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NR:IBO-12/076
April 23 2012

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Subject: SUBMITTAL OF THE *FINAL FIVE-YEAR REVIEW OF CERCLA RESPONSE ACTIONS AT THE NAVAL REACTORS FACILITY*

I am forwarding the *Final Five-Year Review of CERCLA Response Actions at the Naval Reactors Facility*. This document, which is required under the Comprehensive Environmental Response, Compensation, and Liability Act and the National Oil and Hazardous Substance Pollution Contingency Plan, evaluates selected remedies for various Inactive Landfill, No Further Action and Remedial Action sites to ensure these remedies are operating correctly and continue to be protective of human health and the environment.

If you have any questions and/or comments regarding this document, please contact me at (208)533-5969.

Christon M. Henvit

C. M. Henvit
Naval Reactors Idaho Branch Office

Attachment: As stated

cc: Kathleen Hain, DOE-ID
P. Johansen, IDEQ
Rebecca Gerhart, EPA (Idaho Operations) w/attachment

Attachment 1

To NR:IBO-12/076

Final Five-Year Review

of CERCLA Response

Actions at the Naval Reactors Facility

Five-Year Review of CERCLA

Response Actions

at the

Naval Reactors Facility

February 2012

Prepared by:

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Prepared for the
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List of Acronyms

A1W	Large Ship Reactor Prototype (<u>1</u>st <u>A</u>ircraft Carrier design by <u>W</u>estinghouse)
ARAR	Applicable or Relevant and Appropriate Requirements
ASL	Above sea level
BBI	Bechtel Bettis Incorporated
bls	below land surface
BPMC	Bechtel Marine Propulsion Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facility Area
CFR	Code of Federal Regulations
COC	Contaminant of Concern
CQA	Construction Quality Assurance
DOE	Department of Energy
ECF	Expended Core Facility
EPA	Environmental Protection Agency
ESD	Explanation of Significant Difference
FFA/CO	Federal Facility Agreement and Consent Order
FS	Feasibility Study
IDEQ	Idaho Department of Environmental Quality
IC	Institutional Control
ICDF	Idaho CERCLA Disposal Facility
ICMR	Institutional Control Monitoring Report
INL	Idaho National Laboratory
IWD	Industrial Waste Ditch
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
NFA	No Further Action
NNPP	Naval Nuclear Propulsion Program
NR/IBO	Naval Reactors/Idaho Branch Office
NRF	Naval Reactors Facility
O&M	Operations and Maintenance
OU	Operable Unit
PRG	Preliminary Remediation Goal
RA	Remedial Action
RAO	Remedial Action Objective
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act.
RD/RA	Remedial Design/Remedial Action
ROD	Record of Decision
RI/FS	Remedial Investigation and Feasibility Study
RWMC	Radioactive Waste Management Complex
S1W	Submarine Thermal Reactor Prototype (<u>1</u>st <u>S</u>ubmarine design by <u>W</u>estinghouse)
S5G	Submarine Reactor Plant Prototype (<u>5</u>th <u>S</u>ubmarine design by <u>G</u>eneral Electric)
SRP	Snake River Plain
SRPA	Snake River Plain Aquifer
SSC	Soft Sided Container
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon

TOX	Total Organic Halogens
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WAG	Waste Area Group
WEC	Westinghouse Electric Company

List of Units

°F	Degrees Fahrenheit
μ	Micro (a prefix denoting a one-millionth part or 10^{-6})
mg	Milligrams
mi^2	Square Miles
NTU	Nepholametric Turbidity Unit
pCi	Picocurie; one trillionth (10^{-12}) of a curie, a measure of the amount of radioactivity
pCi/g	Picocuries per Gram
pCi/L	Picocuries per Liter
ppb	Parts per Billion
ppbv	Parts per Billion by Volume
$\mu g/m^3$	Micrograms per Cubic Meter
μS/cm	Microsiemens per Centimeter

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Executive Summary

The Idaho National Laboratory (INL), located in southeastern Idaho, is a government-owned reservation managed by the U.S. Department of Energy (DOE). It was listed on the National Priorities List of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in November 1989. In accordance with the requirements of CERCLA, the Environmental Protection Agency (EPA), the State of Idaho, and DOE negotiated a Federal Facility Agreement and Consent Order (FFA/CO). That agreement described the methods by which DOE, EPA, and the State of Idaho would implement CERCLA activities at the INL.

To aid in the management of this project, the INL was divided into Waste Area Groups (WAGs), and the WAGs were further divided into Operable Units (OUs). The FFA/CO and the associated Action Plan identified the appropriate level of investigation for each OU. The Naval Reactors Facility (NRF) was designated as WAG 8; DOE-Naval Reactors/Idaho Branch Office (NR/IBO) is the signatory DOE agency responsible for NRF (WAG 8). Under direction of the Action Plan, OUs 8-05 and 8-06 (Inactive Landfill Sites) at NRF were investigated as “Track 2” sites. The investigation resulted in the identification of three former (inactive) landfill areas that required remedial actions to ensure continued protection of human health and the environment. A Record of Decision (ROD) was signed in 1994, which implemented the presumptive remedy for municipal type landfills at NRF. As part of the presumptive remedy, engineered soil covers were constructed over the inactive landfill areas, and monitoring of soil-gas and groundwater was implemented.

In 1997, a Comprehensive Remedial Investigation/Feasibility Study (RI/FS) was performed, which identified twelve OU 8-08 No Further Action (NFA) sites (areas with a source or potential source present, but for which an exposure pathway is not available) and nine OU 8-08 Remedial Action (RA) sites. A ROD was signed the following year. The ROD identified selected remedies for the various sites including Institutional Controls at the NFA Sites and removal of contaminated soil, concrete, and pipe; off-site disposal of debris; consolidation on-site of soils above remediation goals; and construction of engineered earthen covers at the RA Sites. All on-site remedial actions were complete by the end of 2004.

Bechtel Marine Propulsion Corporation (BMPC), on behalf of the signatories of the FFA/CO, has conducted a Five-Year Review of CERCLA responses at NRF. Since contamination remains at NRF above levels that would allow unrestricted release, CERCLA requires a Five-Year Review to evaluate the continued effectiveness of the selected remedies. The INL recently completed the Five-Year Review of CERCLA Response Actions at the INL – Fiscal Years 2005-2009 for all WAGs except WAG 8 (NRF). WAG 8 is addressed separately since it is under the jurisdiction of the Naval Nuclear Propulsion Program (NNPP) rather than the DOE Idaho Operations Office, and cleanup is overseen and funded solely by the NNPP.

This Five-Year Review concludes that the selected remedies remain protective of human health and the environment. The next NRF Five-Year Review is scheduled for five years from the issuance of this document (2016).

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Idaho National Laboratory (USDOE), Naval Reactors Facility		
EPA ID : ID4890008952		
Region: 10	**State:** ID	**City/County:** Idaho Falls/ Butte Co.

SITE STATUS	
NPL status: [X] Final [ ] Deleted [ ] Other (specify)	
Remediation status (choose all that apply): [ ] Under Construction [ ] Operating [X] Complete	
Multiple OUs?* [X] YES [ ] NO	**Construction completion date:** 2004
Has site been put into reuse? [ ] YES [X] NO	

REVIEW STATUS	
Lead agency: [ ] EPA [ ] State [ ] Tribe [X] Other Federal Agency – U.S. Department of Energy	
Author name: Naval Reactors Facility	
Author title: N/A	**Author affiliation:** Naval Nuclear Propulsion Program/ DOE
Review period: September 2006 to September 2011	
Date(s) of site inspection: Annual Inspections Associated with the Institutional Control Plan	
Type of review: [X] Post-SARA [ ] Pre-SARA [ ] NPL-Removal only [ ] Non-NPL Remedial Action Site [ ] NPL State/Tribe-lead [ ] Regional Discretion	
Review number: [ ] 1 (first) [ ] 2 (second) [X] 3 (third) [ ] Other (specify) ___________	
Triggering action: [ ] Actual RA Onsite Construction at OU #_____ [ ] Actual RA Start at OU#____ [ ] Construction Completion [X] Previous Five-Year Review Report [ ] Other (specify)	
Triggering action date: December 2006	
Due date ***(five years after triggering action date)*****:** December 2011	

*"OU" refers to operable unit

Five-Year Review Summary Form, cont'd.

The following issue may warrant follow-up actions, but does not affect current or future protectiveness.

Issues:

- Siltation in NRF-6

Recommendations and Follow-up Actions:

- Monitor well NRF-6 for signs of siltation in future samples
- Reduce groundwater monitoring frequency in Regional Downgradient wells to every other year
- Reduce groundwater monitoring frequency in Local Downgradient wells to one per year
- Maintain biannual groundwater sampling frequency for NRF-6 until data supports change to once per year
- Maintain biannual groundwater sampling frequency for NRF-16 until next Five-Year Review
- Continue collecting groundwater elevation information from all wells two times per year.
- Reduce soil gas sampling frequency in NRF-51 and NRF-53 to once per year
- Maintain biannual soil gas sample frequency for NRF-1 until data supports change to once per year
- Issue minor change to Record of Decision to remove Institutional Controls at NRF-2, 61, 66, and 81
- Revise and update Institutional Control Plan
- Revise and update Operation and Maintenance Manual

Protectiveness Statement(s):

OU 8-05/06 Landfill Covers: From the visual inspections and soil gas and groundwater data obtained to date, the landfill covers appear to be effective at containing contaminants, by inhibiting infiltration of precipitation and by preventing direct contact with contaminated soils and landfill wastes; therefore, this remedy is protective of human health and the environment. Institutional Controls indicated for the OU 8-05/06 Landfill Covers have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the landfill cover sites.

OU 8-08 No Further Action Sites: Data indicate that the remedies implemented at the OU 8-08 No Further Action Sites are protective of human health and the environment because these remedies have been effective in limiting unauthorized access and excavation. The data also indicates that activities at NRF have not adversely affected the groundwater, thereby supporting the No Further Action designation of the sites. Institutional Controls indicated for the OU 8-08 No Further Action Sites have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the No Further Action Sites.

OU 8-08 Remediated Radiological Sites: The selected remedies at OU 8-08 Remediated Radiological Sites are protective of human health and the environment. The OU 8-08 Remedial Action report indicates that pipe removal and consolidation of contaminated soil has been successful in achieving remedial action objectives. The data also indicates that activities at NRF have not adversely affected the groundwater, thereby supporting the protectiveness statement for the sites. Institutional Controls indicated for the OU 8-08 Remediated Radiological Sites have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the Remediated Radiological Sites.

OU 8-08 Engineered Cover Sites: The selected remedies at OU 8-08 Engineered Cover Sites are protective of human health and the environment. The construction of engineered earthen covers has been successful in achieving remedial action objectives. Exposure pathways that could result in unacceptable risks are being controlled by institutional controls. The data also indicates that activities at NRF have not adversely affected the groundwater, thereby supporting the protectiveness statements for the sites. Institutional Controls indicated for the OU 8-08 Engineered Cover Sites have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the Engineered Cover Sites.

In summary, because the individual remedies at each site are protective of human health and the environment, collectively the selected remedies for the NRF remediated CERCLA sites are protective.

1.0 Introduction

Bechtel Marine Propulsion Corporation (BPMC) operates the Naval Reactors Facility (NRF) for the U. S. Department of Energy (DOE), Office of Naval Reactors (NR). In 1991, DOE signed a Federal Facilities Agreement and Consent Order (FFA/CO) with the Idaho Department of Health and Welfare (now the Idaho Department of Environmental Quality (IDEQ)) and the U. S. Environment Protection Agency (EPA) Region 10, which initiated NRF's participation in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at the Idaho National Laboratory (INL). Between 1992 and 2004, NRF completed a number of remedial activities at several Operable Unit (OU) sites. The CERCLA process requires a Five-Year Review if the selected remedial actions result in any hazardous substances, pollutants, or contaminants remaining at the site at levels that would preclude unlimited use and unrestricted release of the site.

In 2001, a Five-Year Review was performed for the three OU 8-05/06 Inactive Landfill Areas (two OU 8-05 and one OU 8-06 landfill areas) identified as NRF-1, NRF-51, and NRF-53. In 2004, a Five-Year Review was performed for the OU 8-08 No Further Action (NFA) and Remedial Action (RA) Sites. In the 2006 Five-Year Review, the required reviews for all three operable units were combined into a single Five-Year Review for NRF (i.e., addressing OU 8-08 earlier than required to support efficient future reviews). The 2006 review included the three Inactive Landfill Areas identified above and twelve NFA Sites designated as NRF-2, NRF-16, NRF-18A, NRF-22, NRF-23, NRF-42, NRF-43, NRF-61, NRF-66, NRF-81, NRF-82, and NRF-83. The 2006 review also included the OU 8-08 RA Sites designated as NRF-11, NRF-12A, NRF-12B, NRF-14, NRF-17, NRF-19, NRF-21A, NRF-21B, and NRF-80. Because the two Five-Year Reviews were combined and issued in December 2006, a new trigger or target date for issuing subsequent Five-Year Reviews was set.

Figure 1-1 shows the locations of the Inactive Landfill Areas. Figure 1-2 and Figure 1-3 shows the locations of the NFA and RA Sites as they appeared at the beginning of the 2011 review cycle. Figure 1-4 shows the locations of the OU 8-08 Engineered Covers (OU 8-08 RA Sites where covers were constructed).

In 2008, the status of NRF-18A (a NFA Site) was changed to "No Action". The status change at NRF-18A was accomplished by collecting additional sampling data that showed a source did not exist at this site. In 2010, after removal of residual contamination, the need for maintaining institutional controls at NRF-80 was removed. Also, well NRF-13 was removed from the NRF Groundwater Monitoring Network, while NRF-16 a new upgradient well was added.

This Five-Year Review is intended to determine whether the selected remedies remain protective of human health and the environment. In addition, this review reassesses the monitoring programs to ensure the correct constituents are being monitored at the correct frequency.

BMPC, on behalf of the signatories of the FFA/CO, has conducted a Five-Year Review of the remedial actions implemented at NRF for three OU 8-05/06 Inactive Landfill Areas, eleven OU 8-08 NFA Sites, and nine OU 8-08 RA Sites (also referred to as Remediated Radiological Sites and OU 8-08 Engineered Cover Sites). The INL recently completed a site-wide Five-Year Review for all Waste Area Groups (WAGs) except WAG 8 (NRF). WAG 8 is addressed separately since it is under the jurisdiction of the Naval Nuclear Propulsion Program (NNPP) rather than the DOE Idaho Operations Office, and cleanup is overseen and funded solely by the NNPP.

