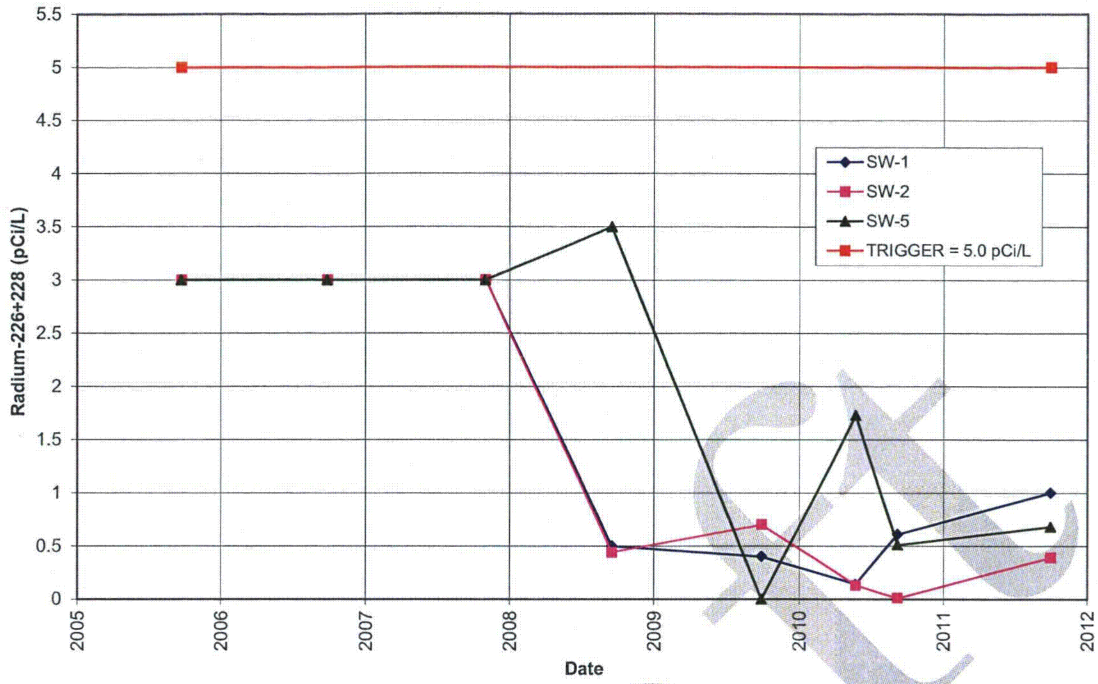
Time-Concentration Plots of Molybdenum Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



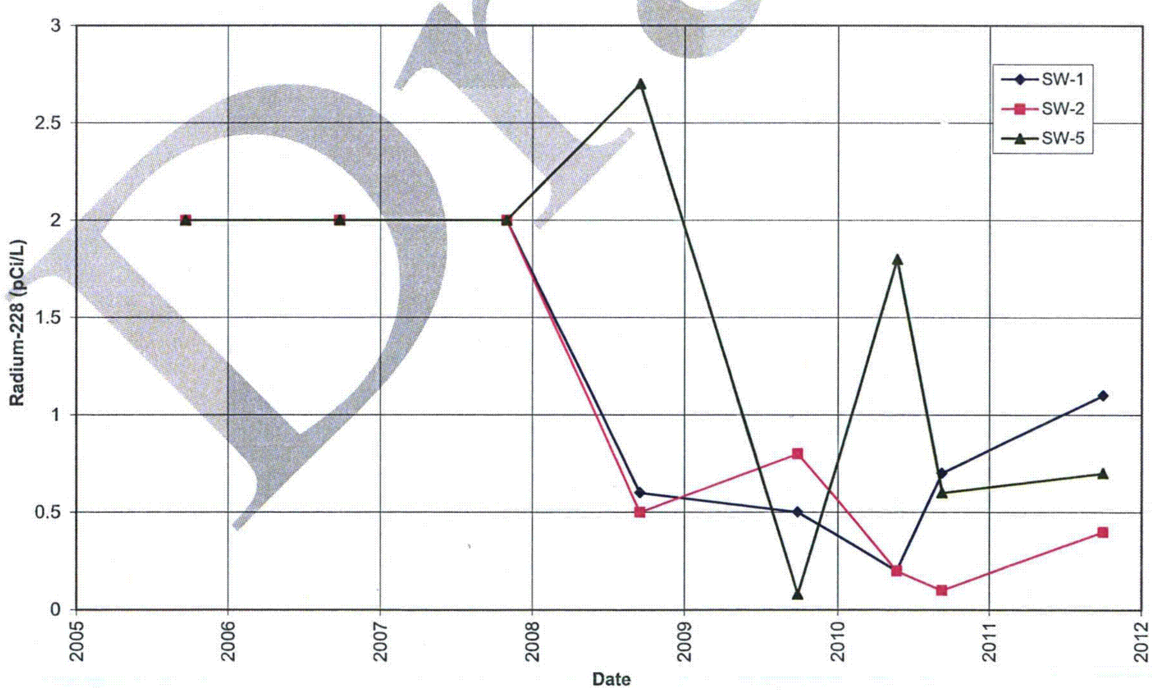
Time-Concentration Plots of Nickel Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