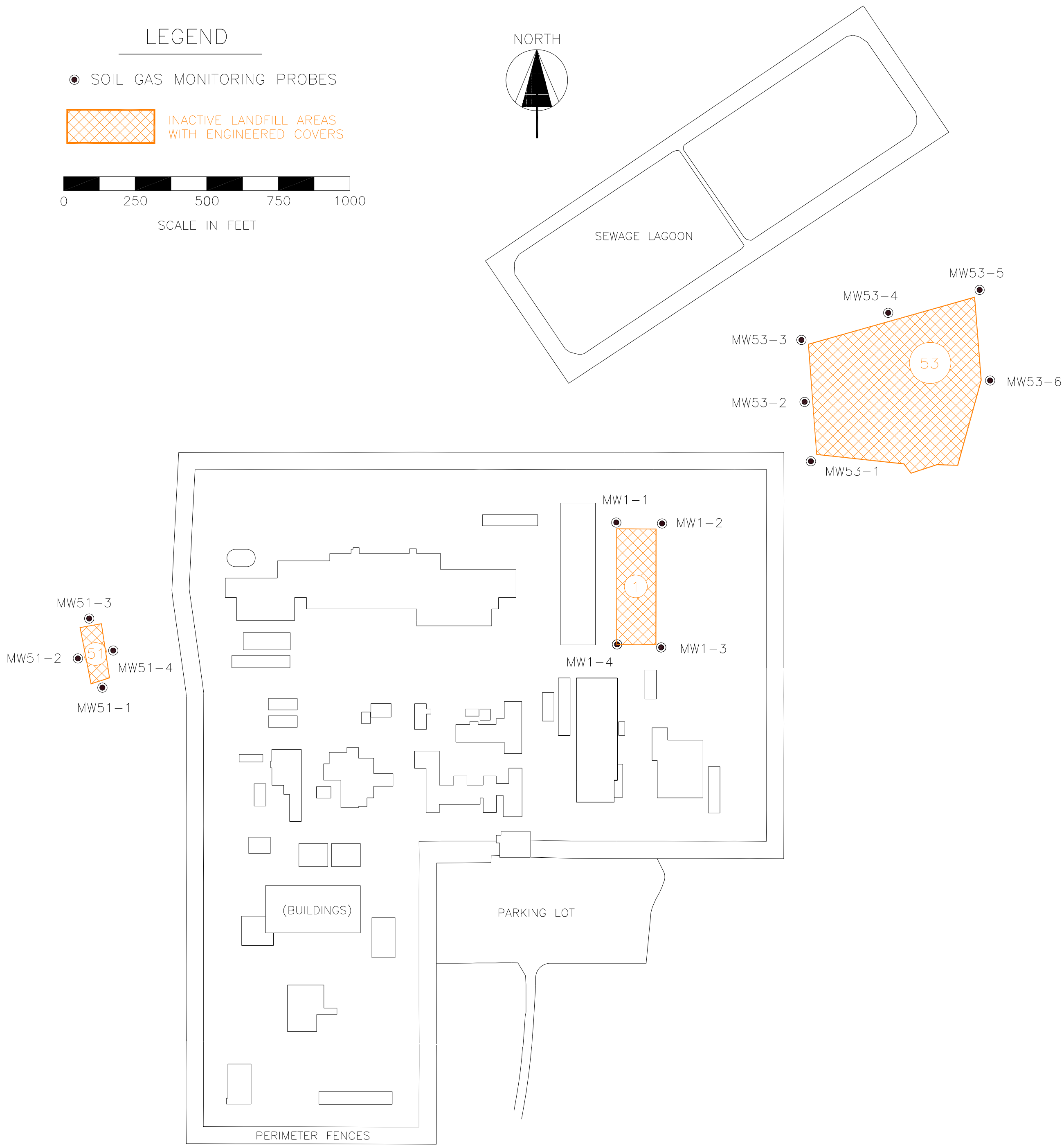


Figure 1-1 Location of NRF OU 8-05/6 Inactive Landfill Areas

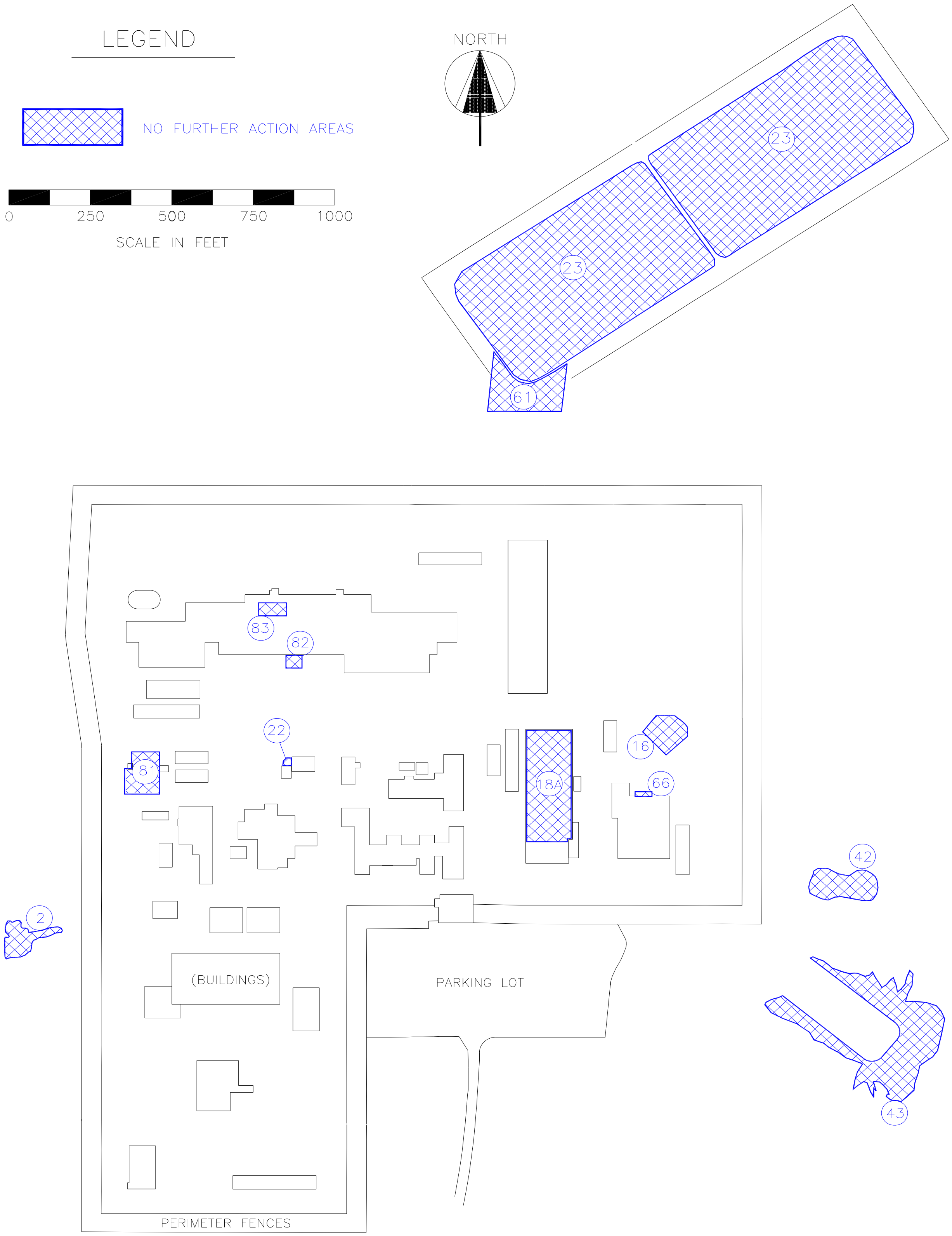


Figure 1-2 Location of OU 8-08 No Further Action Sites

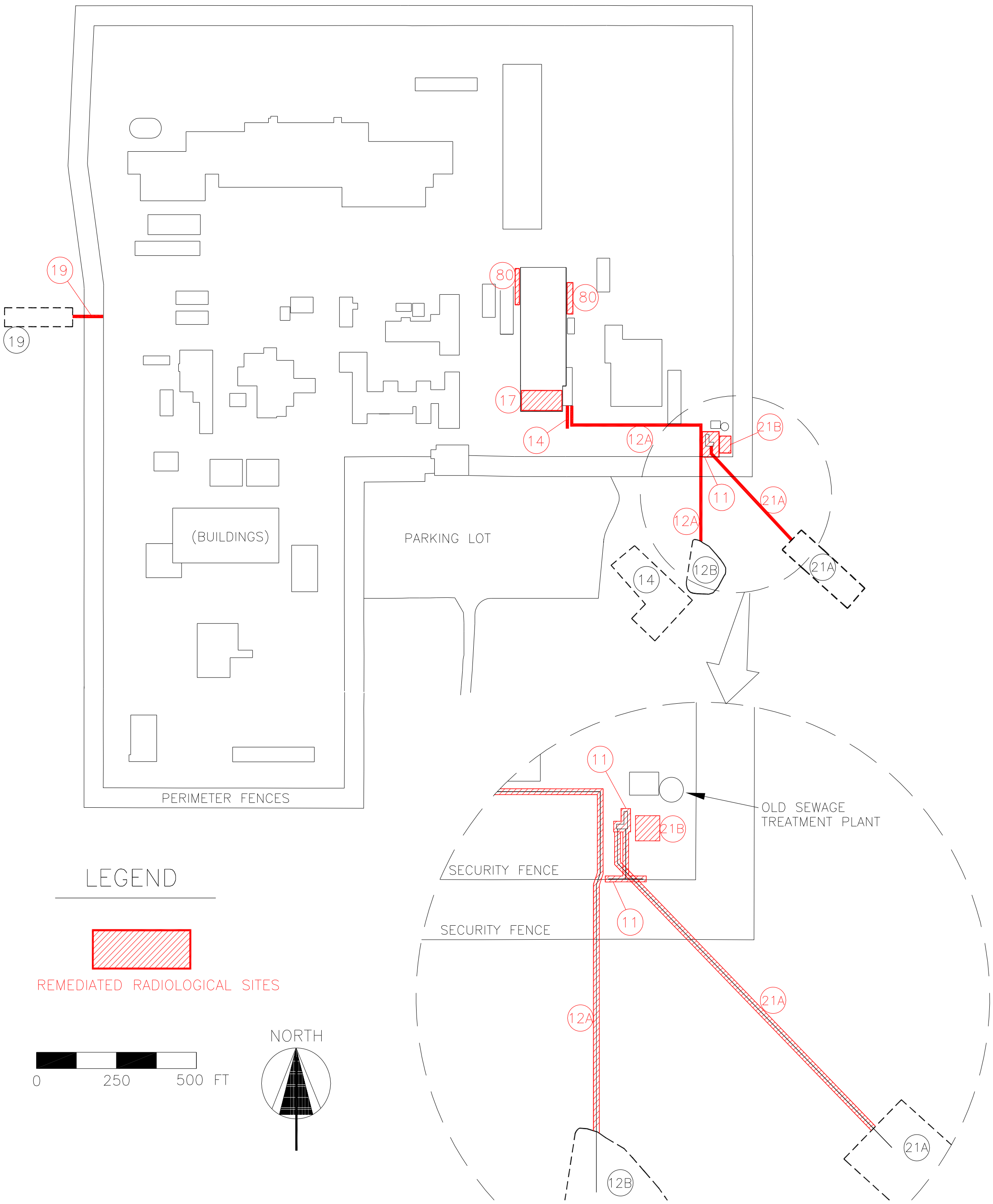


Figure 1-3 Location of OU 8-08 Remediated Radiological Sites

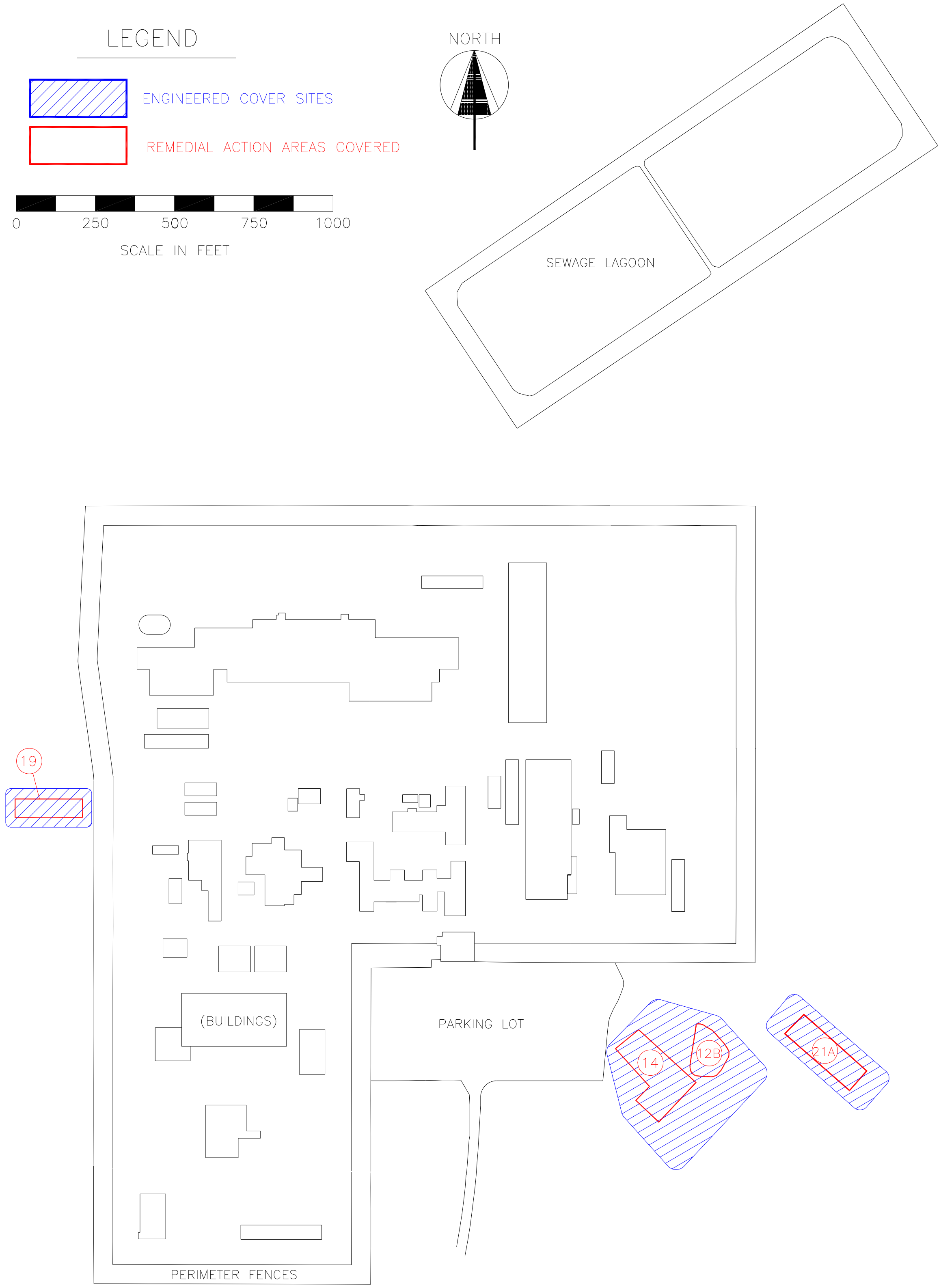


Figure 1-4 Location of OU 8-08 Engineered Covers

The required date for this review is five years after the issuance of the first combined Five-Year Review for the Inactive Landfill Areas and Remedial Action Sites, which was December 2006. Since the first combined Five Year Review covered a period of time up to September 2006, this review will cover the time period from September 2006 to September 2011.

2.0 Site Chronology

Table 2-1 summarizes the chronology of significant events for the NRF OU 8-05/06 Inactive Landfill Areas (including groundwater monitoring wells and soil gas probes). Table 2-2 summarizes the chronology of significant events for the NRF OU 8-08 sites. These lists include key construction and regulatory dates.

Table 2-1 Chronology of NRF Inactive Landfill Areas

Date	Event
1960	Estimated initial closure of landfill site NRF-1
1963	Estimated initial closure of landfill site NRF-51
1970	Estimated initial closure of landfill site NRF-53
Circa 1987	Initial post closure discovery of landfill
November 1989	The INL added to National Priorities List
November 1993	1st Track 2 Investigation completed (NRF-1 and NRF-51)
April 1994	2nd Track 2 Investigation completed (NRF-53)
September 1994	Record of Decision signed
October 1994	Remedial design began
May 1995	Groundwater monitoring wells construction began
August 1995	Remedial design completed
September 1995	Groundwater monitoring wells construction completed
February 1996	Landfill covers construction began
February 1996	Soil gas monitoring probes construction began
June 1996	Soil gas monitoring probes construction completed
September 1996	Landfill covers construction completed
September 1996	Final Inspection of landfill covers completed
February 2001	First Five-Year Review Report for OU 8-05/06
November 2003	Replaced Soil Gas Probes MW1-1 and MW1-2
December 2006	First Combined Five-Year Review Report for OU 8-05/06 and OU 8-08 issued
December 2010	Groundwater monitoring well NRF-16 replaces wells NRF-7, NRF-13 and USGS 12

Table 2-2 Chronology of OU 8-08 Areas

Date	Event
November 1989	The INL added to National Priorities List
September 1997	Completion of Remedial Investigation/Feasibility Study (RI/FS)
September 1998	Record of Decision signed
June 1999	Work at NRF-14 commenced
September 1999	Phase I Remedial Design/Remedial Action (RD/RA) Work Plan issued (remediation)
July 2002	Explanation of Significant Difference (to the Record of Decision) to add a third engineered cover was signed
August 2002	Phase II RD/RA Work Plan issued (cover construction)
June 2003	Phase I work completed
April 2004	Construction of OU 8-08 Engineered Covers began
June 2004	First Five-Year Review Report for OU 8-08 issued
October 2004	Phase II OU 8-08 Engineered Cover construction completed
October 2005	Final Inspection of OU 8-08 Engineered Covers completed
December 2006	First Combined Five-Year Review Report for OU 8-05/06 and OU 8-08 issued
November 2008	NRF 18A is re-designated a No Action site

3.0 Background

3.1 Site Location and Demography

3.1.1 INL

The INL is a government facility managed by the DOE. It is located 32 miles west of Idaho Falls, Idaho, and occupies 894 square miles (mi^2) of the northeastern portion of the Eastern Snake River Plain. Facilities at the INL are primarily dedicated to environmental research, nuclear research and development, and waste management.

3.1.2 NRF

NRF is located on the west central side of the INL, as shown in Figure 3-1 approximately 50 miles west of Idaho Falls, Idaho. NRF was established in 1949 as a testing site for the Naval Nuclear Propulsion Program. The Westinghouse Electric Company (WEC) operated NRF for DOE, Office of Naval Reactors from 1949 through the fall of 1998, at which time site operations were turned over to Bechtel Bettis, Inc (BBI). Several years later BBI became Bechtel Marine Propulsion Corporation or BMPC. NRF covers seven mi^2, of which 80 acres are developed. At various times, up to 3,300 people occupied the site. Approximately 1,360 Bechtel, long-term subcontractor, and DOE employees are currently working at NRF. The nearest public roads to NRF are approximately seven miles west, ten miles north, and ten miles south.

3.1.3 Ecological Characteristics

The INL lies within the sagebrush steppe region of North America. The natural vegetation at the INL typically consists of a predominant shrub canopy with an underlayment of perennial grasses and forbs. The predominant shrub is Wyoming big sagebrush. Other important shrubs include Basin big sagebrush, winterfat, and green rabbit brush. Common native grasses include thickspiked wheatgrass, bottlebrush squirreltail, Indian ricegrass, and needle-and-thread. Less common grasses are bluebunch wheatgrass (common at higher elevations on alluvial fans) and Great Basin wildrye (occurs in areas with deep soils between lava ridges, in sandy soils, and in disturbed sites). In comparison to the rest of the sagebrush steppe region, the INL supports a high diversity of forbs. Some of the common native forbs are globe-mallow, Hood's phlox, various milkvetches, paintbrushes, and mustards (Anderson 2003).

The variety of habitats on the INL supports numerous species of reptiles, birds, and mammals. Several bird species warrant special concern because of their threatened status or sensitivity to disturbance. All birds of prey that exist on the INL are protected species. Of these birds, owls, hawks, and falcons are known to exist or have been spotted at NRF. Other animals that can be found near NRF include: antelope, mule deer, elk, moose, mountain lions, cottontail and pigmy rabbits, ground squirrels, mice, voles, badgers, beavers, raccoons, coyotes, jackrabbits, weasels, bats, lizards, snakes, swans, and a variety of small birds. The sage grouse, a candidate-threatened species, inhabits the Snake River Plain although none have been seen immediately around NRF.

3.2 Site Physical Characteristics

The INL is located on the northeastern portion of the Eastern Snake River Plain, a plateau that is composed primarily of volcanic rocks and relatively minor amounts of sediments. Underlying the INL is a series of basaltic flows containing sedimentary interbeds. The Snake River Plain Aquifer (SRPA) is the largest potable aquifer in Idaho, and underlies the Eastern Snake River Plain and the INL.

3.2.1 Climate Summary

The INL is located in an area with a temperate climate, characterized by warm summers and cold winters. Average daily temperatures range from 7 °F during the winter to 76 °F during the summer. Temperature extremes range from -47 °F to 105 °F. NRF receives approximately 8.3 inches of precipitation per year based on data collected at a weather reporting station located five miles south of the facility.

Since 1972, southeast Idaho has experienced three droughts. Each drought has been successively more severe than the previous drought. As shown in Figure 3-2, the first drought occurred between 1974 and 1979, the second between 1987 and 1993, and the latest between early 1999 and late 2004. Each drought was followed by a prolonged wet period that was less robust than the previous wet period. Figure 3-3 compares precipitation received at the Central Facilities Area located five miles south of NRF to the water table elevation in well USGS 12, which is located approximately three miles north of NRF. Note that changes in water level lag behind changes in average precipitation by approximately two to three years.

Figure 3-3 also indicates that the amount of precipitation on the Snake River Plain near NRF appears to be trending downward. During three dry periods, the troughs corresponding to the droughts and depicted in the graph represented successively lower yearly precipitation. Between January 1972 and the end of December 1991, CFA received a total of 169 inches of precipitation. In comparison, between January 1989 and the end of 2010, a period representing the same amount of time, CFA received a total of 158 inches of precipitation. Furthermore, the regional decline in SRPA water levels follows a similar pattern which indicates that these water levels may be as much influenced by declining long-term precipitation totals as by increased water usage from the SRPA by farmers and occupants. Figure 3-3 also shows that following the first and second droughts, the water level in USGS 12 strongly rebounded; however, following the most recent drought that ended in 2004, the expected rebound in USGS 12 water levels did not occur. The primary factor influencing recharge to USGS 12, which in turn, is reflected in rising water levels is recharge to the Big Lost River sinks. In recent years, the amount of water that flows along the Big Lost River channel to the sinks has decreased even with above average precipitation in the area. The cause for this may be due to aquifer recharge projects upstream of the INL.

Since 1980, the water table at USGS 12 has fallen by approximately 18 feet. Because the hydrogeologic conditions at NRF are similar to those at USGS 12, the water table elevations near NRF are similarly affected by reduced flow conditions in the Big Lost River. For example, the water level in NRF-8 has dropped from approximately 4483 feet above sea level (ASL) in mid-2000 to approximately 4465 feet ASL at the present time. And like USGS 12, the water table has been somewhat static for the past several years. Historical precedence indicates that during previous drought periods, the aquifer water table elevation dropped about 18 feet.

This analysis suggests that in the future NRF may be adversely affected by cyclical droughts in two ways. First, during the next drought cycle, if the pattern discussed above persists, some of the NRF CERCLA monitoring wells may go dry or nearly so. To avert this problem, NRF may be required to lower pump intake levels in the wells. Second, vegetation located on the earthen covers that may be suitable for temperate climates and tolerate short dry periods, may become stressed and die when conditions are drier than those that occurred between May 2003 and April 2004, the driest 12 month period since 1972, when the INL received 3.71 inches of precipitation.

3.2.2 Site Hydrogeology

3.2.2.1 SRPA

The SRPA is the largest source of potable water in Idaho, and underlies the Eastern Snake River Plain and the INL. The aquifer is approximately 200 miles long and 50 miles wide, and covers an area of approximately 9,600 mi^2. The depth to the SRPA at the INL varies from approximately 200 feet in the northeastern corner to approximately 900 feet in the southeastern corner. The distance between these extremes is 42 miles.

The EPA designated the SRPA as a sole-source aquifer under the Safe Drinking Water Act on October 7, 1991. On a large scale, the SRPA is highly permeable because of the presence of fractures in the basalt; however, permeability on a local scale may vary greatly due to the high variability in the physical properties of the aquifer. Groundwater flow in the SRPA is to the south-southwest at rates between 1.5 to 20 feet per day. Near NRF, natural recharge to the SRPA occurs by infiltration of water (from precipitation runoff) from the Big Lost River, Little Lost River and Birch Creek, and to a lesser extent by direct infiltration of water (due to precipitation) into the soil over a wide area. Man made recharge sources to the aquifer at NRF include the Industrial Waste Ditch (IWD) and the sewage lagoon.

The SRPA occurs approximately 387 feet below NRF, and consists of a series of water saturated basalt flows and interlayered volcanic and sedimentary material. Figure 3-4 is a map showing the top of the aquifer near NRF during November 2010 based on water table elevation data collected from NRF wells. Currently water flows beneath NRF from the northeast to the southwest.

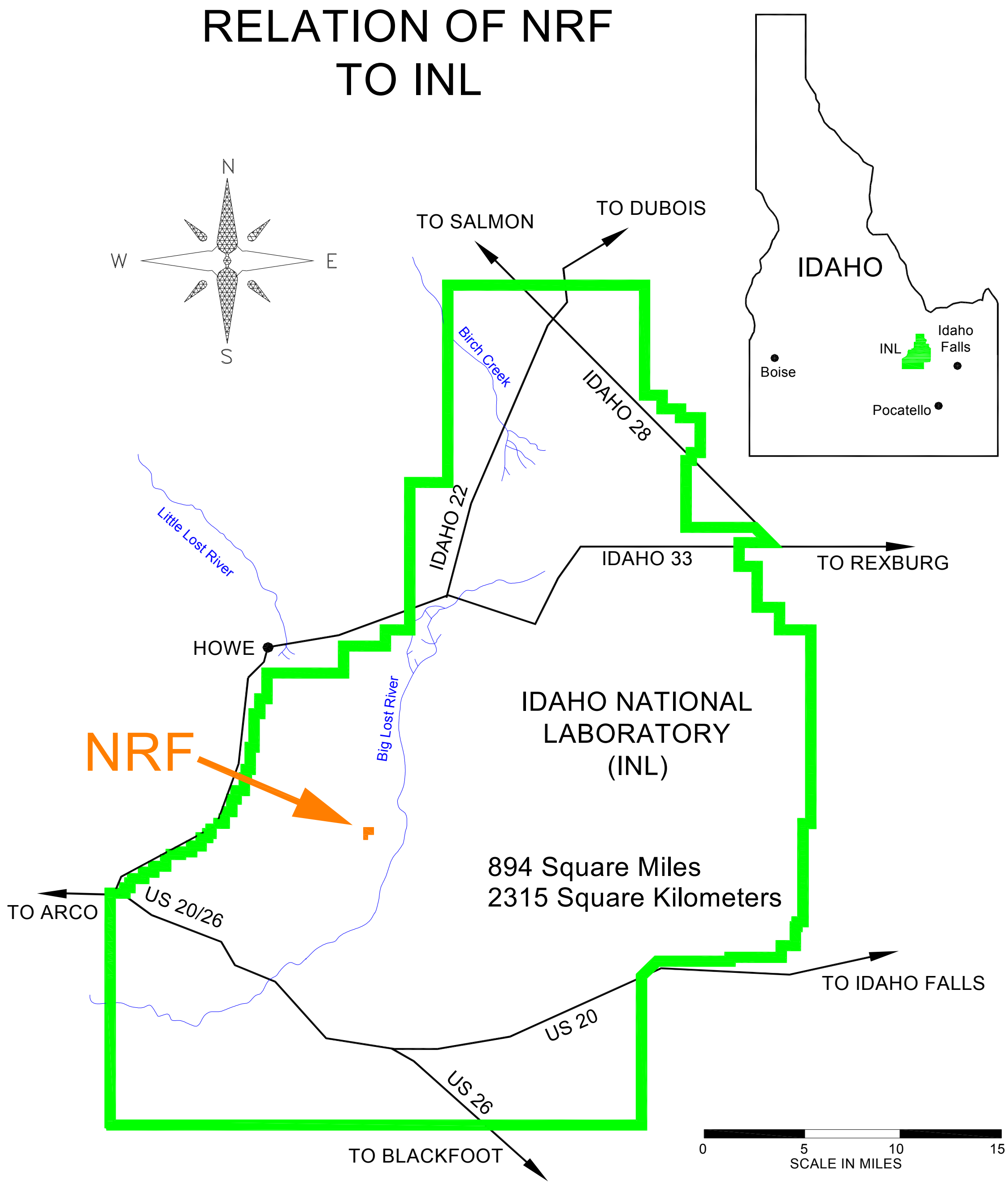


Figure 3-1 Location of Naval Reactors Facility (Waste Area Group 8)