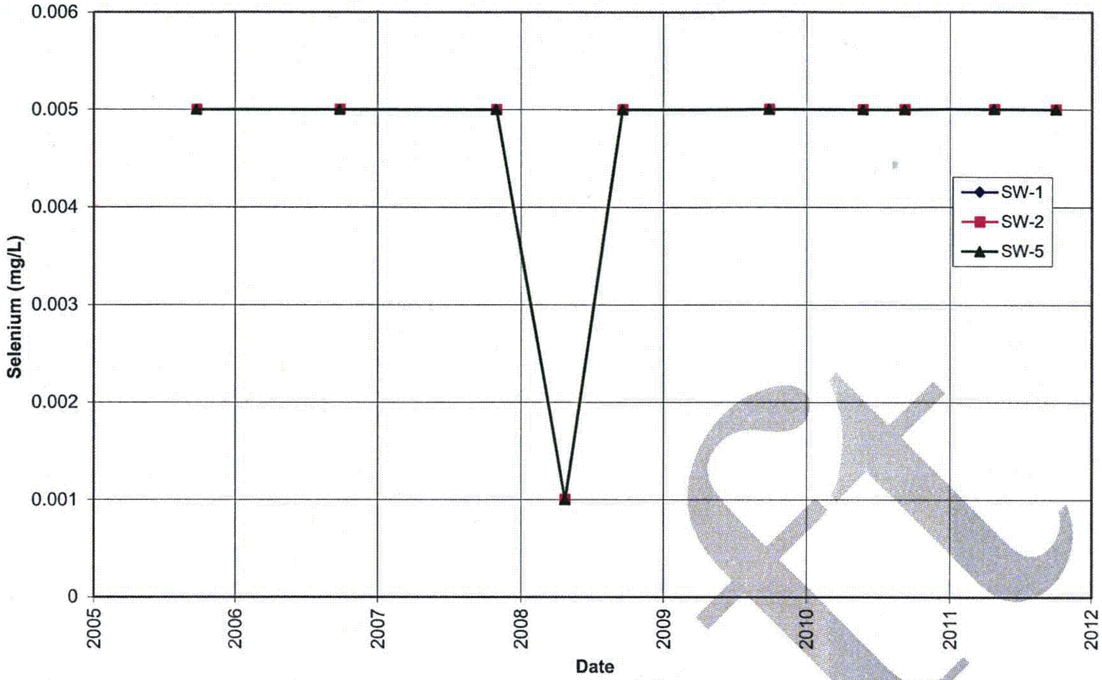
Time-Concentration Plots of Radium-226 Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



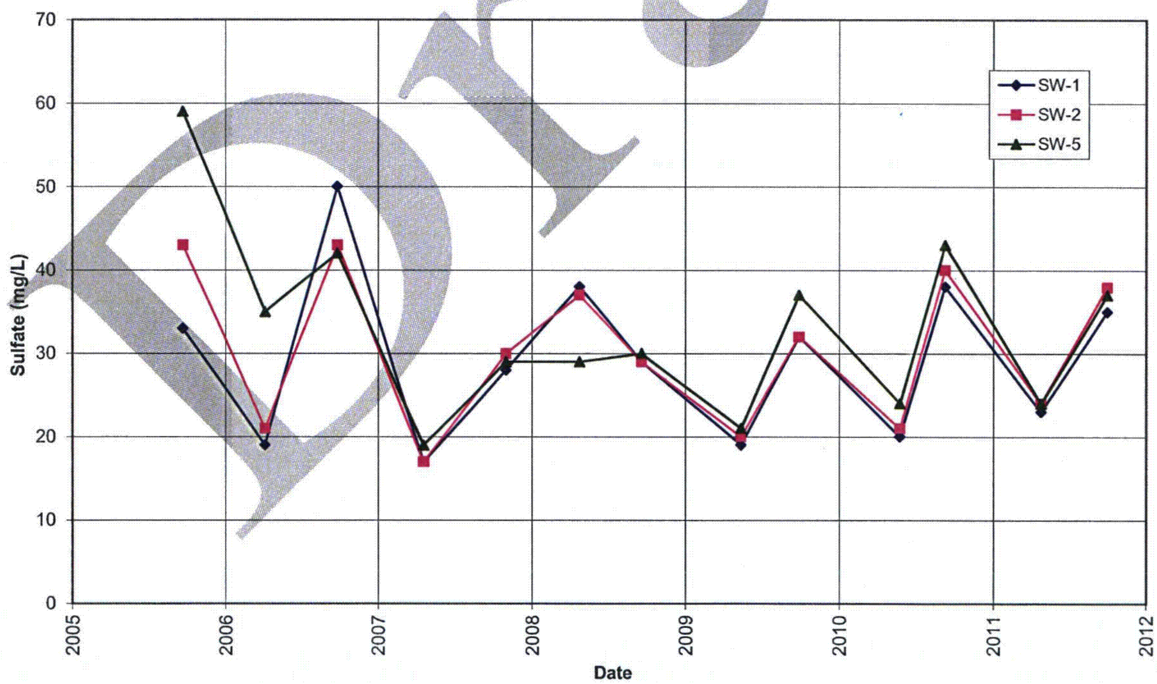
Time-Concentration Plots of Radium-226+228 Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



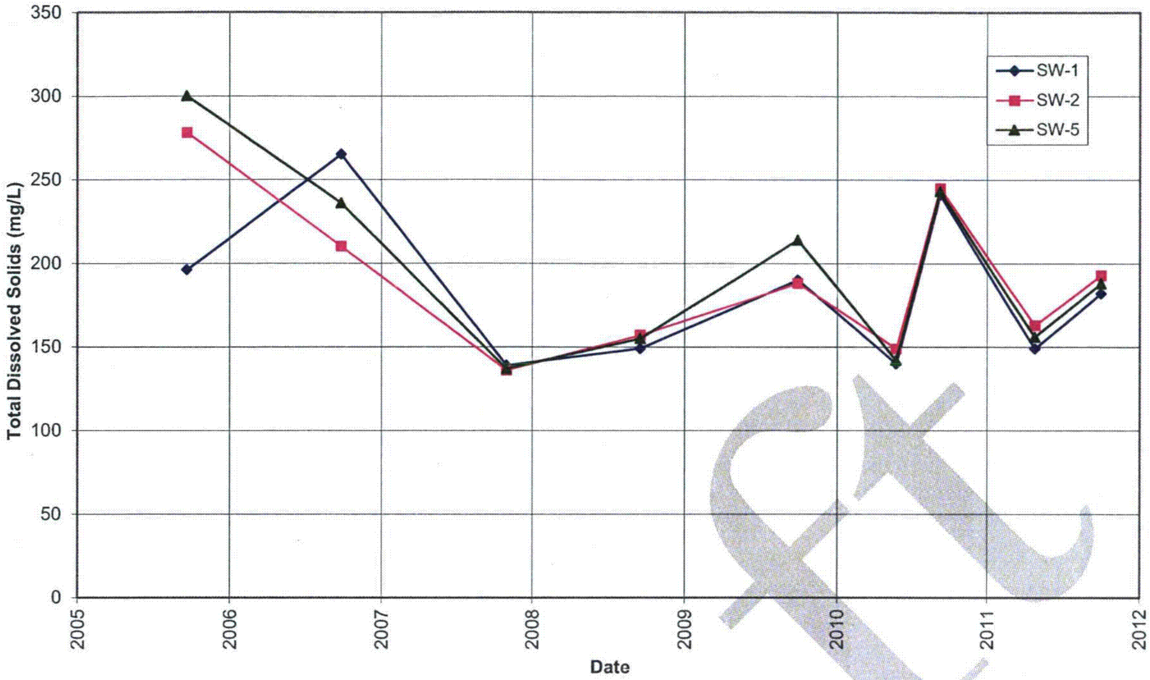
Time-Concentration Plots of Radium-228 Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