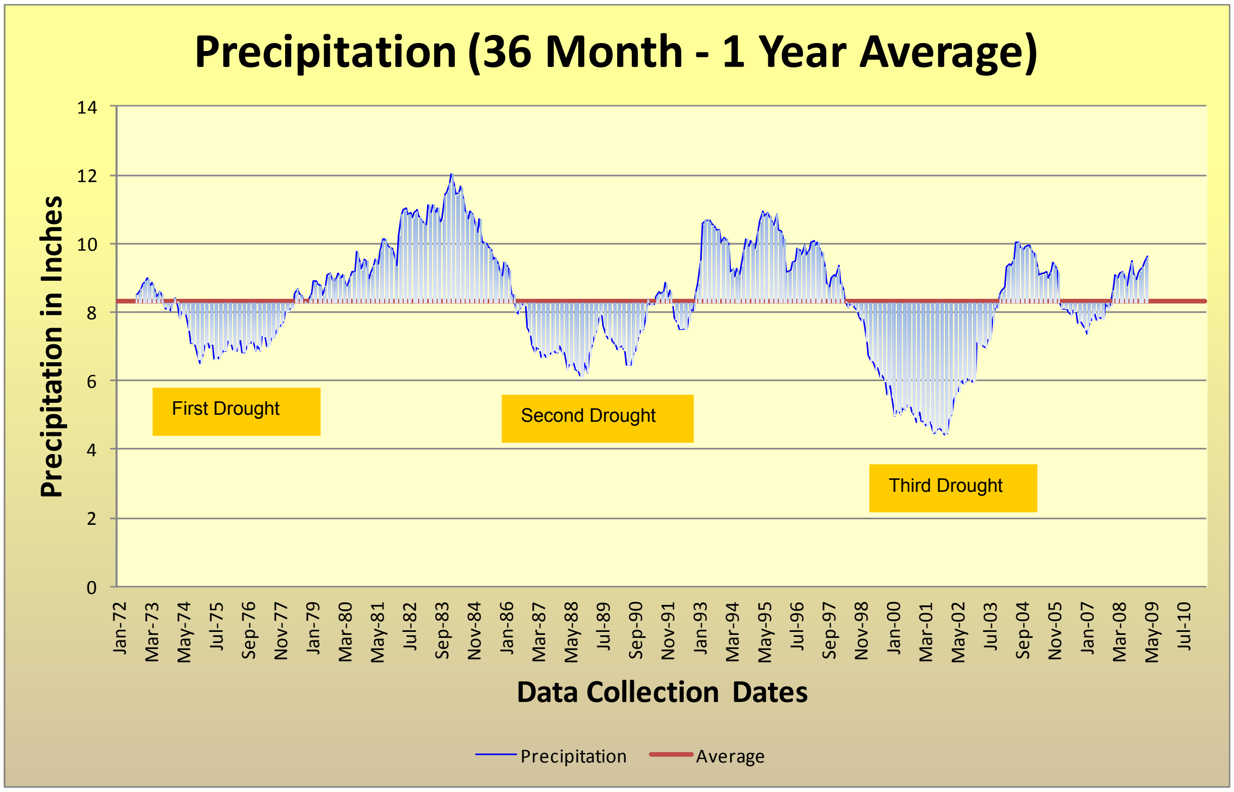


Figure 3-2 36 Month Running Average Precipitation Normalized Over 1 Year

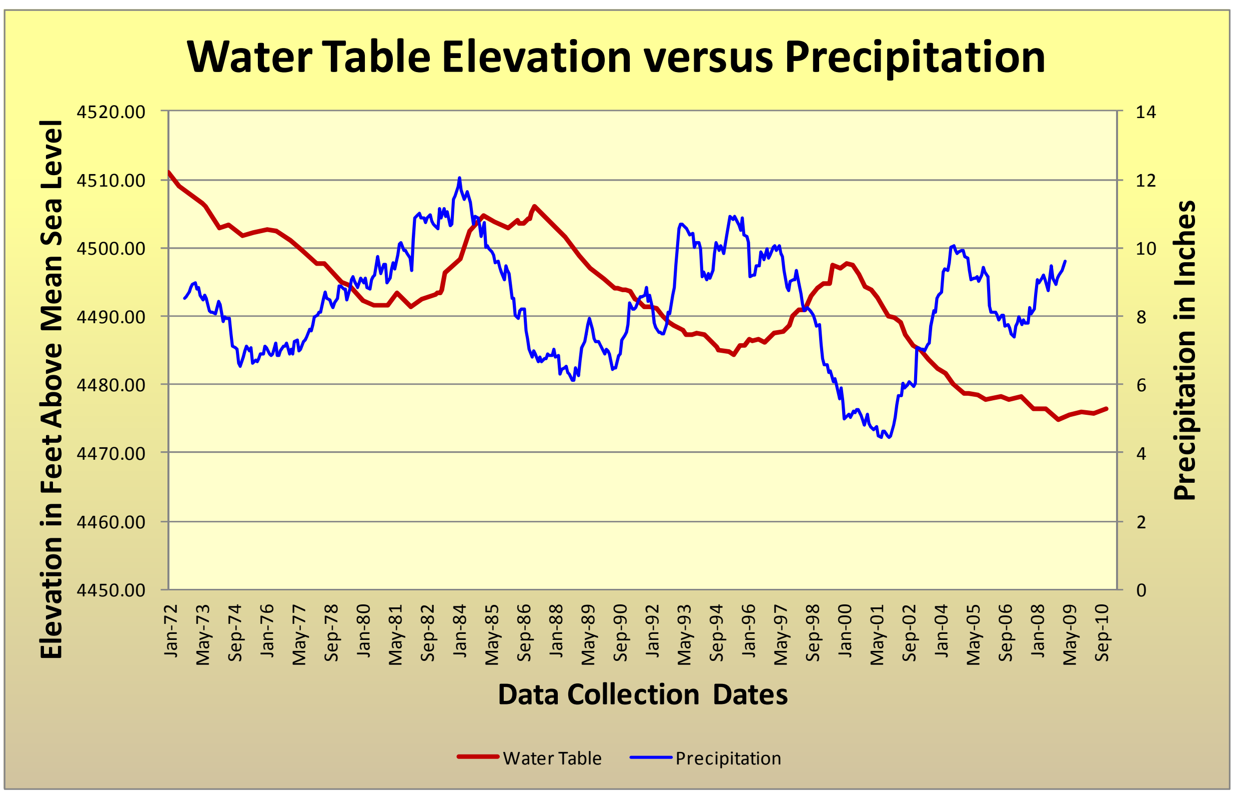


Figure 3-3 Comparison of Precipitation and Water Table Elevation in USGS 12

3.2.2.2 Industrial Waste Ditch

The NRF IWD is located at the northwest corner of NRF and extends approximately 3.2 miles to the northeast. In 1992, the volume of discharge to the IWD reached a maximum of approximately 171 million gallons per year. After the shutdown of the S5G and A1W prototype plants in the mid-1990s, the volume of discharge to the IWD declined rapidly (Figure 3-5). Since 2000, IWD effluent discharge has averaged eight million gallons per year. At its maximum, water flowed in the IWD to a distance of approximately 1.8 miles. Currently water reaches a distance of between 300 and 500 yards.

The IWD was investigated through the Remedial Investigation/Feasibility Study process under CERCLA. The risks to human health and the environment associated with the IWD were determined to be low. The IWD was subsequently designated a "No Action" site in 1994.

3.2.2.3 Sewage Lagoons

The NRF sewage lagoons are two open rectangular ponds that measure 425 feet by 725 feet each. Only the northeast lagoon currently contains water. The lagoons were designed as facultative evaporation ponds; however, a portion of the effluent released to the lagoons infiltrates into the subsurface based on evidence gathered from shallow perched water wells located along the southeast side of the lagoons. Impacts on groundwater quality due to the sewage lagoon are estimated using groundwater monitoring wells located downgradient of the lagoons. Some of the infiltrating water forms a shallow perched water zone beneath the wet lagoon. The perched water zone occurs between 20 and 30 feet below the ground surface on top a clay layer present in the surface alluvium. This clay layer is referred to as the Fluvial (river)/Lacustrine (lake) or F/L deposit (see Section 3.3.5.1). From 1990 to present, NRF released an estimated average of 17 million gallons of effluent to the sewage lagoons annually.

3.2.2.4 Perched Water

Perched water, which lies above the regional water table between 20 and approximately 100 feet below land surface, occurs in several locations at NRF including beneath the IWD, the sewage lagoons, and historically the leaching beds/pits. In general, perched water forms at any location where a substantial surface recharge source is present. The most significant perched water at NRF is located beneath and west of the outfall of the NRF IWD. Figure 3-6 provides a historical perspective of perched water located at NRF. This figure shows the estimated current extent of perched water (from the most current water level measurements) along the IWD and at the sewage lagoons versus its extent in 1993 and 2006. Figure 3-6 also shows the locations and extent of historical perched water zones at the A1W and S1W Leaching Beds and an area located approximately 1000 ft north of the sewage lagoons.

Because of reduced discharge volume to the IWD, the perched water observed at PS-6 (located approximately 1000 ft northeast of well NRF-6) in 1993 is now gone. Similarly, the perched water zone located at the outfall of the IWD has been reduced in areal extent by approximately 20 percent of what it was in 1993. The sewage lagoon perched water zone is estimated to be approximately the same size as in 1993.

3.2.2.5 Groundwater Monitoring

NRF has been routinely collecting groundwater monitoring data since 1989. For the majority of this Five-Year Review cycle, the NRF Groundwater Monitoring Network consisted of 12 wells

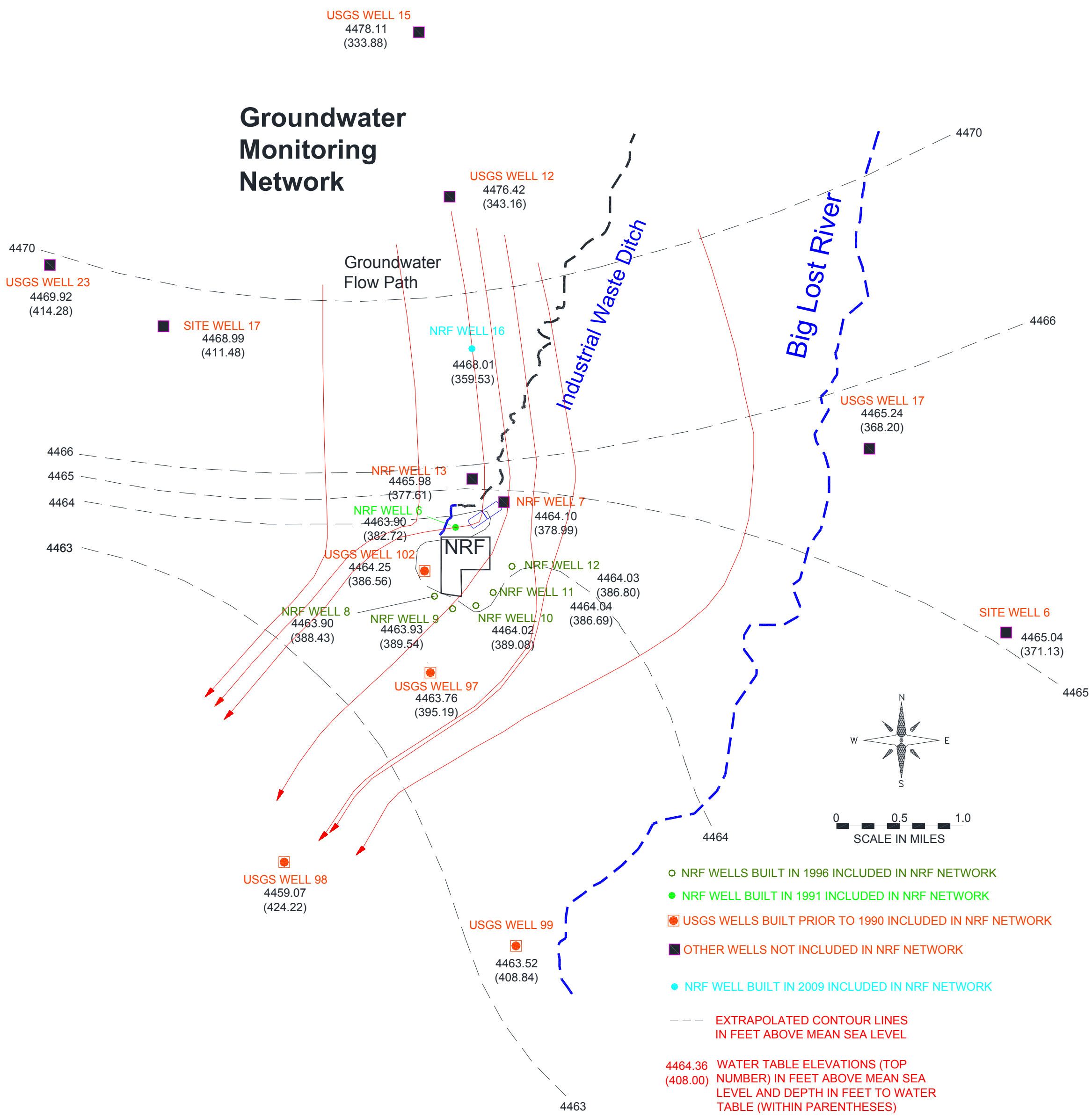


Figure 3-4 Water Table Contour Map with Aquifer Flow Lines – November 2010

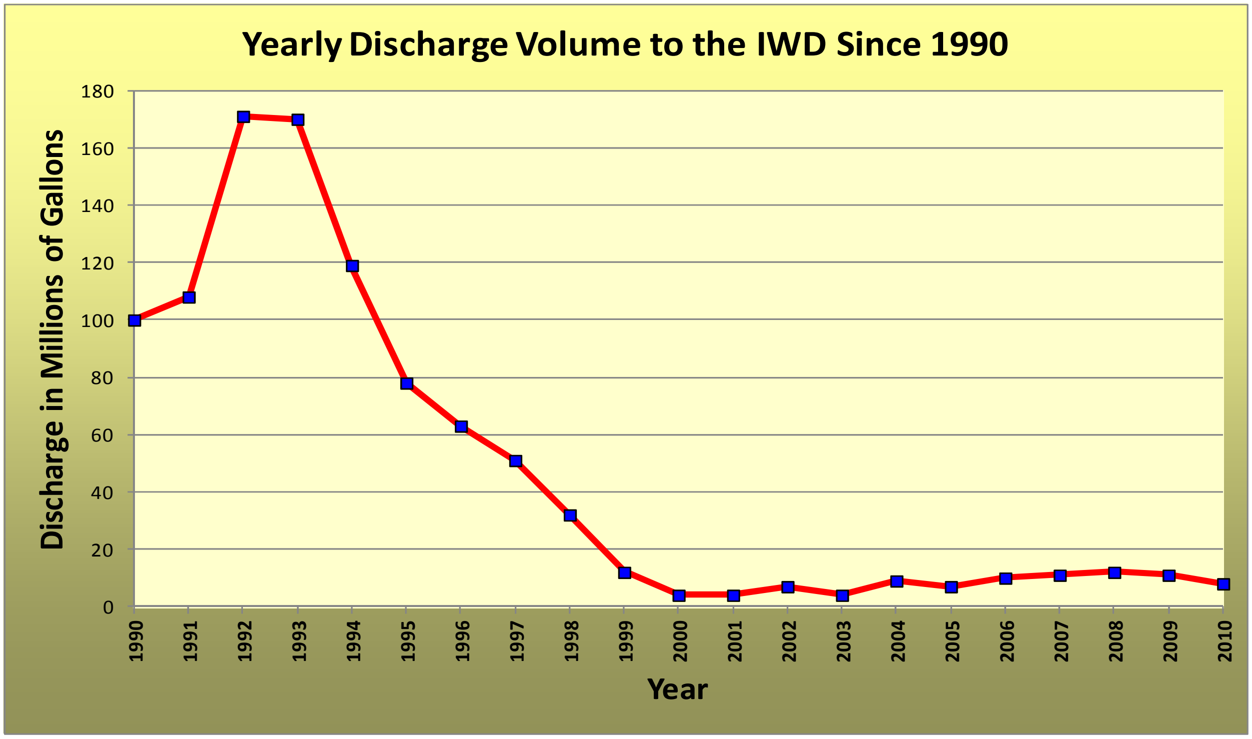


Figure 3-5 Volume of Water Discharged to the NRF IWD

strategically located to monitor upgradient and downgradient water quality. After 2010, the number of wells used in the network was 11.

The 2006 Five-Year Review evaluated the elevated levels of chromium and other metals in NRF-13 water samples and concluded that they were caused by sediments being entrained into the water samples. The sediments contained small amounts of chromium, iron, aluminum and other metals which when analyzed along with the groundwater sample gave the appearance of elevated metal results in the samples. Because of the anomalous data produced by NRF-13, this well was removed from the NRF Groundwater Monitoring Network in early 2007. A new upgradient well (NRF-16), initially constructed to replace NRF-13, was completed north of NRF in the fall of 2009 and was included in the NRF CERCLA monitoring network in 2010. In addition to replacing NRF-13, NRF-16 also replaced NRF-7 and USGS 12 as the upgradient monitoring well used by NRF. Both NRF-7 and USGS 12 continue to be used as monitoring wells for other purposes. NRF-13 continues to be used to collect water table elevation information. Figure 3-7 shows the location of the NRF groundwater monitoring wells used by NRF over the past five years.

The 12 wells which were included in the NRF groundwater monitoring network were grouped into categories that indicate the portion of the aquifer being monitored. These categories are identified as Regional Upgradient, Regional Downgradient, Local Downgradient, and Effluent System. Table 3-1 lists the wells with the associated well category or group.

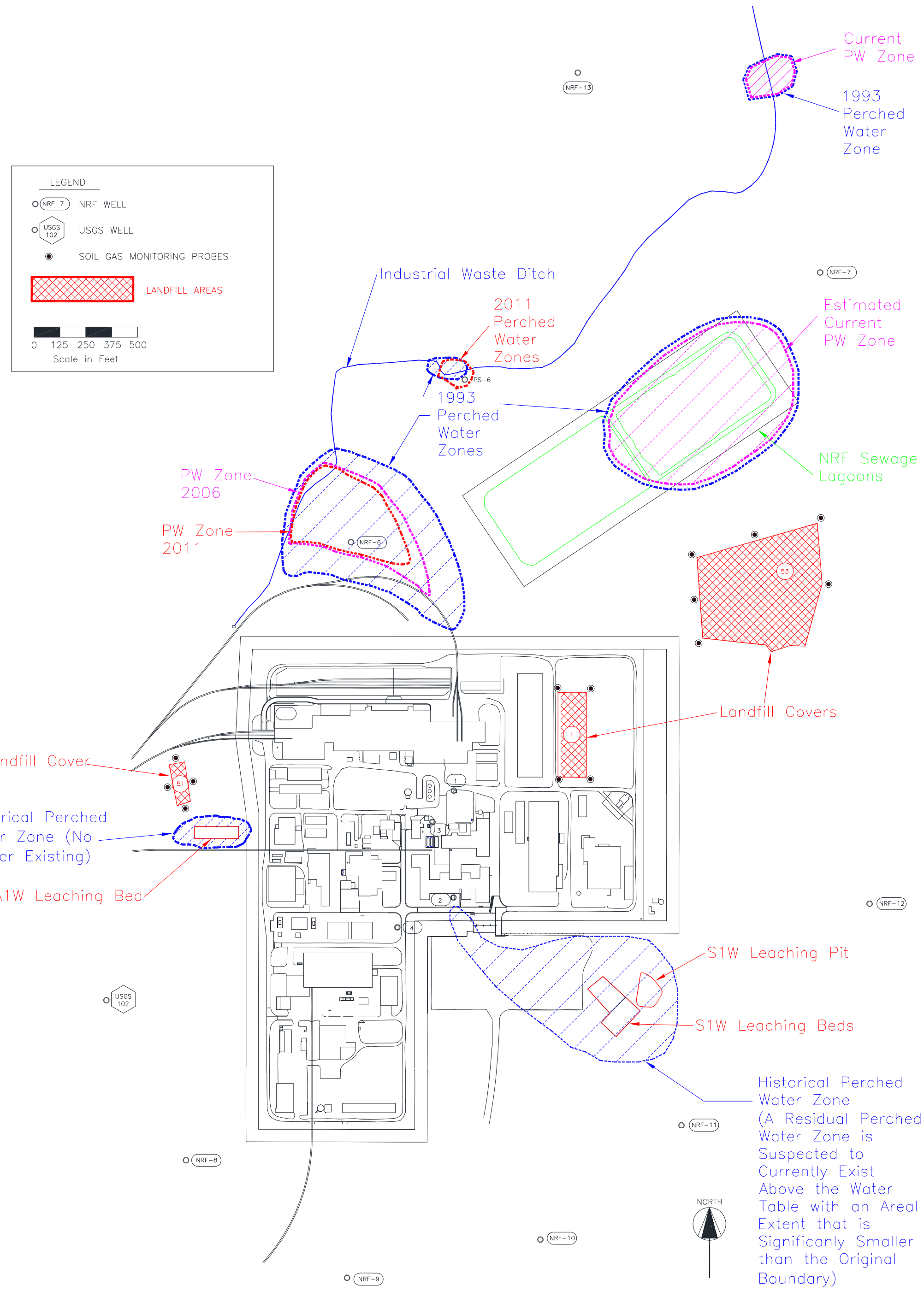


Figure 3-6 Current and Historical Perched Water at NRF

Table 3-1 Well Groups Used During the 2011 Five-Year Review Cycle	
Well Group	**Wells**
Regional Upgradient	USGS 12*, NRF-7*
Regional Downgradient	USGS 97, USGS 98, USGS 99
Effluent System	NRF-6
Local Downgradient	USGS 102, NRF-8, NRF-9, NRF-10, NRF-11, NRF-12

* These wells were replaced by NRF-16 in 2010. For the purposes of this report, and because of limited amount of data available from NRF-16, they were used as Regional Upgradient Wells

3.2.2.6 Water Table Elevations

The water table in the SRPA has been declining for the past several decades due to recurring droughts and increased use. A direct consequence of this decline is that many domestic and agricultural wells in eastern Idaho had to be deepened to prevent them from going dry. The wells at NRF have been similarly affected. In 2005, well USGS 98 was deepened because the pump intake level was approximately one foot below the water level. Hydrographs for wells USGS 12, NRF-6, and USGS 98 (from north to south) are shown in Figure 3-8. These wells are typical of the aquifer conditions near NRF.

These graphs show both cyclical and long-term trends in water table elevation. The graph for USGS 12 best exemplifies the stair-step pattern of decline in water table elevation, with each step corresponding to a drought event. In this well, the water level has declined about 18 feet since 1980 (trough to trough on the graph). The water level in NRF-6 has declined almost 9 feet since 1995. The most important information from these graphs is that water levels can drop rapidly; therefore, NRF must continually track water level changes to ensure ample time is available to deepen wells, if needed. Table 3-2 shows the physical characteristics of the NRF wells. This table indicates that all NRF wells have ample water above the well intake with the exception of USGS 97 (7.71 feet) and USGS 99 (15.02 feet). The intake at USGS 12 is 15.05 feet below the water table; however, since this well will not be used for monitoring by NRF in the future, a declining water level in this well is not as much of a concern as for other NRF wells. As discussed in Section 3.2.1, the lack of flow to the Big Lost River has caused the water level in all NRF wells to become somewhat static during a time that water levels were expected to rise. In the 2006 Five-Year Review, it was anticipated that NRF would not need to deepen any of its wells for possibly five to ten years (2011 to 2016) if trends observed at that time continued. The precipitation trend graph shown in Figure 3-3 began trending upward in 2001. If past patterns had been repeated, the hydrograph created using USGS 12 data shown in Figure 3-3 should have begun increasing in 2003 or 2004. Instead, the water levels in NRF wells have fallen about one foot since the 2006 Five-Year Review. The range of five to ten years (now 2016 to 2021) before deepening of wells may be needed is still believed to be a reasonable estimate if current trends continue (if another drought occurs). Since the expected rise in water levels does not appear to be occurring, the number of wells that could be affected by falling water levels anticipated during the next dry cycle may now include NRF-6 and USGS 98.