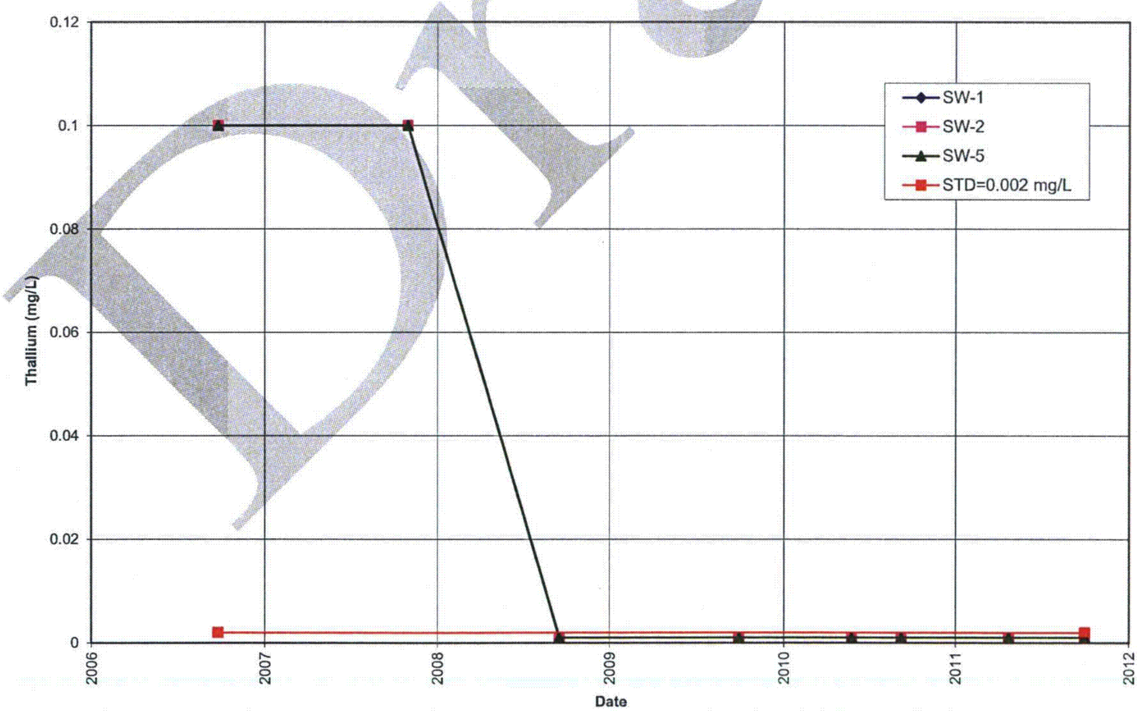
Time-Concentration Plots of Selenium Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Sulfate Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Total Dissolved Solids Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Thallium Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