3.2.2.7 Flood Potential

The land surface at NRF is relatively flat, with elevations ranging from 4,840 feet ASL near the wetted end of the NRF IWD, which is located approximately 400 yards north of NRF, to 4,870 feet ASL along the south side of NRF. Flooding at NRF is not likely, since the facility is not located within the current 100-year flood plain. A flood of the Big Lost River with a recurrence

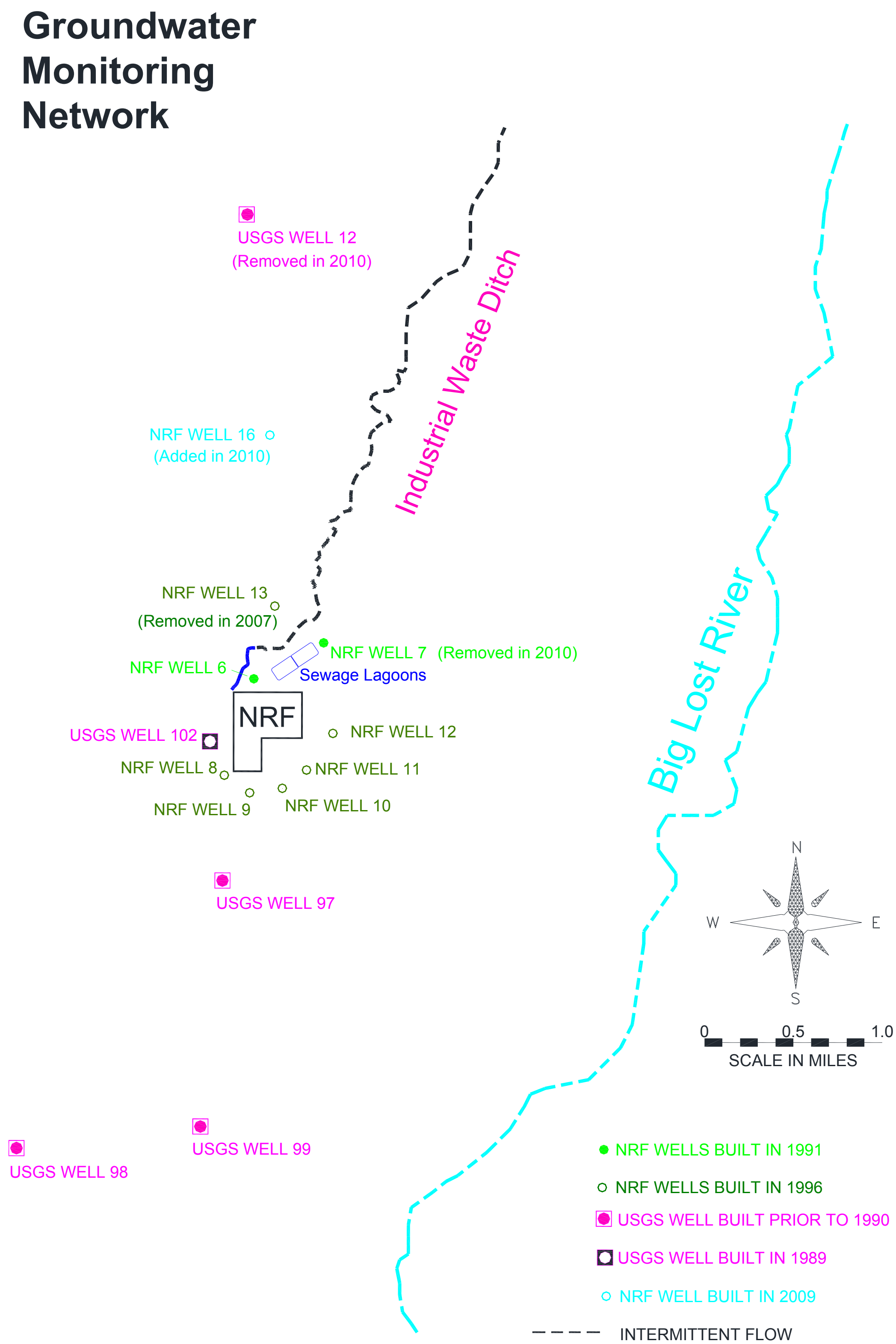


Figure 3-7 Location of NRF Groundwater Monitoring Wells

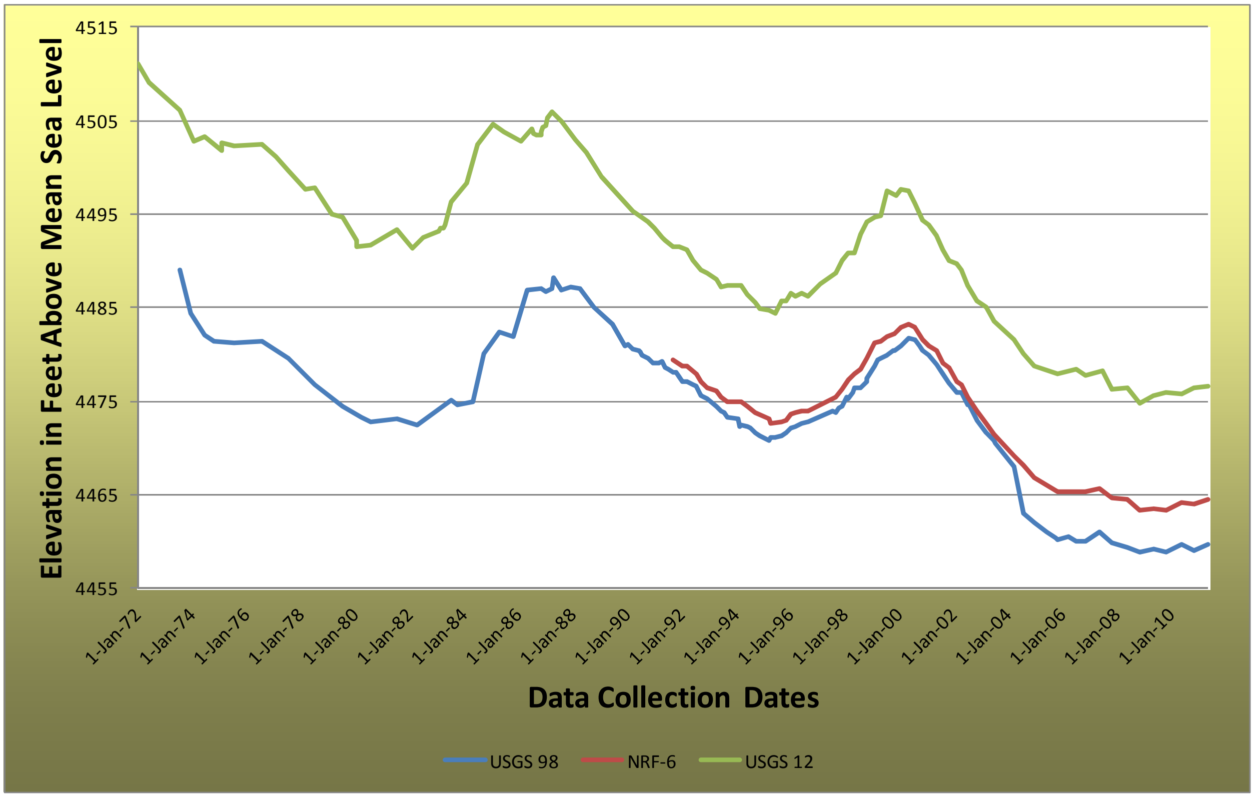


Figure 3-8 Water Table Elevations at USGS 12, USGS 98 and NRF-6

interval in excess of 10,000 years is capable of inundating NRF (Ostenaa 1998, 1999). Recurrence interval refers to how often a flood of a given magnitude is likely to occur.

A diversion dam located approximately 8 miles southwest of NRF diverts water into spreading areas southwest of Radioactive Waste Management Complex (RWMC) to help control flooding downstream. The probability that NRF could be flooded in the future would likely increase without this diversion dam. The diversion dam is under the cognizant of DOE Idaho Operations Office of Environment and Sustainability and is maintained by the Central Facilities Area Operation/Maintenance group. Its present operational integrity is considered good.

3.3 Site Geology

3.3.1 Overview

The INL is located on the northeastern portion of the Eastern Snake River Plain, a plateau that is composed primarily of volcanic rocks and relatively minor amounts of sediments. Underlying the INL is a series of basaltic flows containing some sedimentary layers (called interbeds).

NRF is located on the Big Lost River alluvial plain and is approximately 1.5 miles from the closest portion of the Big Lost River. The thickness of alluvial sediment near NRF ranges from several inches to in excess of 60 feet north of NRF. Near surface sediments at NRF consist of alluvial deposits of the Big Lost River and are composed of loosely compacted river deposits of silt, sand, and pebble-sized gravel. Most of the soil near NRF is described as sandy loam or loess. The loess is an accumulation of wind deposited silt-sized particles probably of glacial origin.

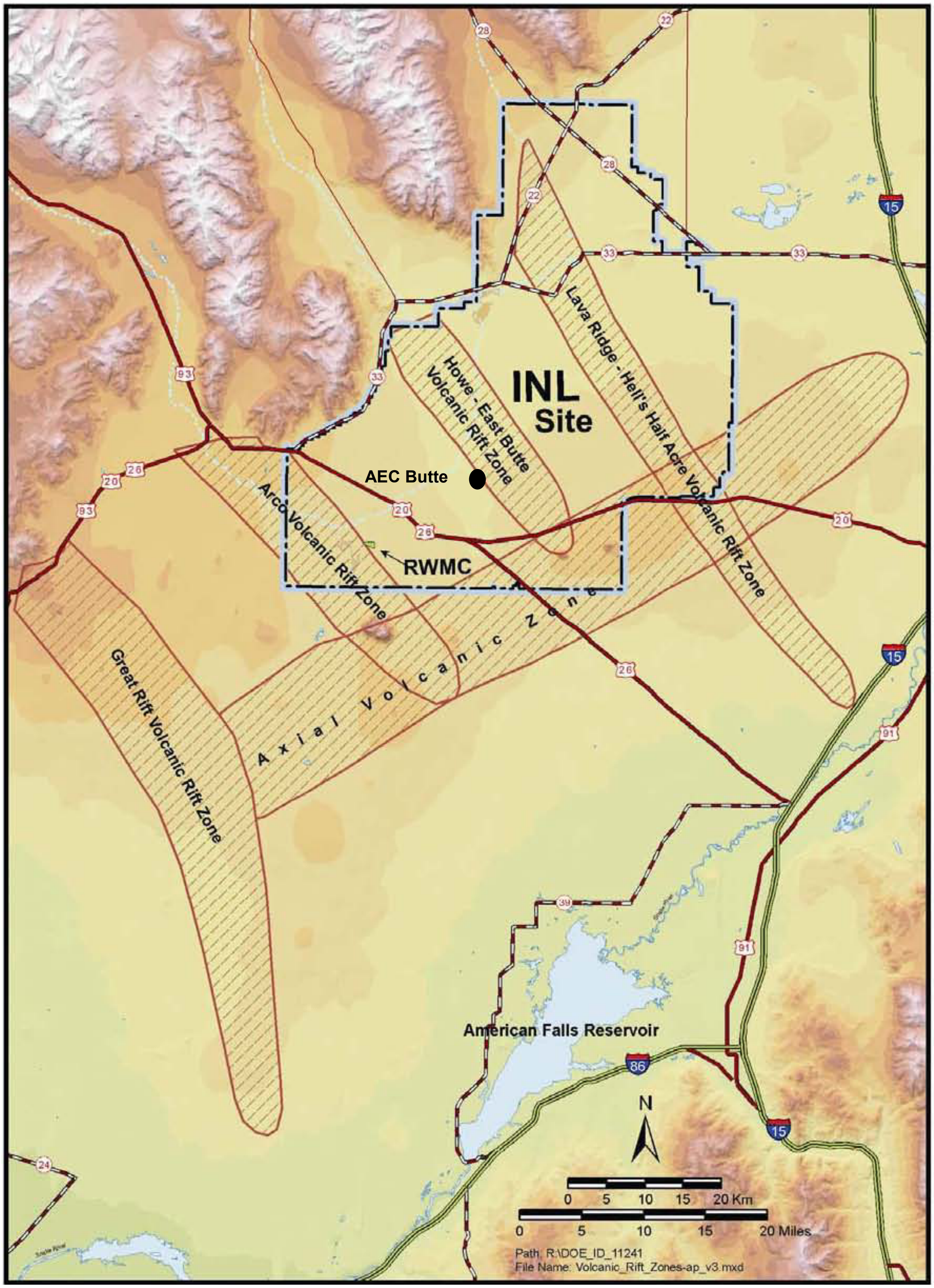


Figure 3-9 Volcanic Rift Zones (modified from Smith, Jackson, and Hackett 2006)

Table 3-2 Physical Characteristics of the NRF Groundwater Monitoring Wells

Well Name	Well Elevation at Surface[1]	Well Elevation at Completion Depth[1]	Elevation of Pump Intake[1]	Most Recent Water Table Elevation[1]	Date Measurement Taken	Water Above Pump Intake in feet	Screened Interval Closest to Pump
NRF-6	4846.62	4429.62	4444.00	4464.41	5/6/11	20.41	Stainless Steel; 4430 - 4488 feet
NRF-7	4843.09	4428.09	4433.00	4465.03	5/17/11	32.08	Stainless Steel; 4428 - 4478 feet
NRF-8	4852.33	4427.33	4437.33	4464.51	5/17/11	27.18	Stainless Steel; 4429 - 4479 feet
NRF-9	4853.47	4428.47	4441.47	4464.48	5/19/11	23.01	Stainless Steel; 4431 - 4481 feet
NRF-10	4853.10	4426.10	4438.10	4464.42	5/17/11	26.32	Stainless Steel; 4426 - 4476 feet
NRF-11	4850.73	4433.73	4441.73	4464.48	5/16/11	22.69	Stainless Steel; 4434 - 4484 feet
NRF-12	4850.83	4429.83	4436.83	4464.63	5/16/11	27.80	Stainless Steel; 4430 - 4480 feet
NRF-16	4827.54	4402.54	4423.54	4468.73	5/18/11	21.00	Stainless Steel; 4406 – 4466 feet
USGS 12	4819.58	4127.58	4461.58	4476.63	5/18/11	15.05	Open Hole; 4128 - 4235 feet
USGS 97	4858.95	4348.95	4456.95	4464.66	5/18/11	7.71	Open Hole; 4348 - 4471 feet
USGS 98	4883.29	4378.29	4440.29	4459.66	5/19/11	19.37	Perforated carbon steel; 4462 - 4482 feet
USGS 99	4872.36	4422.36	4449.36	4464.38	5/19/11	15.02	Perforated carbon steel; 4423 - 4569 feet
USGS 102	4850.81	4406.21	4429.81	4464.97	5/19/11	35.16	Open Hole; 4407 - 4491 feet

[1]All elevations are in feet above mean sea level.

A complex sequence of basalt flows and sedimentary layers underlie NRF. The sedimentary interbeds vary in thickness and lateral extent and separate the basalt flows that underlie the surface sediments. Samples from basalt flows have been correlated into approximately 23 flow groups that erupted from related source areas. Known eruption vents occur to the southwest of NRF, along what is referred to as the Arco volcanic rift zone, to the southeast along the axial volcanic zone, and to the southwest at Atomic Energy Commission Butte as shown in Figure 3-9. The uneven alluvial thickness and undulating basalt surface at NRF are typical of basalt flow morphology.

3.3.2 Geology of the Snake River Plain

The Snake River Plain (SRP) can be described as a bow shaped plain that stretches from Ashton, Idaho at its northeastern edge to Ontario, Oregon at its western edge. Elevation of the plain varies from approximately 6,500 feet ASL near Ashton to approximately 2,100 feet ASL west of Boise, Idaho. Rocks of basaltic composition are prominent at the surface over the entire SRP, thus it is often mistakenly considered to be one region or unit possessing a common structure and origin. From a geological perspective, the SRP can be separated into two or three distinctive regions.

Some researchers (Mabey, 1982), divide the SRP into a western segment, a central segment, and an eastern segment based on the geophysical characteristics of the plain. Other researchers (Leeman, 1982, Alt and Hyndman, 1989) note that the SRP can be divided into two segments based on its physical characteristics. In either case, NRF is located in the eastern portion of the SRP. The eastern and central SRP are not fault bounded. The eastern and central SRP are best described geologically as a thin veneer of basalt overlying a very thick sequence of rhyolite (the fine-grained equivalent of granite). Both the basalt and rhyolite sequences are occasionally interlayered with sedimentary deposits. A study of the rocks encountered in the INEL-1 deep borehole located approximately two miles south of NRF shows that 2,200 feet of interbedded basalt and sediments overlie at least 8,200 feet of rocks composed of compacted volcanic fragments and ash or their derivatives. This log is typical of the central and eastern SRP (Mann, 1986).

3.3.3 Geomorphology

NRF is located on a fluvial plain, the origin of which is attributed to historical deposition of sediments associated with the Big Lost River. Sediments deposited by the Big Lost River consist of interbedded sand, gravel, silt, and clay that in places are in excess of sixty feet thick. The sand, gravel, and silt of the alluvial plain were deposited historically during a period of time that possessed a climate that was considerably wetter than the climate of today. At present, the plain is experiencing a period of reduced-deposition. The fluvial plain surrounding NRF is oriented generally north-south, and is bounded on the east by basalt outcrops. These outcrops rise to a maximum height of approximately 30 feet above the adjacent fluvial plain. Northwest of NRF, an arcuate-shaped ridge is present at the surface. Best seen on aerial photographs, this feature is reported to be a series of extinct eruption vents (EG&G, 1988). These vents begin several miles west of NRF, but are not visible at the surface at NRF. Low lying, highly or moderately weathered basalt flows rising between 10 and 30 feet above the fluvial plain are located approximately 1/2 mile west of NRF. Beyond these low lying hills is the Lost River Mountain Range. These mountains rise to an elevation in excess of 9,000 feet ASL.

Aerial photographs taken of the area surrounding NRF show a mosaic of abandoned or dry meandering channels. Several prominent features are evident in these photographs, including a number of point bar deposits and abandoned oxbows. A major abandoned meander channel is located approximately 600 feet due west of the IWD. This channel is 12 feet across and 6 to 8 feet deep. At the surface, abandoned meander channels are present in varying states of erosion. The regional surface surrounding NRF gently dips to the north, and ranges in elevation from 4,870 feet ASL south of NRF to 4,830 feet ASL north of NRF. The elevation within the NRF security fence ranges from 4,848 feet ASL to 4,852 feet ASL. Several man-made irrigation canals cross the desert terrain near NRF. The most prominent of these canals is located approximately 1/4-mile north-northwest of NRF. This canal is 20 feet wide and 15 feet deep. It rises above the desert floor 8 to 10 feet. Water no longer flows in these channels and canals, and they do not appreciably influence the hydrogeology of the IWD. These features would affect the hydrology of NRF only during an extreme flood event (like the 10,000 year flood) associated with the Big Lost River.

3.3.4 Structural Geology

The eastern SRP lies within the Basin and Range physiographic province, but within itself exhibits few characteristics typical of the basin and range spreading. The general appearance of the plain suggests that it was formed from rifting oriented along a northeast/southwest trending axis. This would result in the apparent lateral separation of the northwest-southeast trending mountains, which are located on either side of the SRP. In actuality, rifting is occurring, but the orientation is along a northwest-southeast trending axis. Several prominent rift features embedded in the SRP are observable on high altitude reconnaissance maps of the eastern SRP. These features are believed to be extensions of the normal faults that bound the ranges located to the north and south of the plain.

A combination of the North American continent moving westward, and a rifting center located near the eastern edge of the Great Basin, has caused a stretching of the crust. This stretching is exhibited in the form of down dropped valleys and raised mountains in most of the Great Basin. In the SRP, this stretching is accommodated by plastic flow and infilling with basalt (Alt and Hyndman, 1989; Mabey, 1982; Leeman, 1982).

3.3.5 Lithostratigraphy

The following four sections discuss the important rock and sediment layers present beneath NRF. The four layers include the near surface alluvium, the boundary between the near surface alluvium and the basalt, interbeds contained within the basalt, and the basalt itself. Much of what is known about the physical characteristics of the rocks and sediments is derived from the numerous boreholes and wells that have been drilled at NRF over the past 50 years.

3.3.5.1 Near Surface Alluvium

There are two types of surface sedimentary deposits typically found at NRF. The topsoils are primarily loess deposits believed to be of wind-blown origin. Analysis of the loess shows that its primary constituent is the clay montmorillonite combined with lesser amounts of the clay illite, quartz, feldspar, and various carbonate minerals (Chen-Northern Report, 1991). Montmorillonite is a water-absorbing (swelling) clay and possesses an affinity for adsorbing positively charged ions (Deer et. al, 1978, p. 250). The thickness of the loess near NRF varies from several inches to over ten feet (EG&G Report, 1988, Phase I Closure Plan and Sample Collection Report, WEC, 1988). In some isolated locations near NRF, the removal of fine dirt by the wind has caused fine grain sand dune deposits to form. In most places near NRF, the loess and sand deposits overlie river deposited gravels and sands.

NRF is located near the western edge of a river (meander) plain. This plain is several miles wide and consists of well rounded to sub-angular, moderately to poorly sorted sand and gravel interbedded with silt and clay. Much of the sand and gravel is stratified, which is evidence of its river origin. The gravels consist of a wide variety of rock types, the source of which are the mountains located north and west of NRF, and include material of sedimentary, metamorphic, or igneous (plutonic) origin. Individual pebbles range in size from three quarters of an inch to two inches in diameter. Some of the pebbles are composed of basalt derived from the basalt flows that surround the river plain. The shape of individual gravel pebbles is indicative of distance of transport and resistance to abrasion. Clay and fine silt interbeds are found sporadically throughout the river sediments, but are commonly found at the basalt/sediment interface. These clay interbeds usually possess lower permeability than the surrounding sand and gravel. Past geologic investigations have demonstrated that the formation of perched water is facilitated by infilling of fractures in the top of the basalt with clay (Cecil et. al, 1991).

The gravels of the Big Lost River either directly overlie a thin soil/clay layer immediately overlying the basalt or a widespread clay and silt deposit interpreted to be of fluvial or lacustrine origin (F/L deposit). The contact between the alluvium and clay and silt deposit has been described as abrupt to gradational. In areas where alluvium was observed to overlay basalt, the contact was often marked by an increase in the percentage of basalt pieces imbedded within a one to two foot layer of soil located directly above the basalt bedrock. These soils ranged from white to light brown in color and are interpreted to be a buried soil horizon that developed prior to the deposition of the fluvium. The F/L deposit is coarser grained and darker in color than the soil covering the bedrock. The F/L deposit was determined to be present wherever the elevation of the top of the basalt was below approximately 4,825 feet ASL.

The F/L deposit is characterized by light brown silty clay interbedded with fine sand and occasional gravels. These layers occur as repetitive fining upward sequences that range in thickness from four inches to one foot. Near the contact with the underlying basalt, these fining units are occasionally interlayered with basaltic gravels. Percolating water that originates from surface discharge sources or precipitation appears to be inhibited by the clay content of this unit. A large portion of the IWD is underlain by the F/L deposit. Borehole data indicates that the surface of this deposit slopes to the southeast in the vicinity of the IWD. At other locations beneath NRF this surface slopes in other directions. For example, beneath the Inactive Landfill NRF-1, this surface slopes to the southwest and may aid in the migration of soil gas in that direction.

3.3.5.2 Top of Basalt

Over the past 35 years, a number of boreholes have been drilled near NRF that have penetrated to the top of the basalt. These data were used to construct a map of the top of the basalt (WEC, 1997 b, Appendix H, Figures 2-8 and 2-10). It is important to understand how the surface of the basalt changes laterally because of evidence that shows that this surface can potentially impede the downward migration of water thus promoting the formation of perched water at this interface. If the surface that causes the perched water to form is sloped, then perched water will flow down slope along that surface. Any contaminants that may be present in the water will be carried along with the water to locations that may be some distance from their origin. This phenomenon has the potential of creating phantom contamination. That is, the occurrence of contamination for which no apparent source exists.

3.3.5.3 Interbeds - Occurrence and Distribution

Sedimentary interbeds separate many of the basalt flows that occur beneath NRF. These interbeds vary in composition, thickness, and areal extent. Four major interbeds have been identified in the subsurface. The first important interbed is brick red to red-orange in color and occurs at a depth that varies from 70 to 120 feet. This interbed is widespread and ranges in thickness from less than six inches to over 14 feet. This interbed is composed of poorly sorted mixtures of angular to subangular sand sized grains. The term lithic wacke was used to describe the sediments in these interbeds and refers to immature sandstones with high clay content and a large number of rock fragments other than quartz and chert (Chen-Northern, 1991, and Blatt et. al., Origin of Sedimentary Rocks). Dominant grain fragments are composed of basalt and quartz, with the finer constituents consisting of silt and clay. The sediments of this interbed appear to be loosely consolidated in the subsurface. Perched water has been associated with this interbed, although it is not positively known whether the interbed itself, or a tight (possessing low hydraulic conductivity) basalt located immediately beneath, is the perching layer. Because of its wide-ranging occurrence and physical properties, this interbed can inhibit potential contaminant migration though various absorption mechanisms.

Other important interbeds occurring at 200 feet, 270 feet, and 370 feet have been identified from geophysical logs from many wells near NRF. Several minor interbeds are also present. These interbeds are generally limited in areal extent. As these interbeds impede the downward flow of water, and if sloped, will direct the subsurface flow of water, they can contribute to a phenomenon known as stair-step subsurface flow. This mechanism is known to transport water hundreds of feet (or even greater distances) from its original source (Magnuson 1995).

3.3.5.4 Basalt

Underlying the alluvium is approximately 1,500 to 2,000 feet of transitional-olivine to alkaline-olivine basalts. Minerals indentified in thin section samples (a thin section is a very thin slice of rock glued to a glass slide that is examined under a microscope) include magnesium olivine, clinopyroxene, calcic-plagioclase, spinel, and magnetite (Chen-Northern, 1991). The depth from the land surface to the top of the basalt surface ranges from zero to 60 feet, but is typically 30 feet. The basalt consists of individual flows ranging in thickness from 5 feet to over 70 feet. Basalt that is void of interconnected vesicles and fractures is nearly impermeable. The hydraulic conductivity (an approximation of a material's ability to pass water) measurements from basalt cores collected from a borehole located just north of the NRF site are generally in the range of 1×10^{-8} cm/sec (Chen-Northern, 1991). However, local fracturing greatly increases effective conductivity values. Extremely variable transmissivity (hydraulic conductivity times the aquifer thickness) values are common at NRF as is evidenced by values from wells NRF-2 and NRF-7, which are located approximately 1,200 feet apart. Measured transmissivity in these wells were 3.1 ft^2/day in well NRF-7 and 576,000 ft^2/day in NRF-2. A well with a transmissivity value of 3.1 ft^2/day can produce approximately 3,000 gallons of water per day while a well with a transmissivity of 576,000 ft^2/day can produce in excess of 3,000,000 gallons of water per day.

Based on evidence observed from cores collected at NRF, it appears that most of the fractures in the basalt are probably the result of the cooling process. If this is so, these fractures will be confined to one flow, and will not transect other flows. These fractures appear to be randomly distributed in the horizontal plane, but are concentrated at the top of individual flows in the vertical plane. Some flows are completely fracture-free, while other flows are fractured from top to bottom. No evidence exists to substantiate the conclusion that one set of fractures is continuous from the surface to the aquifer (i.e., providing an uninterrupted pathway for potential contaminants to follow). There is evidence that indicates that some portions of the basalt, perhaps occurring in quasi-linear trends, are more highly fractured than the surrounding basalt. An increase in the frequency of fractures in the basalt would expedite surface water infiltration into the aquifer. It would be improper to assume that these ”fracture zones” act as conduits, allowing surface water to flow unimpeded from the surface directly to the aquifer. Water that may infiltrate along these hypothetical trends would interact with surface soils, clay-lined fractures, and the soils contained in interbeds. In areas where these trends are present, however, travel time through the basalt would tend to decrease.

3.4 Land Use and Resources

3.4.1 Past and Current Land Use

The INL was established in 1949 as the National Reactor Testing Station by the United States Atomic Energy Commission as a site for building, testing, and operating nuclear reactors, fuel processing plants, and support facilities with maximum safety and isolation. In 1974, the area was designated as the Idaho National Engineering Laboratory to reflect the broad scope of engineering activities conducted there. The name was changed to the Idaho National Engineering and Environmental Laboratory in 1997 to reflect the redirection of its mission to include environmental research. In 2005, the name was changed to the INL to emphasize its role as one of the United States’ leading national laboratories.

The Bureau of Land Management manages the areas surrounding the INL for multipurpose use. Communities nearest to the INL are Atomic City (south), Arco (west), Butte City (west), Howe (northwest), Mud Lake (northeast), and Terreton (northeast). In the counties surrounding the INL, approximately 45% is agricultural land, 45% is open land, and 10% is urban. Fences and security personnel strictly control public access to facilities at the INL. A total of 90 miles of paved highways pass through the INL and are used by the public.

NRF consists of three former Naval nuclear reactor prototype plants, the Expended Core Facility (ECF), and miscellaneous support buildings. Construction of the Submarine Thermal Reactor Prototype (S1W) at NRF began in 1951. The prototype completed operation in 1989. The Large Ship Reactor Prototype (A1W) was constructed in 1958 and completed operation in January 1994. The Submarine Reactor Plant Prototype (S5G) was constructed in 1965 and completed operation in May 1995. The prototypes were used to train sailors for the nuclear Navy and were used for research and development purposes. ECF, which receives, inspects, and conducts research on Naval nuclear fuel, was constructed in 1958 and is still in operation. The Dry Storage Overpack Facility was completed in 2001 to store expended Naval nuclear fuel in a non-aqueous environment.

3.4.2 Projected Land Uses

NRF is projected to continue operations until at least 2035. Operations will continue to include receiving, inspecting, and conducting research on Naval nuclear fuel, as well as the temporary dry storage of Naval nuclear fuel until a permanent national repository is available. Other NRF operations will include the decontamination and disposition actions associated with retired buildings and facilities.

3.4.3 Groundwater Use

The SRPA is the largest aquifer in Idaho and the principal source of drinking water for thousands of Idaho residents. For the majority of the past century, water withdrawal from the SRPA was limited to its periphery at relatively small quantities. In the past forty years, demand for both potable water and water for agricultural uses has increased in response to an increasing population base in eastern Idaho. Increased water demand coupled with several extended droughts has caused a decline in the SRPA water table. Demand for water in eastern Idaho is expected to increase in the future, which will result in a continued decline of the water table.

3.4.3.1 Past Uses at NRF

NRF has been in operation since the early 1950s. Up through the mid-1990s, the site was primarily used for training Navy personnel to operate nuclear propulsion plants aboard Naval vessels. Well NRF-1, drilled in 1950, supplied early demand for water at NRF. Water from this well was used for drinking, irrigation, sewerage, and cooling the S1W prototype plant. As the number of plants increased so did the number of Navy students and full time employees. The demand for water also increased. Additional water wells were constructed in 1951 (NRF-2), 1956 (NRF-3), and 1964 (NRF-4). During its peak period in the mid-1980s, NRF had three operating prototypes (S1W, S5G, and A1W), ECF, and approximately 3,300 full-time and part-time employees, and Naval personnel. At that time, peak water demand was approximately 300,000,000 gallons per year. Most groundwater used at NRF was eventually returned to the environment in one of several ways. NRF water was discharged to the IWD or to the Sewage Lagoons where it was evaporated, used by vegetation, or infiltrated into the subsurface. The balance of the water was used to irrigate lawns or was supplied to cooling towers for indirectly cooling operating reactors (evaporative losses).

3.4.3.2 Present Use at NRF

Current water usage at NRF is approximately 27,000,000 gallons per year. This use is primarily limited to domestic consumption, irrigation, and ECF operation. The environmental fate for groundwater is the same as described above except that cooling tower evaporation is no longer occurring. Approximately 1,360 BMPC, long-term subcontractor, and DOE employees are currently working at NRF.

3.4.3.3 Future Use at NRF

Water usage at NRF is expected to remain stable over the next five years.

3.5 History and Description of Sites

3.5.1 Landfill Sites

NRF operations over the time period when the landfills were active consisted of Naval ship reactor prototype facilities and support operations (i.e., cooling systems operations; water treatment operations; laboratory operations; production support operations from paint, electrical, machine, and equipment maintenance shops; and subcontractor construction support operations). The characteristics of the refuse disposed of in the three landfills were influenced by the NRF facilities and the various support operations. The typical waste disposal practice at the sites was to dispose of refuse in trenches, incinerate the combustible refuse, and then bury the residual material. When these sites were abandoned, the remains were left in place and covered with soil from the surrounding area.

The resulting primary contaminant source at all three landfill areas is refuse material and refuse degradation products buried at the sites. From records kept since 1971 of wastes sent from NRF to the Central Facilities Area landfill, it is estimated that almost two-thirds of the waste would have consisted of office trash. Less than one percent of the waste would have consisted of solid and liquid chemicals, waste oil, and solvents (WEC 1994a).

In addition, during the operational period of these landfills, major construction activities were carried out. These activities included the construction of two prototype plants and other support buildings (i.e., training facilities, storage buildings, etc.). These construction activities would have contributed a considerable amount of construction debris to these landfills, therefore decreasing the estimated hazard (i.e., reduced percentage of chemicals). Figure 1-1 shows the location of the landfills.

Since soil remains at these sites which contain contaminants of concern above risk based concentrations that prevent unrestricted use of the area, Institutional Controls (ICs) have been implemented. ICs used at NRF preserve the underlying assumptions of the RI/FSs developed for WAG 8 that will protect human health and the environment. Section 7.2.1 discusses site ICs in more detail.

3.5.1.1 NRF-1 Field Area North of S1W

Use of NRF-1 started in approximately 1951 and continued until 1960. The locations of the primary disposal areas within NRF-1 were identified from old drawings, photographs, verbal testimony, and records. NRF-1 covers an area of 192,500 square feet (350 feet wide and 550 feet long). Within this area, there was a previously utilized trench containing buried waste and a mounded area consisting of surface debris and soil. The buried waste disposal trench is located on the west side of the site. The depth of this trench ranges from approximately four feet on the north end to 25 feet on the south end relative to the surrounding grade. The dimensions of this trench are 120 feet wide and 375 feet long. From historical records, photographs, and drawings, the bulk of the waste was disposed of at the southern half of the site where the trench dimensions were greater. The north end of the trench was covered when Spray Pond #2 was constructed around 1954 (WEC 1995), thus limiting the amount of wastes that were disposed of at the north end of the trench.

3.5.1.2 NRF-51 West Refuse Pit

NRF-51 started operating in about 1957 and continued until 1963. Previous investigations indicated the shape of this unit was irregular with curved boundaries. The overall size of the site was originally estimated to be approximately 450 feet long, varying in width from 100 to 175 feet. Based on photographs and a magnetometer survey of the location, only one disposal trench was identified. The trench was originally estimated to be approximately 250 feet in length, 15 to 20 feet wide, and 10 to 15 feet deep (WEC 1993). The length and width of the trench were further refined by a magnetometer survey which determined it to be 175 feet long and 40 feet wide (WEC 1995). Analysis of photographs indicated the materials disposed of at NRF-51 tended to be construction debris rather than the types of wastes found in the other two units. In addition, it was noted that there were no drums in the trench at the time the photographs were taken. It is believed that a portion of this site was previously used as a construction staging area.

3.5.1.3 NRF-53 East Refuse Pit and Trenching Area

NRF-53 was used as a disposal area from about 1956 to 1970. The various types of waste that may have been disposed of in this area include waste petroleum products, small quantities of waste paints and solvents, construction debris, scrap metal, and cafeteria waste. Geophysical data indicated that there were at least five pits or trenches at NRF-53. Based on the geophysical data and verbal testimony, the trenches were estimated to have been up to 90 feet wide by seven to ten feet deep and up to 350 feet long. The area of site NRF-53 that included both surface debris and the trenches was approximately 400,000 square feet.

3.5.2 No Further Action Sites

The NFA designation was created by the FFA/CO signatory agencies for those sites with a source or potential source present, but for which an exposure route was not available. The following sections discuss each of the NFA Sites. Figure 1-2 shows the location of the NFA Sites. Note that NRF-18A, a former NFA site, was re-designated as a NA site and is no longer included in this review.

Since soil remains at these sites which contain contaminants of concern above risk based concentrations that prevent unrestricted use of the area ICs have been implemented. ICs used at NRF preserve the underlying assumptions of the RI/FSs developed for WAG 8 that will protect human health and the environment. Section 7.2.1 discusses site ICs in more detail.

3.5.2.1 NRF-2 Old Ditch Surge Pond

This site was originally a gravel or soil pit. In 1959 the pit was connected to the NRF interior waste ditch system and a pond area formed. The pond and connecting ditch were used from approximately 1959 to 1985. Low-levels of radioactivity and slightly elevated levels of metals were detected in the pond. The pond became contaminated with very low levels of radioactivity when water with trace amounts of cobalt-60 and cesium-137 was released to the ditch in the late 1960s. Accumulation of radioactivity in the upper several feet of ditch sediments produced slightly elevated activity levels that are below remediation goals established in the ROD (WEC 1998).

3.5.2.2 NRF-16 Radiography Building Collection Tanks

This building was originally a decontamination building used for cleaning radioactive equipment. The decontamination solutions were sent to two underground tanks. These tanks were used from 1954 to 1960. Adjacent to the building was a concrete pad that was used for outdoor storage of radioactive material. The concrete pad was removed in 1979. The tanks were removed in 1993 with no indication of leakage. Sampling results showed arsenic (which was found at depth adjacent to the underground tanks), cesium-137, cobalt-60, and uranium-235 above risk-based screening levels; however, the risk assessment performed for this site was very conservative and a risk management decision was made that the actual risks are acceptable (WEC 1998).

3.5.2.3 NRF-22 A1W Painting Locker French Drain

This site is the location of a former French drain that may have received paints, solvents, and possibly mercury. A removal action was performed in 1994 after receiving public comment on the proposed action. Sampling performed after the removal action showed elevated levels of lead and mercury remained. The excavated hole was 12 feet deep and was grouted to the surface eliminating all exposure pathways. A risk assessment of the site after the removal action estimated the risk to be low. Although no exposure route is present, a source remains at the site.

3.5.2.4 NRF-23 Sewage Lagoons

This site is the current sewage lagoons. The lagoons are two open rectangular ponds that measure 425 feet by 725 feet each. The northeast lagoon is currently active, while the southwest lagoon is typically dry and receives overflow from the active lagoon on occasion. Both lagoons are lined with clay. The sewage lagoons were built in 1960 and expanded to their current length in 1972. The lagoons were designed to be evaporative ponds; however, subsurface seepage of liquid effluent from the active lagoon has created a shallow perched water zone beneath the pond (see Section 3.2.2.3). This water contains non-hazardous chemicals (salts). Analysis results of sediment samples has shown the presence of slightly elevated levels of metals and radionuclides and only trace amounts of organic compounds in the upper 12 inches of soil. Most contaminants are believed to be contained within the lagoon sludge or lagoon clay lining. The risk assessment for the site was very conservative and a risk management decision was made that the actual risks are acceptable (WEC 1998).

3.5.2.5 NRF-42 Old Sewage Effluent Ponds

This site is the location of a former temporary sewage pond used in the 1950s. There is no direct evidence that a hazardous source exists at the site; however, process knowledge gained from sampling of the current sewage lagoons suggests that elevated amounts of metals, semi-volatile organics, and low-level radionuclide contaminants may be present. The site is currently covered with a ten-foot layer of soil. Based on current conditions (i.e., ten foot soil cover), the risk associated with this site was estimated to be low.

3.5.2.6 NRF-43 Seepage Basin Pumpout Area

This site is an area that physically surrounds NRF-21A (Old Sewage Basin) and was formed when the contents of NRF-21A were pumped out into the surrounding area in 1958. The effluent to NRF-21A had been cross-contaminated with radioactivity in 1956. Characterization sampling performed in 1996 showed arsenic, cesium-137, carbon-14 and plutonium-239 above risk-based screening levels; however, the risk assessment performed for this site was very conservative and a risk management decision was made that the actual risks are acceptable (WEC 1998). During the spring and summer of 2002, in conjunction with remediation of NRF-21A, the amount of contaminated soil and the size of NRF-21A were found to be larger than anticipated. A portion of NRF-21A extended into the previously identified NRF-43 area. NRF and the regulatory agencies decided that the NRF-21A basin area, including the portion that extended into NRF-43, would be capped with an engineered cover similar in design to those intended for NRF-12B/14 and NRF-19. This decision was documented in an Explanation of Significant Difference (ESD) issued in 2002. Construction of the cover was completed in 2004.

3.5.2.7 NRF-61 Old Radioactive Materials Storage and Laydown Area

This site is the historic location of a radioactive material storage and laydown area that was used from 1954 to 1960. Soil sampling from 1992 showed detectable amounts of cesium-137 that were well below remediation levels. The risk associated with this site was determined to be low.

3.5.2.8 NRF-66 Hot Storage Pit

This site is an area where a tanker truck collected radioactive liquid waste for transportation to other INL facilities for processing. Spills reportedly occurred in this area. Contaminated soil was removed from the area in 1980. Sampling during the remedial investigation showed slightly elevated amounts of cesium-137 that were well below remediation levels.

3.5.2.9 NRF-81 A1W Processing Building Area Soil

This site is the area around a radioactive materials processing building where known spills have occurred in the past. Typically, these spills were cleaned up to the maximum extent possible at the time. Cesium-137 and cobalt-60 were the only radionuclides detected during past sampling, and all results were below remediation levels.

3.5.2.10 NRF-82 Evaporator Bottoms Tank Release

This site consists of the soil above an underground storage tank vault. One spill was known to have occurred at the area in 1972. The spill was cleaned up to the standards at the time, but slightly elevated amounts of radioactivity were reported after the cleanup. Additional cleanup was performed in 1977. The remaining radioactivity is below remediation levels.

3.5.2.11 NRF-83 ECF Hot Cells Release Area

NRF-83 is located within an operational building (ECF). Radioactive liquid was released in 1972 from a pipe to a concrete trench. The soil below and adjacent to the trench also became contaminated. Cleanup actions taken in 1972 did not include the soil below the trench. The contaminated soil was discovered in 1997 when a concrete pad adjacent to the concrete trench was removed during ECF upgrade work. Elevated amounts of cobalt-60 and cesium-137 are present in the soil. All accessible contaminated soil was removed and replaced with clean soil during the construction project. Thirty-seven cubic yards of contaminated soil are estimated to remain under the trench to preserve the integrity of the trench. A new concrete pad was poured at the location of the old concrete pad excavation. The contaminated soil below the trench is not presently accessible and no exposure route is available.

3.5.3 OU 8-08 Remedial Action Sites

Nine sites were determined in the NRF Comprehensive RI/FS (WEC, 1997b) to have unacceptable or potentially unacceptable risks that must be addressed. The primary radionuclides of concern were cesium-137 and strontium-90, both of which have a 30-year half-life. During remedial activities, contaminated soil was removed from eight sites (three of which were associated with sites that were later capped) and consolidated in the S1W Leaching Beds area. These eight sites are referred to as Remediated Radiological Sites. Figure 1-3 shows the location of the Remediated Radiological Sites. Four sites are topped with three engineered covers (two sites are under one cover). These sites are referred to as OU 8-08 Engineered Cover Sites. Figure 1-4 shows the location of the Engineered Cover Sites.

The following sections discuss each of the nine OU 8-08 RA Sites. Since soil remains at these sites which contain contaminants of concern above risk based concentrations that prevent unrestricted use of the area, Institutional Controls (ICs) have been implemented. ICs used at NRF preserve the underlying assumptions of the RI/FSs developed for WAG 8 that will protect human health and the environment. Section 7.2.1 discusses site ICs in more detail.

3.5.3.1 Remediated Radiological Sites

3.5.3.1.1 NRF-11 S1W Tile Drainfield and L-Shaped Sump

This site consisted of a below-surface concrete L-shaped sump and four underground perforated drainfield pipes of various lengths downstream of the sump. The drainfield was likely used between 1953 and 1955 for sewage and radioactive liquid discharges. The drainfield area was approximately 36 feet wide by 150 feet long and consisted of four perforated pipes buried parallel to each other approximately 11 feet deep. Each outside leg of the drainfield extended about 150 feet, while both inner legs were 50 feet long. The drainfield was connected to the sump, which was an L-shaped concrete structure. Each leg of the sump was 11 feet long and three feet wide with a maximum depth of approximately 12 feet. The sump was isolated from the drainfield in 1955 but was used until 1960 as part of the sewage system.

3.5.3.1.2 NRF-12A Underground Piping to Leaching Pit

This site consisted of an underground pipe (465 feet in length) that ran from the S1W Retention Basins (NRF-17) to a subsurface concrete manhole. This pipe is known to have leaked on occasion. From the manhole, a perforated pipe used for draining and leaching purposes ran approximately 400 feet to the S1W Leaching Pit (NRF-12B) at a depth of approximately eight to ten feet. This site was used from 1955 through 1961 for radioactive liquid discharges.