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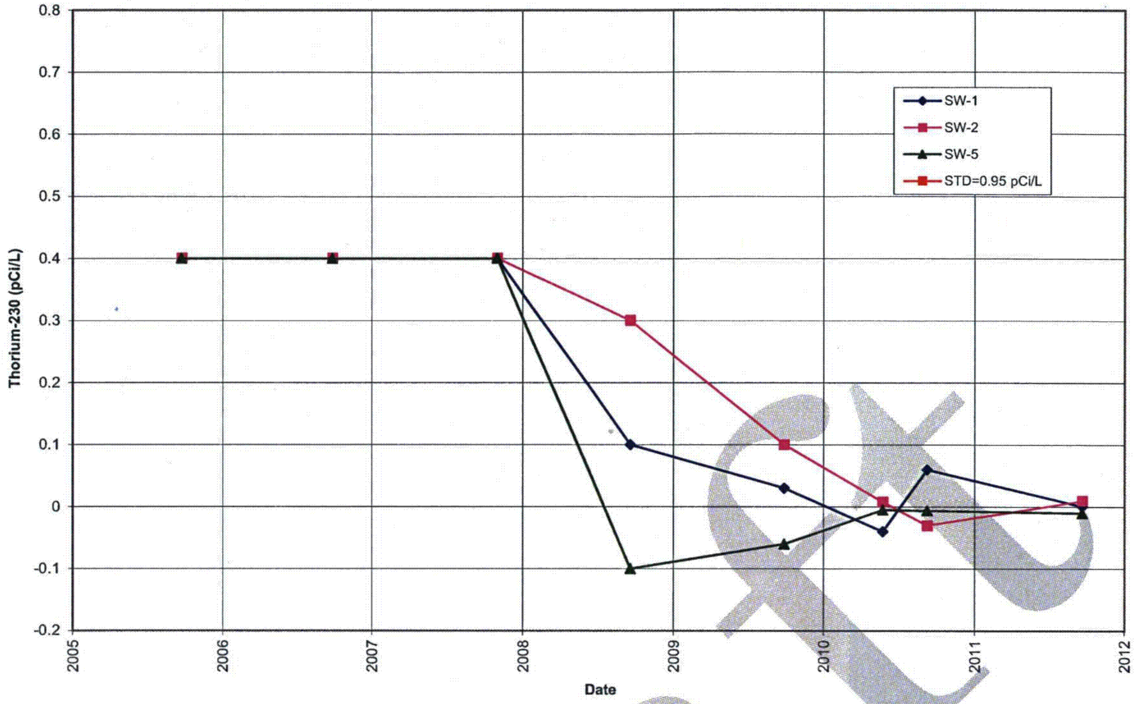
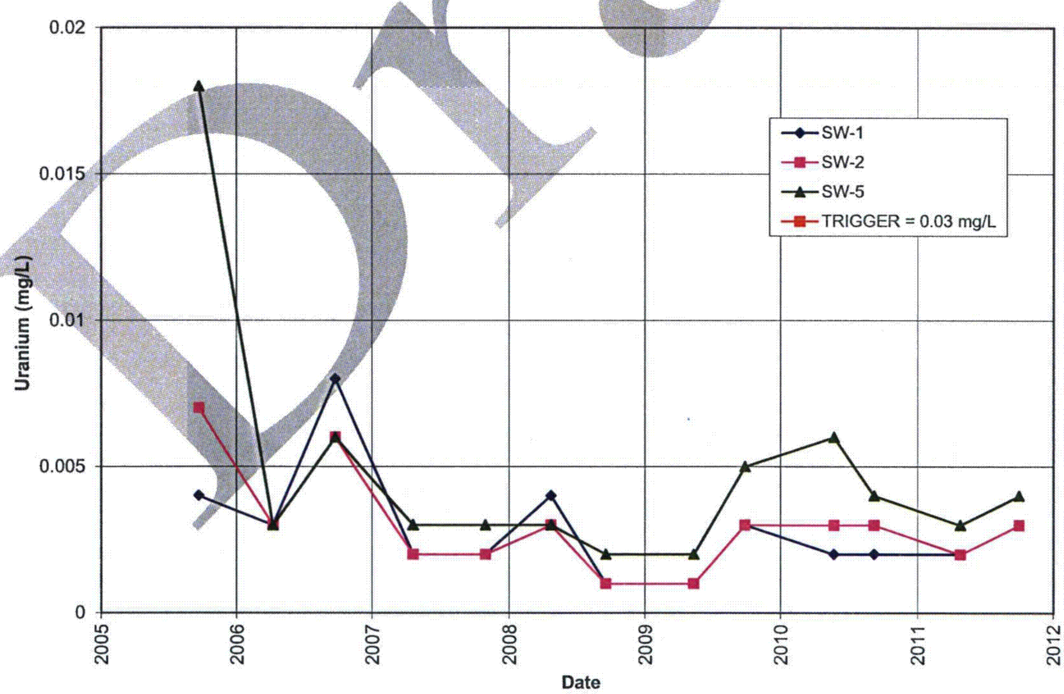


Time-Concentration Plots of Thorium-230 Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site



Time-Concentration Plots of Uranium Concentration in Groundwater in the Surface Water (Sweetwater River), Split Rock, Wyoming, Disposal Site

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NRC Acceptance Documentation

This documentation was added following acceptance of this Long-Term Surveillance by the U.S. Nuclear Regulatory Commission

(to be inserted upon receipt)

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