3.5.3.1.3 NRF-14 Underground Piping to Leaching Bed

This site included the underground pipe (approximately 530 feet) leading to the leaching beds from the S1W Retention Basins (NRF-17). The pipe was laid in 1960 and delivered radioactive effluent from the S1W, S5G, and A1W prototype plants to the leaching bed.

3.5.3.1.4 NRF-17 S1W Retention Basins

This site consisted of two concrete basins partially below grade that collected radioactive water from various facilities. This was a storage area prior to releasing the water to NRF-11, NRF-12A/12B, and NRF-14. The basins were constructed in 1951. The basins comprised two adjacent concrete structures, each 140 feet long by 34 feet wide. One of the basins was known to have leaked approximately 33,000 gallons in 1971. The leak was directly below the basins.

3.5.3.1.5 NRF-19 Underground Piping to A1W Leaching Bed

This site consisted of two underground pipes leading to the A1W Leaching Bed (NRF-19). The pipes were placed in service in 1957 and delivered radioactive effluent from A1W to the leaching bed. One pipe was six inches in diameter and was referred to as the dilution pipe. This pipe was used to transfer radioactive effluent from a dilution tank to the leaching bed. Another pipe was two inches in diameter and was referred to as the bilge pipe. This pipe was used to transfer liquid collected in the prototype plant bilges to the leaching bed.

3.5.3.1.6 NRF-21A Underground Piping to Old Sewage Basin

This site consisted of a ten-inch concrete pipe, constructed in a bell and spigot configuration that led to the Old Sewage Basin from the L-shaped sump (part of NRF-11). Each section of concrete pipe was three feet long and each joint appeared to be grouted to prevent leakage. The concrete pipe leading to the sewage basin was approximately 435 feet long and ranged from seven feet deep near the L-shaped sump to 11 feet deep at the sewage basin. Leakage along the joints caused the surrounding soil to be contaminated.

NRF-21A also includes the Old Sewage Basin itself. During the spring and summer of 2002, in conjunction with remediation of NRF-21A, the amount of contaminated soil and the size of the NRF-21A basin area were found to be larger than anticipated. A portion of NRF-21A extended into the previously identified NRF-43 area. NRF and the regulatory agencies decided that the NRF-21A basin area, including the portion that extended into NRF-43, would be capped with an engineered cover similar in design to those intended for NRF-12B/14 and NRF-19, rather than continuing with excavation of the NRF-21A basin area.

3.5.3.1.7 NRF-21B Sludge Drying Bed

This site consisted of a concrete bed that received sludge from the sewage system. It was cross-contaminated from a radiological system. The bed was constructed in 1951 as part of the sewage system at NRF. The bed was a concrete slab that was 28 feet long by 29 feet wide and was approximately five feet below grade.

3.5.3.1.8 NRF-80 A1W/S1W Radioactive Line near BB19

This area consisted of an underground pipe that was known to have leaked near the west side of the S1W Spray Pond. This pipe carried radioactive water for eventual discharge to the S1W Leaching Beds (NRF-14). This pipe was buried approximately six feet below the surface. During decontamination and disposition work at NRF in 1995, portions of the pipe were removed and contamination was detected in the soil. NRF-80 also includes an area on the east side of the S1W spray pond where remedial actions were not necessary but residual contamination existed.

3.5.3.2 OU 8-08 Engineered Cover Sites

3.5.3.2.1 NRF-12B S1W Leaching Pit

This site consisted of a former pit area that was used for radioactive discharges. The pit was constructed at the end of the drainfield piping (NRF-12A) in 1957 and was used until 1961. The pit was filled with soil, and in 1978, an asphalt cap was placed over the pit. The asphalt cap was removed during the summer of 2003. A single cover addresses both NRF-12B and NRF-14.

3.5.3.2.2 NRF-14 S1W Leaching Beds

This site consisted of two leaching beds, one constructed in 1960, and the other in 1963. These beds were open ponds that collected radioactive water and allowed the water to leach into the subsurface or evaporate. Each bed was about 75 feet by 125 feet at the water line and was 13 to 15 feet deep. The ponds were used until 1979. Large cobblestones were placed in the leaching beds in 1972. Earthen ramps were constructed to allow sampling equipment into the beds in 1992. A single cover addresses both NRF-12B and NRF-14.

3.5.3.2.3 NRF-19 A1W Leaching Bed

This site consisted of an underground leaching bed. Perforated pipes ran through an engineered leaching bed that consisted of various layers of gravel and sand. The bed was constructed west of NRF in 1957, and was used continually from 1958 to 1964 and sporadically between 1964 and 1972. The bed was 200 feet long and 50 feet wide.

3.5.3.2.4 NRF-21A Old Sewage Basin

This site consisted of an open pond used for non-radiological discharges that was cross-contaminated from a radiological system. An unknown amount of radioactive effluent was sent to the sewage basin. The sewage basin was constructed in 1956 and measured 72 feet by 72 feet by 11 feet deep. The basin was enlarged in 1957 in the southeast direction and was used until 1960. The basin was then filled in with soil. This cover was selected after the ROD was issued due to the unexpected extent of contamination, and was documented via an ESD to the ROD.

3.6 Summary of Contaminants of Concern at NRF

3.6.1 Landfill Sites

Evaluation of historical sample data and records indicated that three waste types of specific interest were placed into the landfill areas: waste oil, solvents, and chemicals. As a result of the evaluation of data for the three designated landfill areas, several contaminants of concern (COCs) were identified as shown in Table 3-3.

Table 3-3 Contaminants of Concern in the Landfill Areas

Site	Metals	Volatile Organics
NRF-1 NRF-51 NRF-53	Chromium, mercury, and silver	1,1,1-trichloroethane, tetrachloroethylene, trichlorofluoromethane (Freon 11), Dichlorodifluoromethane (Freon 12) (1), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), chloroform, and trichloroethylene

(1) Freon 12 was detected in soil gas samples collected at NRF-1 after remedial actions were completed.

3.6.2 No Further Action Sites

Table 3-4 summarizes COCs for the NFA Sites.

3.6.3 Remedial Action Sites

Table 3-5 summarizes COCs for the RA Sites. This table shows the COCs prior to remediation and the COCs remaining after remedial actions.

Table 3-4 Contaminants of Concern at No Further Action Sites	
Site	**Contaminants of Concern**
NRF-2	Cesium-137
NRF-16	Cesium-137, Uranium-235
NRF-22	Lead, Mercury
NRF-23	Cesium-137
NRF-42	Cesium-137
NRF-43	Cesium-137
NRF-61	Cesium-137
NRF-66	Cesium-137
NRF-81	Cesium-137, Uranium-235
NRF-82	Cesium-137
NRF-83	Cesium-137, Cobalt-60

Table 3-5 Contaminants of Concern at Remedial Action Sites		
Site	**COC Prior to Remedial Actions(1)**	**COC After Remedial Actions(2)**
NRF-11	Cesium-137, Plutonium-244	Cesium-137
NRF-12A	Cesium-137, Nickel-63, Plutonium-244, Strontium-90	Cesium-137, Strontium-90
NRF-12B	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Lead, Plutonium-238, Strontium-90	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Lead, Plutonium-238, Strontium-90
NRF-14 (Cover Area)	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Lead, Plutonium-238, Strontium-90	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Plutonium-238, Plutonium-244(3), Strontium-90, Uranium-235(3), Lead
NRF-14 (Pipe area)	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Plutonium-238, Strontium-90	Aroclor-1242(4), Cesium-137
NRF-17	Americium-241, Cesium-137, Nickel-63, Neptunium-237, Plutonium-238, Plutonium-244, Strontium-90, Uranium-235	Cesium-137, Strontium-90
NRF-19 (Cover Area)	Americium-241, Cesium-137, Nickel-63, Plutonium-238, Strontium-90	Americium-241, Cesium-137, Nickel-63, Plutonium-238, Strontium-90
NRF-19 (Pipe Area)	Americium-241, Cesium-137, Nickel-63, Plutonium-238, Strontium-90	Cesium-137, Strontium-90
NRF-21A (Cover Area)	Cesium-137	Cesium-137
NRF-21A (Pipe Area)	Cesium-137	Cesium-137
NRF-21B	Cesium-137, Uranium-235	Cesium-137
NRF-80(5)	Cesium-137	Cesium-137, Cobalt-60(6)

(1) COCs were identified in the NRF Comprehensive RI/FS (based on the 100-year future residential scenario)
(2) COCs were based on confirmatory sampling performed during Remedial Actions and the potential unrestricted release of the area (present day residential)
(3) These are identified as COCs because this area was used to consolidate soil from other sites where these were identified as COCs.

(4) Even though Aroclor-1242 was not originally a COC, the confirmatory sampling for the remedial actions at this site included Aroclor-1242 (as well as other PCBs) since there was a potential to find PCBs during the excavation of contaminated soil. Aroclor-1242 was detected (below the ten foot depth) at levels greater than residential unrestricted release values but less than occupational values.
(5) Residual contamination was removed in 2010 and COCs are no longer present. Refer to Section 4.2.6.2.
(6) Cobalt-60 (Co-60) was not a COC requiring remedial action as determined in the ROD. However, this was based on the assumption of 100 years of controls and the resulting radioactive decay of Co-60. Co-60 was a COC when considering the potential for present-day unrestricted release of an area.

3.6.4 Groundwater Contaminants

Groundwater at NRF contains both natural and anthropogenic constituents. The kinds of naturally occurring groundwater constituents present in the groundwater are determined by the chemical properties of the rocks located in the groundwater source area and along the groundwater flow path. Examples of naturally occurring groundwater constituents near NRF are calcium, potassium, and magnesium.

Through the course of NRF's operation, some chemicals and radionuclides have been released to the environment, either accidentally or intentionally in accordance with practices acceptable at the time. Many of these same constituents are detectable in the groundwater today. The IWD RI/FS Work Plan and the NRF Comprehensive RI/FS provided lists of potential contaminants released at NRF. Not all of these constituents have been observed in the groundwater. Several reasons for this include limited source, low migration potential, dilution, or degradation through various natural processes, and very conservative estimates of the quantities (greater quantity assumed than is actually present) of the constituents released. The following constituents have been consistently observed in groundwater at NRF (Effluent System and Local Downgradient well groups) in concentrations (greater than three standard deviations) above local background levels: aluminum, nickel, iron, chromium, calcium, potassium, magnesium, sodium, chloride, and sulfate. Small quantities of chloroform and tetrachloroethylene have also been detected. The natural background concentration for these organic compounds is zero. Tritium in groundwater also exceeds (greater than three standard deviations) local background concentrations. All organic and radionuclide data are significantly below their respective Federal or State regulatory level (e.g., EPA drinking water standards).

Water upgradient to NRF could theoretically contain man-caused contamination that is unrelated to the NNPP. The Big and Little Lost River systems are the primary source of recharge to the SRPA north (or upgradient) of NRF. No contaminants are known to exist in groundwater sampled by the Regional Upgradient wells.

4.0 Remedial Actions

4.1 Remedy Selection

4.1.1 Remedy Selection for Landfill Sites (OU 8-05/06)

A Feasibility Study (FS) was performed for the landfill areas (WEC, 1994c). The FS was a comprehensive evaluation of potential remedial action alternatives for OUs 8-05 and 8-06 landfills that represent NRF-1, NRF-51, and NRF-53. The presumptive remedy for CERCLA municipal landfills as given in the EPA directive 9355.0-049FS, "Presumptive Remedy for CERCLA Municipal Landfill Sites," was used for these landfill units, since they were similar in nature and content to municipal landfills and the EPA directive expects the presumptive remedy to be used at all appropriate sites. Using the presumptive remedy eliminated the need for the initial identification and screening of alternatives during the FS.

The Remedial Action Objectives (RAOs) for the landfill areas were developed in accordance with the Presumptive Remedy for CERCLA Municipal Landfill Sites. The RAOs specified the contaminants and media of interest, exposure pathways, and preliminary remediation goals, to support development of a range of source containment alternatives. The attainability of the RAOs to protect human health and the environment was addressed through the detailed evaluation of each remedial action alternative. Compliance with potential chemical-specific applicable or relevant and appropriate requirements (ARARs) was one method used to evaluate the extent to which each remedial action alternative would meet the RAOs.

The RAOs for the environmental media of groundwater, soil, and surface water for the landfills were identified as follows:

Human Health:

- Ensure that the SRPA downgradient of NRF has no contaminant levels above Maximum Contaminant Levels (MCLs) due to migration of contaminants from the landfills.
- Minimize infiltration and resulting contaminant leaching to the SRPA.
- Restrict intrusion into the landfill contents. (Since the landfill contents were not sampled and characterized, it was not possible to accurately assess the risk for future receptors).
- Prevent direct contact with the landfill contents.
- Control surface water runoff and erosion of the landfill covers.
- Meet all ARARs.

Environmental Protection:

- Meet all ARARs.

The specific elements of the selected remedy developed to meet the RAOs are as follows:

- Groundwater and soil gas monitoring
- Placement of an engineered landfill cover
- Institutional controls
- Periodic inspections and maintenance.

The following describes how the elements of the selected remedy meet the RAOs.

- Groundwater monitoring is performed to assess the effectiveness of the landfill cover in limiting the migration of contaminants to the aquifer by ensuring that contaminant levels are not above MCLs.
- Soil gas monitoring is conducted to assess the effectiveness of the landfill cover in limiting infiltration of contaminants into the subsurface and limiting migration of contaminants through the cover.

- A landfill cover was placed over each site to prevent direct contact with contaminated soils and reduce the potential for migration of contaminants from the identified landfill sites.

- To restrict intrusion into and further prevent potential exposure to the landfill contents, institutional controls (i.e, access and land use restrictions) were implemented.

- The soil cover design incorporates erosion control measures (i.e., use of a vegetative cover) to reduce the effects from rain and wind. The soil cover design also incorporates cover slope requirements that promote surface water runoff.

- Inspections are performed in accordance with the Operation and Maintenance Plan.

- Selected remedy elements meet all identified ARARs including those associated with the final closure of landfills.

4.1.2 Remedy Selection for No Further Actions Sites (OU 8-08)

A NFA decision was made by NR/IBO, IDEQ, and EPA for those sites with a source or potential source present, but for which an exposure pathway is not available under current conditions. The NFA decision means the site is included in a CERCLA review performed at least every five years to ensure that site conditions used to evaluate the site have not changed and to verify the effectiveness of the NFA decision. This remedy selection did not require any additional remedial action other than ICs such as signs and fencing, administrative controls on excavation, and inspections.

4.1.3 Remedy Selection for Remedial Action Sites (OU 8-08)

The ROD-selected remedy for the RA Sites was “Limited Excavation, Disposal, and Containment.” This remedy was divided into two phases to expedite the remedial action process. The Phase I RD/RA Work Plan activities included excavation of contaminated soil above cleanup levels, consolidation of contaminated soil from other RA Sites to NRF-14, removal and characterization of piping and concrete fixtures for disposal off-site (away from NRF), and backfilling with clean soil. The Phase II RD/RA Work Plan activities originally included construction of engineered covers over the filled S1W Leaching Pit/Bed area (NRF-12B/14) and A1W Leaching Bed (NRF-19). In 2002, the selected remedy for site NRF-21A was modified per an Explanation of Significant Difference (ESD) to the ROD to include construction of the same type of engineered cover over NRF-21A.

To protect human health and the environment, RAOs for the RA Sites were developed and documented in the ROD. These RAOs are discussed below:

Human Health:

- Prevent external gamma radiation exposure from all radionuclides of concern that exceed a total exposure pathway excess cancer risk of 1 in 10,000 for the future 100-year residential receptor.

- Prevent ingestion of soil and food crops contaminated with radionuclides of concern that exceed a total pathway excess cancer risk of 1 in 10,000 for the future 100-year residential receptor.

- Prevent exposure to soil contaminated with lead that exceeds the EPA recommended screening level of 400 parts per million (ppm) for lead cleanup.

Environmental:

- Prevent erosion or intrusion by resident plant or animal species in contaminated soils that could cause the release of contaminated soils.

- Prevent exposure to COCs that may cause adverse effects on populations of resident species.

The specific elements of the selected remedy developed to meet the RAOs are as follows:

- Removal of contaminated soil above the remediation goals and contaminated debris
- On-site consolidation of contaminated soil
- Placement of an engineered cover with a biobarrier over the designated sites
- Institutional controls
- Soil moisture, soil and groundwater monitoring
- Periodic inspection and maintenance.

The following describes how the elements of the selected remedy meet the RAOs.

- Soil above remediation goals was removed to a minimum depth of ten feet from the designated sites (NRF-11, NRF-12A, NRF-17, NRF-21A, NRF-21B, and NRF-80). Soil was consolidated at NRF-14 where an engineered cover was constructed.

- Contaminated structures were demolished and disposed of.

- Lead had been detected in only one sample in a location (NRF-12B) where an engineered cover was placed.

- An engineered cover was constructed over the designated sites to prevent exposure and ingestion of contaminants by the receptors. The cover design incorporates erosion control measures (i.e., use of a vegetative cover) to reduce the effects from rain and wind and intrusion by plant or animal species in contaminated soil (i.e., the use of a biobarrier).

- To prevent unauthorized intrusion and excavation and to control land use and transfer, Institutional Controls were implemented to address human health risk posed by the RA Sites and also address ecological risk.

- In addition to engineered earthen covers, the selected remedy at NRF-12B/14, NRF-19, and NRF-21A also included installation of soil moisture probes. Soil and groundwater sampling were also implemented to monitor any potential releases from the covered areas.

- Inspections are performed in accordance with the Operation and Maintenance Plan.

4.2 Remedy Implementation and Maintenance

Remedy implementation included the remedial design, remedial actions, and subsequent operations and maintenance (O&M). Details of remedy implementation are summarized below. A more detailed account of remedy implementation for the inactive landfills can be found in the RA Report for the Inactive Landfills (WEC, 1997a). A detailed description of remedial actions associated with the OU 8-08 Sites, including construction of the OU 8-08 Engineered Covers is located in the OU 8-08 RA Report (BBI, 2006). Actions recently completed at NRF-18A, NRF-43, and NRF-80 are discussed in Section 4.2.7.

4.2.1 Landfill Covers

The regulatory requirements regarding final closure of landfills (WEC, 1995) provide for the placement of a final cover designed and constructed to:

- Have a permeability (where permeability is expressed as hydraulic conductivity with units of centimeters per second (cm/sec)) less than or equal to the natural subsoils of the surrounding area,
- Function with minimal maintenance,
- Promote drainage and minimize erosion,
- Accommodate settling and subsidence to maintain integrity of the cover, and
- Minimize the migration of liquids.

The design criteria for the landfill covers included the selection of appropriate soils that minimize erosion with properties (i.e., permeability) that will also limit infiltration. The cover design incorporated an appropriate slope that provides adequate surface runoff. To further minimize erosion and the migration of liquids through the landfill, the landfill cover included a top vegetative layer. To minimize settling and subsidence, the surfaces of the landfill areas were preloaded with fill material, compacted, and leveled to the same elevation as the surrounding natural surfaces, which provided a stable base for the cover. The landfill cover was then placed over the top of each of the landfill areas, moderately compacted (except the upper foot of topsoil), completed with a proper surface slope, and seeded. To minimize maintenance of the vegetative cover, indigenous plants were used.

4.2.1.1 Cover Construction

Landfill cover construction operations are summarized below. The construction activities included: (1) site clearing, (2) landfill unit base layer fill and grading, (3) subsurface soil cover construction, (4) topsoil cover construction, and (5) vegetative cover.

Site Clearing

Site clearing activities removed vegetation greater than three inches in diameter and surface debris, and provided scarification of the landfill base to facilitate blending of newly placed soil layers. Cleared soils that were sufficiently free of debris were stockpiled adjacent to each landfill for use as the top soil cover, since these soils contained organic matter beneficial to re-establishing the vegetative cover.

Base Layer

A motor grader, bulldozers, water truck, and smooth drum roller and/or sheep's foot roller were used to knock down, process, and compact the fill material into place for the landfill cover base at each of the landfill areas. Each of the three landfill units was filled, compacted, and graded as necessary to achieve a three to five percent gradient.

Subsurface Soil Cover

Each of the three landfill units was filled and graded using appropriate soil for the subsurface cover layer to achieve a minimum three foot cover at NRF-1 and a minimum two foot cover at NRF-51 and NRF-53 with a three to five percent gradient.

Top Layer

Each of the three landfill units was filled and graded to achieve a minimum one foot final topsoil cover with a three to five percent gradient. Soil for the topsoil cover was loosely placed with minimum compaction, to ensure the establishment of adequate vegetation. The final topsoil cover thickness at NRF-51 and NRF-53 was one foot. The final topsoil cover thickness at NRF-1 averaged 1.5 feet.

Vegetative Cover

The vegetative cover consisted of indigenous vegetation with the characteristics specified in the RD/RA Work Plan (WEC 1995). The specific plant mixtures described in the Work Plan were also recommended for use as appropriate vegetative cover for erosion control based on studies at other the INL sites.

Mulching, seeding, and fertilization were performed in accordance with the RD/RA Work Plan. Mulch was applied after placement of the top layer in early summer to minimize erosion. Prior to application of the mulch, the soil surface was scarified using a spring-tooth harrow to loosen the soil and permit anchoring of the mulch. Straw mulch was applied and then anchored in the soil using a crimping disk. Fertilization and seeding were done in late summer to provide a greater chance for plant growth in the spring.

4.2.2 Groundwater Monitoring Network

4.2.2.1 Network Design (Location and Number of Wells)

Groundwater monitoring was part of the remedy selected for the Landfill Areas. The NRF Groundwater Monitoring Network consists of individual wells designed and built over a period of approximately 55 years. In 1995, NRF built six groundwater monitoring wells (NRF-8 through NRF-13). These wells were administratively included into a network with existing wells that were located upgradient (USGS 12 and NRF-7) and downgradient (USGS 97, -98, -99, and -102) of NRF. Two wells (NRF-6 and NRF-13) were part of the Effluent System Monitoring Group until early 2007. Because of problems encountered with well NRF-13, as discussed in Appendix A of the 2006 Five-Year Review (BBI 2006), it was determined that NRF-13 could no longer be used to reliably monitor the quality of NRF effluent; therefore, this well was removed from the CERCLA monitoring network beginning May 2007. In 2009, NRF completed construction of a new well (NRF-16). This well was designed and located to monitor water quality upgradient to NRF. In late 2010, after ensuring that samples from well NRF-16 reflected upgradient water quality, NRF discontinued using wells NRF-7 and USGS 12 as upgradient monitoring wells and begin using well NRF-16 in the CERCLA groundwater monitoring network.

The locations of five wells constructed in 1995 (NRF-8 through 12) were optimized with the aid of a computer program called Monitoring Efficiency Model (MEMO). These wells, along with USGS 102, were placed along a semi-circular arc just south of NRF. These became the Local Downgradient well group. The purpose of these wells was to be the first line of detection for constituents that may have been released from NRF. The location of NRF-16 was chosen to be as close to NRF as possible without being influenced by the facility activities, while lying along a groundwater flow path that both passes through the well and beneath NRF.

The current configuration of the NRF Groundwater Monitoring Network allows NRF to collect samples for comparison to assess what impacts, if any, operations at NRF have on the aquifer.

4.2.2.2 Constituent Analysis Design

The identification of analytes to be monitored at NRF focuses on those that had been identified from the following: compounds that had been identified in process waste streams, potential degradation products, those addressed in 40 CFR 141 considered as relevant and appropriate, and detection of the constituents in samples taken from monitoring wells and other site investigation sampling activities (i.e., soil and soil gas sampling). Selection of target compounds for analysis was based on whether a compound is characteristic of the waste, easily and reliably detected analytically, and/or addressed by an applicable regulation to be monitored. The constituents for which analyses are performed are presented in Table 4-1. The analysis of water samples for Total Organic Halogens (TOX) was discontinued in November 2007 as recommended during the 2006 Five-Year Review.

4.2.2.3 Well Construction

The wells constructed specifically for the NRF groundwater network were designed to similar specifications. The goal was to create wells that were cost effective, met or exceeded State and Federal guidelines, and provided the data needed by NRF. The typical NRF well has a surface casing ranging from 12 to 22 inches in diameter. This surface casing terminates at the top of the first basalt encountered and is grouted in place. Most NRF wells are constructed with ten-inch diameter carbon steel casing from the surface to approximately 50 feet above the aquifer. In some wells, this casing is 7 inches (NRF-16) or 12 inches in diameter. This casing is also grouted in place in such a manner as to prevent the grout from bridging and separating from the borehole wall. The casing in the NRF wells then telescopes down to 5 or 6-inches and is composed of stainless steel that is isolated from the carbon steel casing with dielectric insulating material. The bottom 50 feet of the casing consists of stainless steel screen. Either welds or internal threads join all casings.

Each well is fitted with a submersible pump connected to a three-phase five-horsepower motor. Water is pushed to the surface through a 1¼ to 1½-inch stainless steel riser pipe. Figure 4-1 shows the major design elements of the typical NRF groundwater monitoring wells.

4.2.3 Soil Gas Monitoring Probes

4.2.3.1 Design Criteria

Soil gas monitoring was part of the remedy selected for the Landfill Areas. To assess the effectiveness of the three landfill covers in limiting water infiltration and soil gas emissions, soil gas monitoring (utilizing a soil gas emissions survey) was implemented at the cover and probe locations shown in Figure 1-1.

Soil gas monitoring was initiated and conducted periodically after the landfill cover had been placed at each location. The monitoring included a soil gas emissions survey over the landfill cover and the placement of permanent soil gas monitoring probes around the perimeter of the landfill areas for the collection and analysis of subsurface soil gas samples. The soil gas emissions survey was utilized to assess the effectiveness of the landfill cover. The soil gas monitoring probes were used to detect any potential gaseous contaminant migration. The soil gas probes were designed with a screened section at the top of the basalt or at the top of the fluvial/lacustrine layer, as applicable. A top removable sampling assembly is attached to the probe opening for access during sampling evolutions (WEC, 1997a).

4.2.3.2 Soil Gas Probe Construction

Soil gas monitor probes were installed after the placement of the final topsoil layer at each landfill. The drill rig used a four-inch hollow stem auger that produced a six-inch diameter hole. Monitoring locations were selected and staked prior to drilling. Fourteen monitor probes were installed with a PVC casing size of 1.05-inch outer diameter (0.75 inch inner diameter), a surface protective casing size of six inches, a bentonite seal of three feet, and use of 8-12 silica sand to form the sand pack around the probes. Figure 4-2 depicts the typical soil gas monitor probe construction. Borings were advanced to depths as determined by the presence of fluvial/lacustrine deposits or the presence of basalt. Monitor probe depths ranged from 12.5 to 26.5 feet (WEC, 1997a). Protection of the monitor probes was achieved through the installation of six-inch steel casings with lockable caps.

4.2.4 No Further Action Sites

The primary remedial action implemented at the NFA Sites is ICs. NFA Sites have been posted with signs that indicate site identification, site hazard, access restrictions, and a point of contact. Sites NRF-16, NRF-23, NRF-61, NRF-66, and NRF-81 are enclosed within fences. The remaining sites are either outside the NRF site fence (thus away from the general NRF population) or are beneath structures (resulting in limited access). All sites are inspected at least annually followed by the issuance of an Institutional Control Monitoring Report (ICMR) containing the results of the inspections.

4.2.5 Remedial Action Sites

Remediation work associated with the OU 8-08 RA Sites was divided into two major tasks called Phase I and Phase II Remedial Design/Remedial Action (RD/RA). The Phase I and Phase II RD/RA Work Plans for OU 8-08 provided the design criteria for the selected remedies.

Phase I remedial actions began in 1999 and were completed in June 2003, and involved excavation at eight of the nine sites with potentially elevated risk levels. These remedial actions resulted in the removal of contaminated soil above remediation goals as stated in the ROD from the surface to at least ten feet below ground surface. NRF-12B did not require excavation because this site was selected for the placement of an engineered cover.

Phase II work, which included construction of the earthen covers (at NRF-12B/14, NRF-19, and NRF-21A) and installation of soil moisture probes, began in April 2004 and was completed in October 2004.

4.2.5.1 Phase I Remedial Actions

The remedial actions for Phase I included three major work projects that facilitated the overall work effort. The work projects for Phase I were defined as follows: (1) excavation activities, (2) debris characterization and disposal, and (3) soil consolidation.

4.2.5.1.1 Excavation Activities

The excavation project involved the following work elements:

- Soil excavation;
- Demolition (often reversed with soil excavation, as appropriate);
- Confirmatory sampling; and,
- Site Restoration (backfill to grade, repave, etc.).

Soil Excavation

Most soil excavation was performed using a backhoe, trackhoe, or remotely operated demolition robot (primarily used for soil removal at NRF-17). Removed pieces of asphalt paving or concrete and grubbing wastes (sagebrush, grasses, etc.) were segregated as much as practical from contaminated soils. In some cases, such as near obstructions, at areas with high contamination levels or for small quantity soil removal, hand shoveling was performed.

Excavation occurred in eight of the nine RA Sites (the exception being NRF-12B). Soil with cesium-137 greater than 16.7 picocuries per gram (pCi/g) was excavated to a minimum depth of ten feet (strontium-90 and lead were not identified above cleanup levels in any of the excavation sites). Concrete structures that extended below the ten foot depth at NRF-11 and NRF-12A were also removed. Additional soil below ten feet was excavated at several locations, to support potential unrestricted release of such areas within the 100-year future land use period (i.e., following sufficient radioactive decay). Table 4-2 summarizes remedial activities associated with Phase I work.

Demolition

Several sites required demolition of concrete structures or removal of piping. The demolition of most structures simply required reducing the structure to a size needed for disposition actions. The debris was characterized prior to disposal. Excavated metallic pipe was size-reduced for disposal. Cement or ceramic type piping was removed in sections at the bell and spigot connections. The pipe was properly characterized and packaged for disposal at the RWMC on the INL.

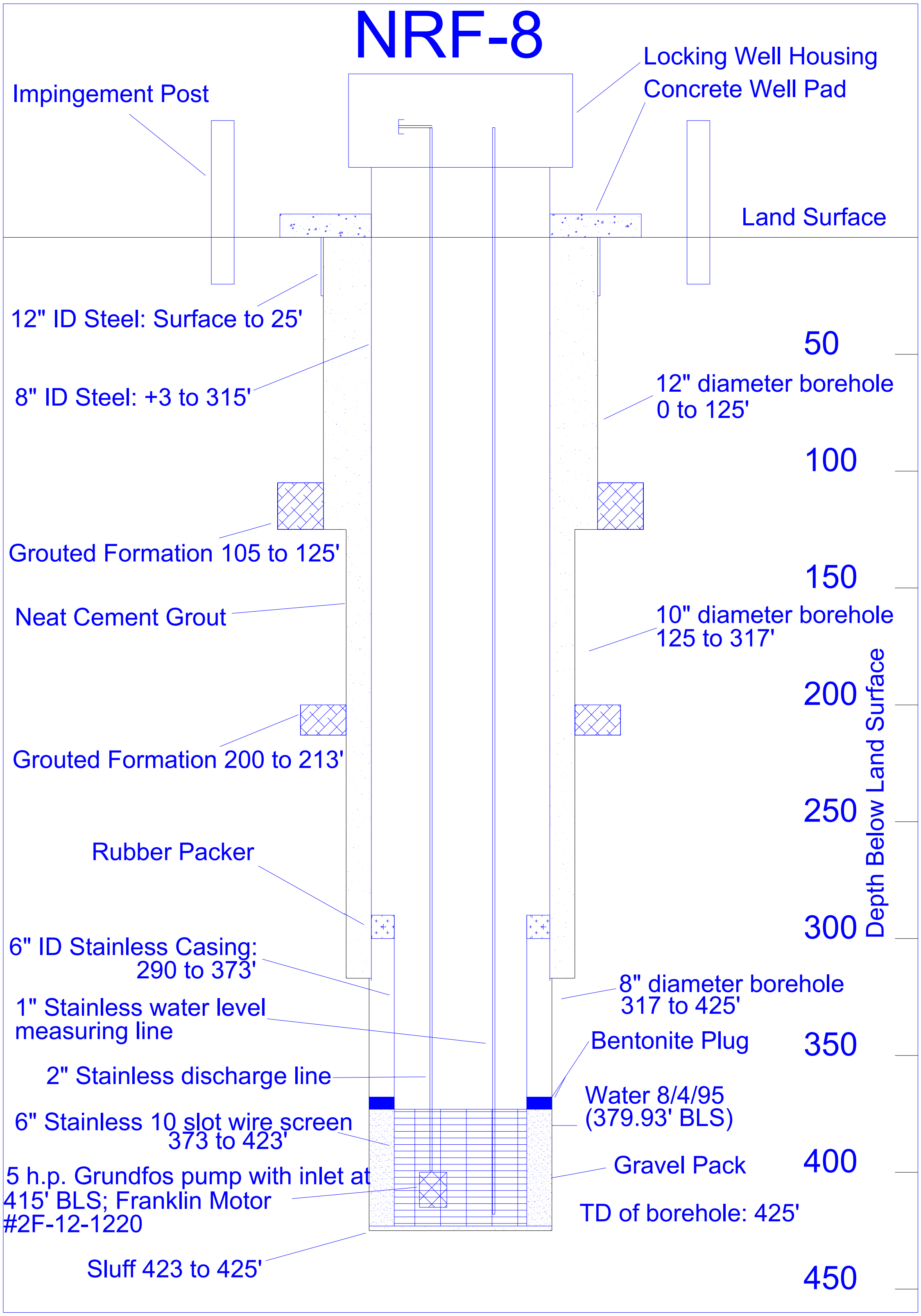


Figure 4-1 Typical Groundwater Well Construction Diagram

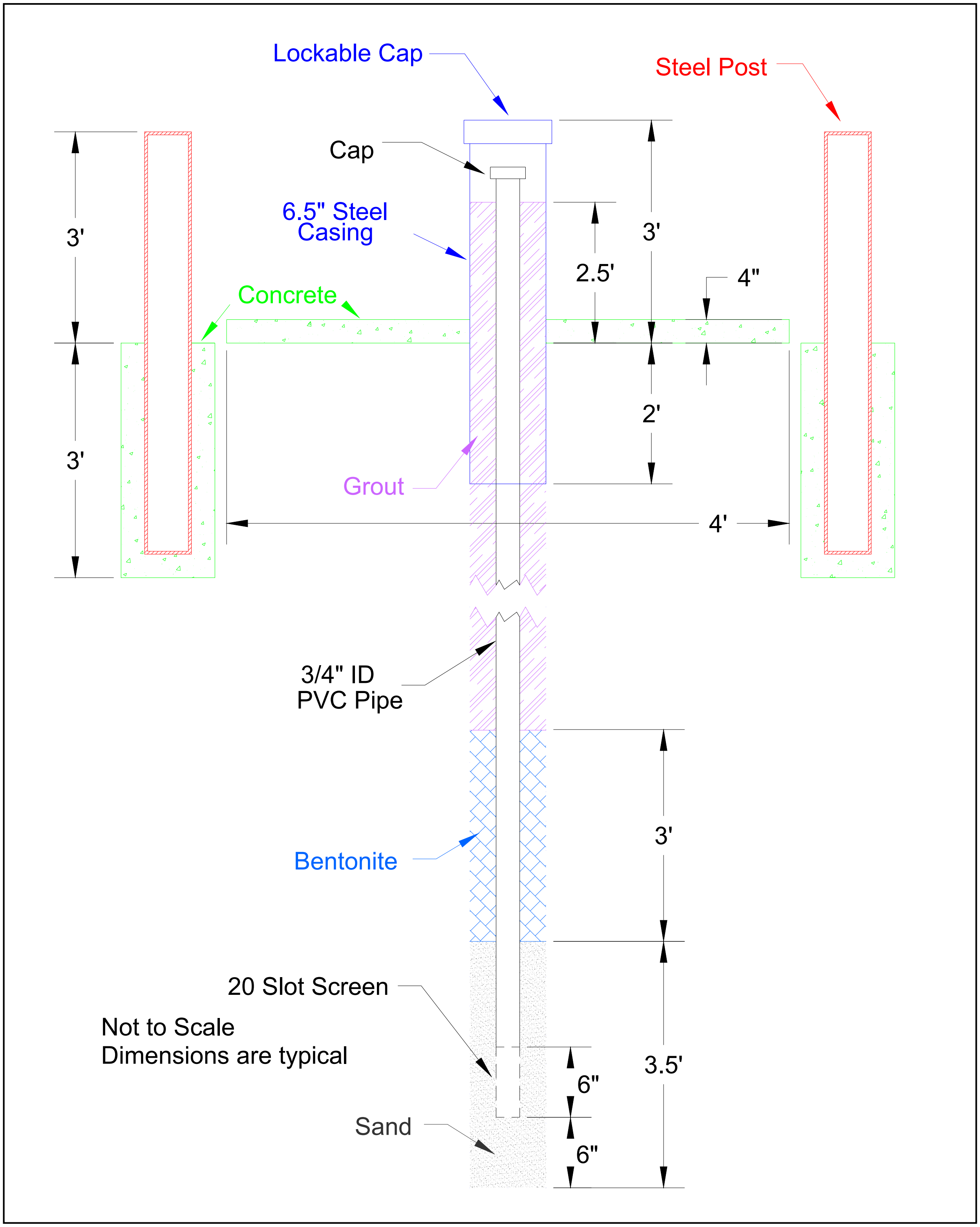


Figure 4-2 Typical Soil Gas Probe Construction Diagram

Table 4-1 Groundwater Monitroing Constituents			
Constituent	Analytical Method	MCL (mg/L)	MCLG** (mg/L)
Aluminum	6010B ICP	0.2***	*
Antimony	6020 ICP/MS	0.006	0.006
Arsenic	6020 ICP/MS	0.01	0.01
Barium	6010B ICP	2	2
Beryllium	6010B ICP	0.004	0.004
Cadmium	6010B ICP	0.005	0.005
Calcium	6010B ICP	*	*
Chromium	6020 ICP/MS	0.1	0.1
Copper	6010B ICP	1.3	1.3
Iron	6010B ICP	0.3***	*
Lead	6010B ICP	0.015****	0
Magnesium	6010B ICP	*	*
Manganese	6010B ICP	0.05***	*
Mercury	7470A CVAA	0.002	0.002
Nickel	6010B ICP	*	*
Potassium	6010B ICP	*	*
Selenium	6010B ICP	0.05	0.05
Silver	6010B ICP	0.1***	*
Sodium	6010B ICP	*	*
Thallium	6020 ICP/MS	0.002	0.0005
Zinc	6010B ICP	5***	*
Sulfate	300	250***	*
Chloride	300	250***	*
Nitrate as Nitrogen	353.2	10	10
Nitrite as Nitrogen	300.0	1	1
Ni-63	DOE STL-RC-0055	4 mrem/year	*
Sr-90	DOE SR-03-RC MOD	8 pCi/L	*
Tritium	R-1173-76	20,000 pCi/L	*
Quantitative Isotopic Gamma	EPA 901.1 MOD	*	*
Volatile Organic Compounds			
Acetone	525.2 GC/MS	*	*
Benzene	525.2 GC/MS	0.005	0
Carbon Tetrachloride	525.2 GC/MS	0.005	0
Chlorobenzene	525.2 GC/MS	0.1	0.1
Cis-1,2-Dichloroethylene	525.2 GC/MS	0.07	0.07
1,1-Dichloroethane	525.2 GC/MS	*	*
1,2-Dichloroethane	525.2 GC/MS	0.005	0
1,1-Dichloroethylene	525.2 GC/MS	0.007	0.007
Ethylbenzene	525.2 GC/MS	0.7	0.7
Methylene Chloride	525.2 GC/MS	0.005	0
Naphthalene	525.2 GC/MS	*	*
1,1,2,2-Tetrachloroethane	525.2 GC/MS	*	*
Tetrachloroethylene	525.2 GC/MS	0.005	0
Toluene	525.2 GC/MS	1	1
Trans-1,2-Dichloroethylene	525.2 GC/MS	0.1	0.1
1,1,1-Trichloroethane	524.2 GC/MS	0.2	0.2

Table 4-1 Groundwater Monitroing Constituents (Continued)			
Constituent	Analytical Method	MCL (mg/L)	MCLG** (mg/L)
1,1,2-Trichloroethane	524.2 GC/MS	0.005	0.003
Trichloroethylene	524.2 GC/MS	0.005	0
Trichlorofluoromethane	524.2 GC/MS	*	*
Vinyl Chloride	524.2 GC/MS	0.002	0
Xylenes (total = o+p+m)	524.2 GC/MS	10	10
Semi-Volatile Organic Compounds			
Anthracene	525.2 GC/MS	*	*
Benzo(a)anthracene	525.2 GC/MS	*	*
Benzo(a)pyrene	525.2 GC/MS	0.0002	0
Benzo(b)fluoranthene	525.2 GC/MS	*	*
Benzo(k)fluoranthene	525.2 GC/MS	*	*
Chrysene	525.2 GC/MS	*	*
Di(2-ethylhexyl) phthalate	525.2 GC/MS	0.006	0
Di-n-butylphthalate	525.2 GC/MS	*	*
Fluoranthene	525.2 GC/MS	*	*
Indeno[1,2,3-cd]pyrene	525.2 GC/MS	*	*
Isophorone	525.2 GC/MS	*	*
Phenanthrene	525.2 GC/MS	*	*
Pyrene	525.2 GC/MS	*	*

* Not Applicable
**MCLG – Maximum Contaminant Limit Goal
***Secondary Maximum Contaminant Limit
****Treatment Technique – A required process intended to reduce the level of a contaminant in drinking water - Action Level

Table 4-2 Summary Data for Selected OU 8-08 Five-Year Review Report			
Site	**Feet of Pipe Removed**	**Volume of Soil Removed**	**Volume of Concrete Removed**
NRF-11 (Including L-Shaped Sump)	488' 6"	120 yd^3	21 yd^3
NRF-12A (Including Concrete Manhole)	824' 8"	5505 yd^3	2.6 yd^3
NRF-12B/14	N/A	N/A	N/A[(a)]
NRF-14 (supply line)	530'	165 yd^3	N/A
NRF-17	N/A	1120 yd^3	1,875 yd^3
NRF-19	200'	86 yd^3	N/A
NRF-21A	435'	890 yd^3	N/A
NRF-21B (Sludge Drying Bed)	N/A	60 yd^3	19 yd^3
NRF-80	93'	4 yd^3	N/A
TOTALS	**2571' 2"**	**7,950 yd^3**	**1,917.6 yd^3**

(a) No concrete was removed, but 400 yd^3 of asphalt was removed

Confirmatory Sampling

Soil samples were collected periodically during remediation work and analyzed by NRF Chemistry for total and isotopic gamma activity. Radiation surveys were performed on the excavated soil and periodically in the excavated hole. Samples were also collected during and after the excavation and demolition work. After achieving satisfactory preliminary results from NRF data indicating completion of remedial actions, follow-up samples were taken for off-site independent analyses to provide the actual confirmation data needed. The off-site analyses verified that the preliminary NRF data was accurate, and confirmed that remediation goals were met. Hence, the confirmatory sampling ensured soil above cleanup levels was removed and provided information on the contaminant levels, if any, that remained in the soil.

Site Restoration

Fill material was taken locally from the NRF gravel pit located southwest of the NRF site and from excavation activities associated with construction actions at ECF. All excavated holes were filled to grade with clean soil and compacted.

All excavated areas were generally returned to preexisting conditions (e.g., to historic pre-NRF site grade) as much as possible. Compaction of the soil was 90% or better and, in roadways, 95% or better. Where required, sites were repaved with asphalt after soil removal.

4.2.5.1.2 Debris Characterization and Disposal

The characterization and disposal of debris (e.g., concrete and piping) from the RA Sites was conducted in accordance with a Waste Management Plan (BBI, 1999). Most of the debris was radioactive and was packaged in accordance with the INL Reusable Property, Recyclable Materials, and Waste Acceptance Criteria and disposed of at the RWMC. None of the debris generated during the remedial actions was hazardous according to the Resource Conservation and Recovery Act (RCRA); therefore, disposal at a RCRA licensed facility or in accordance with the INL Site Treatment Plan was not required.

4.2.5.1.3 Soil Consolidation

Excavated soil containing radioactivity above cleanup levels or above 30 picocuries per gram (pCi/g) total gamma activity was consolidated into the S1W Leaching Beds (NRF-14). The soil was placed into soft sided containers (SSCs), temporarily stored, transported to, and placed in the leaching beds area (still in the containers). A temporary road leading to the S1W Leaching Beds was constructed to support the heavy equipment used to move the SSCs.

4.2.5.2 Phase II Remedial Actions

The OU 8-08 Phase II remedial actions entailed the construction of engineered covers over three designated areas, NRF-12B/14, NRF-19, and NRF-21A. The controlling elements in the design of the engineered covers included providing a barrier to prevent exposure to and direct contact with contaminated soil, limiting biotic intrusion, limiting infiltration, and providing erosion control. Therefore, the engineered covers were constructed incorporating the following design considerations: (1) the use of appropriate soil material and vegetation that minimize erosion; (2) features that limit infiltration (use of soil with an appropriate hydraulic conductivity, soil layer of a sufficient thickness for adequate water storage, and vegetation for evapotranspiration); (3) appropriate material and thickness to provide a barrier that will prevent exposure to and direct contact with the contaminated soil by any individual and also inhibit biotic intrusion; and (4) appropriate slope to provide adequate drainage. The engineered cover design consists of three components: a top soil layer for the vegetative cover, a subsurface soil layer, and a biobarrier layer. The engineered cover layers, beginning with the biobarrier layer, were placed on top of a base support layer. In turn, the base support layer was only applied after a stable subgrade was established, to minimize subsidence. Neutron access tubes for soil moisture monitoring were also installed during this project.

The engineered cover installation project entailed the following work elements:

- Pre-construction testing at the individual sites for hydraulic conductivity determination of the soil beneath the contamination layer;
- Site preparation and mobilization;
- Construction of engineered covers over the designated areas, including geotechnical testing of the soil material;
- Completion work activities.

A summary of these tasks is provided below.

4.2.5.2.1 Pre-construction Testing

Pre-construction testing activities consisted of drilling a total of nine soil borings (three around the perimeter of each planned cover area) for obtaining samples of the soil layer beneath the contamination layer. This was to verify that the hydraulic conductivity of the underlying soil layer was greater than or equal to the proposed hydraulic conductivity of the engineered cover. These data were needed to ensure that the cover would adequately minimize infiltration and prevent leachate from accumulating under the contamination layer (this phenomenon is known as the bathtub effect). The hydraulic conductivity for all of the samples was greater than the required hydraulic conductivity for the engineered covers ($1X10^{-5}$ cm/sec). Results of the geotechnical investigation indicated that conditions were suitable to construct the engineered covers as designed.

4.2.5.2.2 Site Preparation and Mobilization

The site preparation phase included site clearing and other preliminary steps, the sampling of borrow and in-place soils, and site surveying activities. Mobilization included establishing the project trailer, grading, and preparation of an equipment yard, and the transport of equipment and equipment services to the site. Areas with preexisting natural soil cover were cleared of vegetation within the cover area, followed by filling and compaction of any areas that contained pits, cavities, or any other type of depressions that might be an indication of subsidence. The asphalt cover over NRF-12B was broken up and removed. Existing fencing at NRF-12B/14 and at NRF-19 was removed. Site preparations at NRF-21A included leveling the remaining three to five foot mounded area to the surrounding grade.

To ensure the areas were suitable for the placement of engineered covers, clean fill material was placed over all three cover locations. This fill material was placed as a stable subgrade. The thickness of this subgrade was at least one foot. The fill material used for this subgrade was obtained from the NRF gravel pit. Inspections prior to commencing construction determined that there were no soft spots or any other defects at any of the three areas to be covered.

4.2.5.2.2.1 Borrow Soil Testing and Source Management

Four types of soil materials were used as engineered cover material (or pre-cover material) including pit-run gravel for the base support layer, crushed gravel and cobble for the biobarrier layer, clay-rich native soil for the subsurface layer, and native soil with some gravel for the top layer. Geotechnical testing of the soil borrow material, which included the collection of soil samples, was performed to assess the suitability of soil for use as cover material. Suitable material was excavated (using a bulldozer) and processed (e.g., pit-run gravel was crushed and sorted) as required, and loaded into transport trucks. The cobble was obtained from an off-site commercial vendor.

4.2.5.2.2.2 Site Surveying

Site surveying activities commenced during mobilization and continued through the cover installation process. Site surveys were performed after the placement of each cover layer. The survey data were used to develop the as-built drawings, including cross-sections, and to provide a verification of the actual quantities of material used.

4.2.5.2.3 OU 8-08 Engineered Cover Construction

The engineered covers constructed at the three designated areas, NRF-12B/14, NRF-19, and NRF-21A, all employed the same construction methods. The cover construction activities included: (1) base support layer fill and grading, (2) biobarrier cover construction, (3) subsurface soil cover construction, and (4) topsoil cover construction. Gravel material was used to form the base support layer for the engineered cover to provide stability by minimizing or eliminating subsidence. This subgrade consisted of a compacted layer of pit-run gravel with a minimum thickness of one foot. The base support layer serves as a base/foundation that provides additional stability (sufficient load bearing capacity) for the upper three soil layers of the engineered cover, thereby minimizing subsidence problems with the cover. The biobarrier layer was constructed by placing cobble between two layers of crushed gravel. The purpose of the biobarrier layer is to inhibit biotic intrusion. The subsurface cover layer was constructed for minimizing water infiltration. The cover side slopes (where the cover edges will meet with the surrounding natural surfaces) were constructed as to achieve a maximum three horizontal to one vertical (3H:1V) ratio. Water was added during construction to aid compaction and prevent desiccation cracking. The soil was placed in five, ten-inch lifts (four feet minimum total thickness) at all cover locations.

A six to twelve inch topsoil cover layer was also constructed with soil material designed to support native vegetation, inhibit erosion, and promote drainage by placement of a three to five percent top slope. Soil material for the topsoil layer was loosely placed, with minimum compaction resulting from grading the material to the final surface grade. Construction Quality Assurance (CQA) practices were implemented to ensure construction quality. All CQA test results were within the acceptable limits (BBI, 2006). The general cross-section of the engineered covers is shown in Figure 4-3. The engineered cover top view with finished grade for each of the three areas is shown in Figure 4-4 and Figure 4-5.

4.2.5.2.4 Completion Work Activities

The project completion phase included the installation of neutron access tubes for soil moisture monitoring, final surveying of the engineered covers, area seeding including the placement of mulch, pre-final and final inspections by regulators, and the preparation of the OU 8-08 RA Report. A summary of the installation of neutron access tubes for soil moisture monitoring and area seeding/mulching are described in the following sections.

4.2.5.2.4.1 Soil Moisture Neutron Access Tube Installation

Six neutron access tubes were installed. The access tubes were placed about a foot deep into the base support layer (i.e., they are located in the central portion of the covers where the base support layer is thickest). Tubes consisted of two-inch nominal size steel pipe, approximately seven feet in length. Two monitoring locations were selected per site. A bentonite seal was placed at the surface around each access tube, and then soil was placed on top of the bentonite seal and mounded to shed precipitation away from the access tube. Figure 4-6 depicts the typical access tube construction.

4.2.5.2.4.2 Fertilization, Seeding, and Mulching

Fertilization, seeding, and mulching were performed after cover construction. Prior to seeding, fertilizer was applied at all three cover areas. Following fertilization, the soil surface was tilled two to three inches deep. Seeding was performed at all three cover areas with native plant species including sagebrush. The covers were mulched immediately after the fertilization and seeding were completed. Supplemental irrigation was temporarily applied at each location to promote plant growth.

4.2.6 Unexploded Ordinance Response Actions

4.2.6.1 WAG 10 Institutional Controlled Area and NRF Boundaries

WAG 10 comprises miscellaneous surface sites and liquid disposal areas throughout the INL that are not included within other WAGs (WAGs 1 through 9). WAG 10 also includes regional SRPA concerns related to the INL that cannot be addressed on a WAG-specific basis. The boundary of WAG 10 is the INL boundary, or beyond as necessary to encompass real or potential impact from INL activities, and any areas within the INL not covered by other WAGs.

NRF, which is WAG 8, is encompassed by the WAG 10 OU 10-04, Site ORD-03, *Naval Firing Site and Downrange Area* (i.e., Naval Proving Ground). Institutional controls have been established within this area per the *INL Site-Wide Institutional Controls, and Operations and Maintenance Plan for CERCLA Response Actions* (DOE-ID, 2011a) primarily due to concerns related to unexploded ordnance (UXO).

4.2.6.2 Institutional Controls at Munitions Sites within NRF Boundaries

The Department of Energy, Idaho Operations (DOE-ID) has established ICs for the INL Munitions Response Area (WAG 10 OU 10-04 Site ORD-03, Naval Proving Grounds) that includes NRF property (DOE-ID, 2011a). NRF will follow the protocol for ICs and response to UXO established by DOE-ID, which include:

- Providing awareness training for all employees or subcontractors who may access the area or perform a soil disturbance activity outside the NRF perimeter fence.
- Completing an NRF Soil Disturbance Notification Form for any activity that would disturb the soil. Soil disturbance includes activities such as excavation, drilling, and seismic testing but does not include such activities as routine inspections, surface soil sampling, and surveys.
- Conducting a UXO survey by the INL UXO expert team that will include a 100% visual and 100% geophysical survey (for any potential subsurface UXO). All anomalies are investigated by the UXO survey team expert who clears the area from future UXO concerns. Response to any UXO discovered by the INL UXO team will follow the DOE-ID established process for assessing, remediating, and disposing of the UXO by the INL UXO team.

- Providing a summary of the soil disturbance activity and the results of any UXO surveys in the annual NRF Institutional Control Monitoring Report. DOE-ID may also report the results of UXO surveys on NRF property through their established process.

NRF property that is excluded from the above process include areas within the NRF perimeter fence and extending out 50 feet from the fence (this is a highly disturbed area that typically includes a perimeter road), areas that have been highly disturbed such as previous construction or excavation sites, and established work areas associated with roads or wells. DOE-ID will notify NRF of any changes to ICs or response actions that may impact NRF property.

4.2.7 Post ROD Response Actions

Per the EPA guidance for 5-year reviews, post-ROD removal actions are discussed under the remedy implementation section. The response actions that are discussed in this section pertain to NFA Sites NRF-18A and NRF-43 and RA Site NRF-80. The removal actions for NRF-18A and NRF-80 have been completed. The removal action associated with NRF-43 is ongoing with a tentative completion date in late 2012.

4.2.7.1 NRF-18A Response Action

In anticipation of constructing a new office building within the footprint of the S1W Spray Pond, conditions at NRF-18A (the soil beneath the S1W Spray Pond #1 and associated fire protection system) were re-evaluated starting in late 2007. The original risk assessment conducted in 1994 showed a low risk for NRF-18A assuming that the spray pond remains in place, thus limiting exposure to the soil below the basins in the event that any contamination was present. The primary contaminant of concern associated with NRF-18A was chromium. Because of the low risk conclusion, NRF-18A was designated a NFA site in the 1998 ROD. The ROD further stated that it would remain a NFA site until additional data were available to more accurately assess it.

The re-evaluation of NRF-18A conducted in 2008 included additional sampling in accordance with a sampling and analysis plan (BBI, 2007). The NRF-18A sample analytical results showed that chromium was not present above EPA screening levels used to determine human health and the environment risks. In addition, the sample results for other analyzed constituents (i.e., heavy metals, polychlorinated biphenyls, etc.) were also shown to have no risk or an acceptable risk. A recommendation of “No Action” and supporting analytical results were presented in *The Recommended Course of Action for NRF-18A* (BBI, 2008). This document discussed and recommended the following actions pertaining to the S1W Spray Pond #1:

- Adding the Spray Pond #1 structure to the INL General Decommissioning Action Memorandum (DOE 2009), which would allow disposal of the low-level radioactive waste to the Idaho CERCLA Disposal Facility (ICDF);
- Identifying the soil beneath the S1W Spray Pond #1 and the associated fire protection system as a No Action area. This would release NRF-18A from future institutional controls.

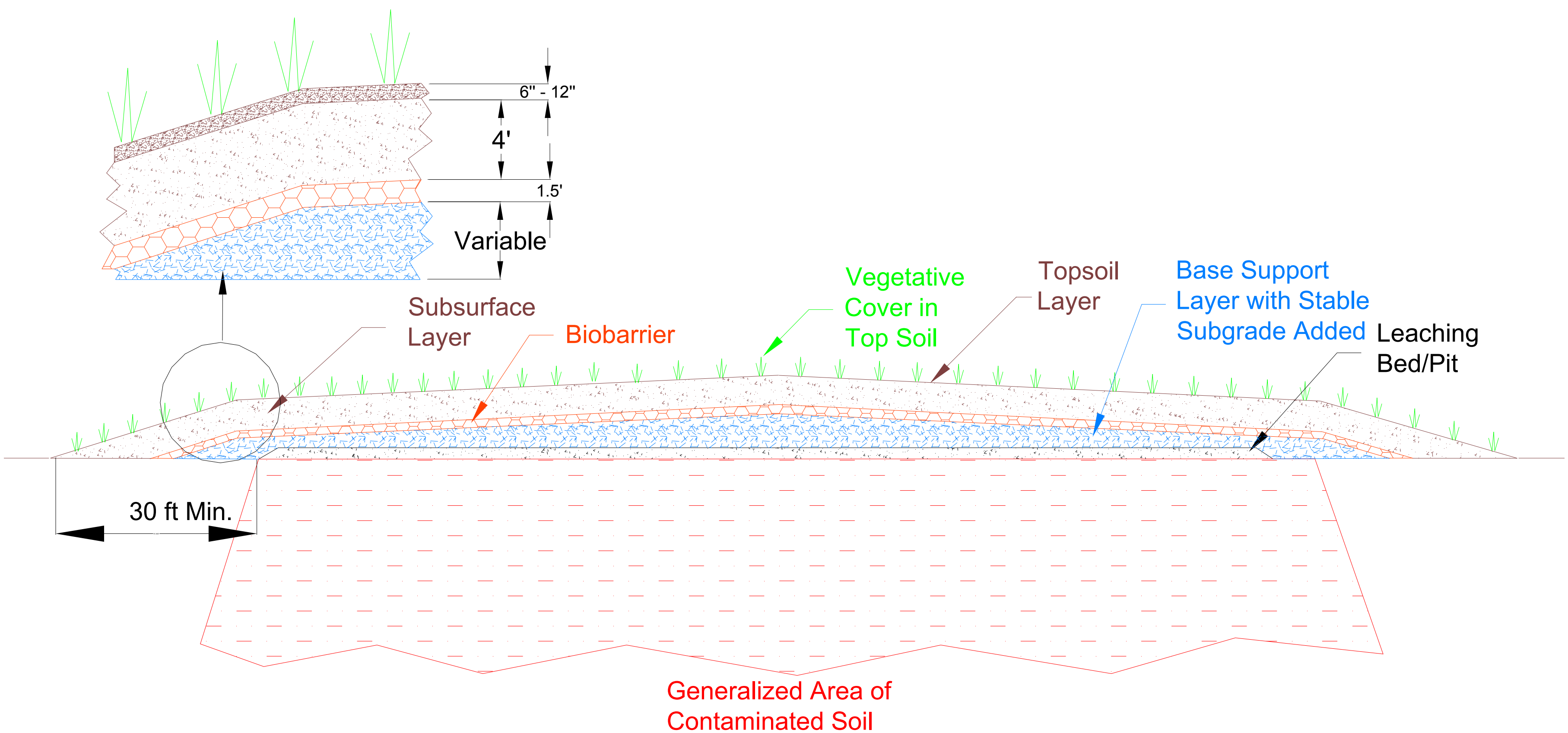


Figure 4-3 General Cross-section of OU 8-08 Engineered Cover

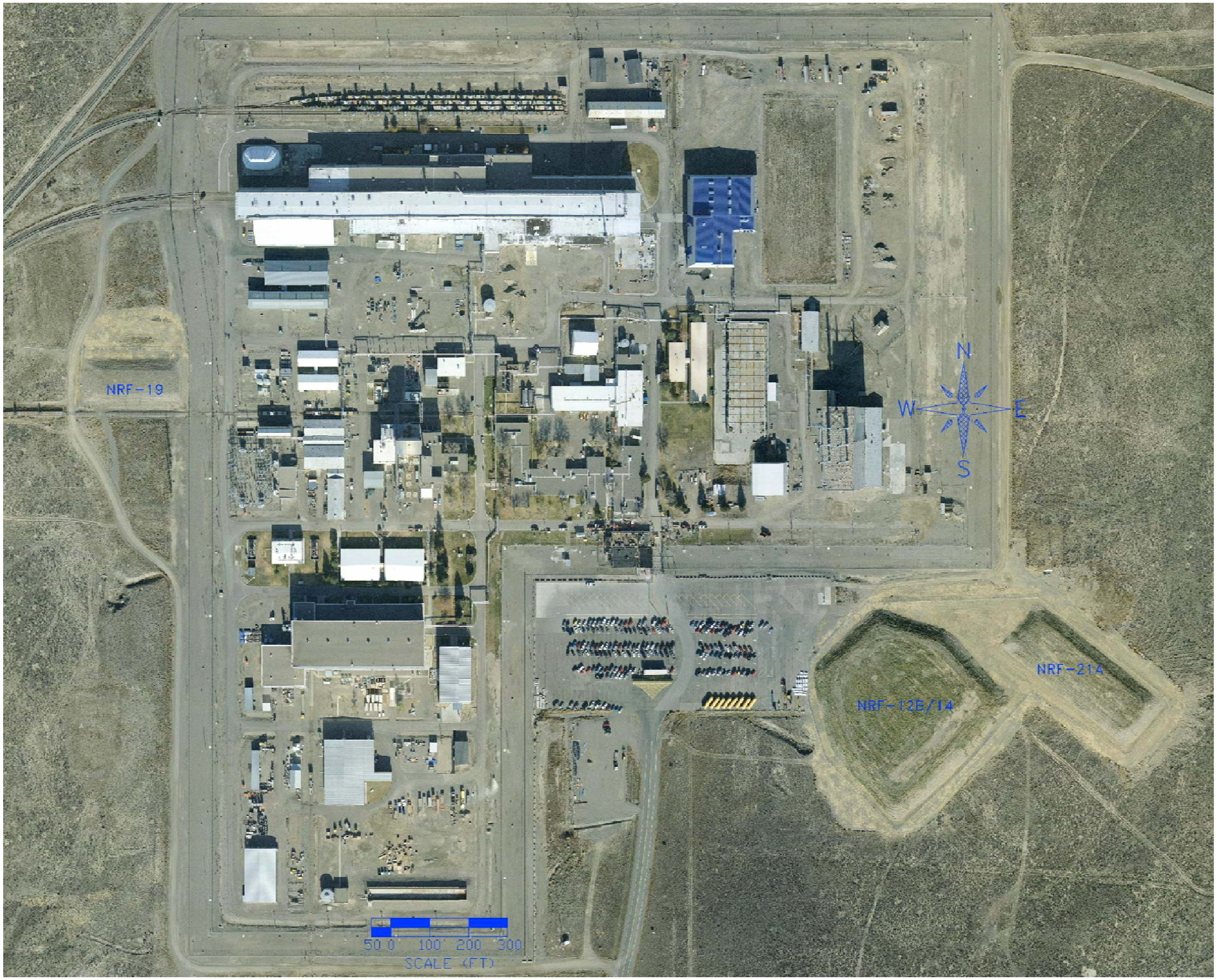


Figure 4-4 NRF-12B/14, NRF-21A, and NRF-19 OU 8-08 Engineered Cover Areas

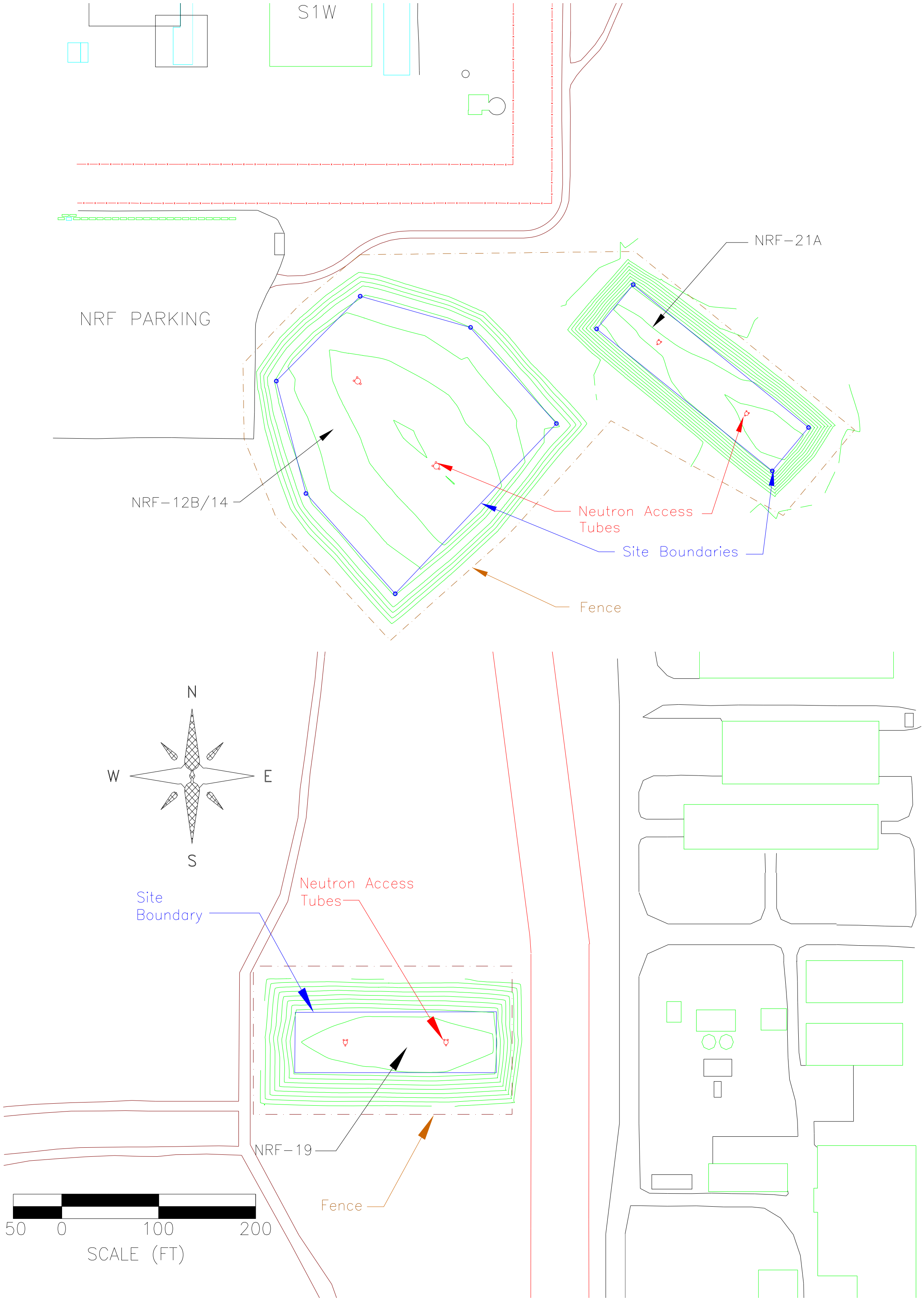


Figure 4-5 NRF-12B/14, NRF-21A, and NRF-19 Engineered Cover Areas

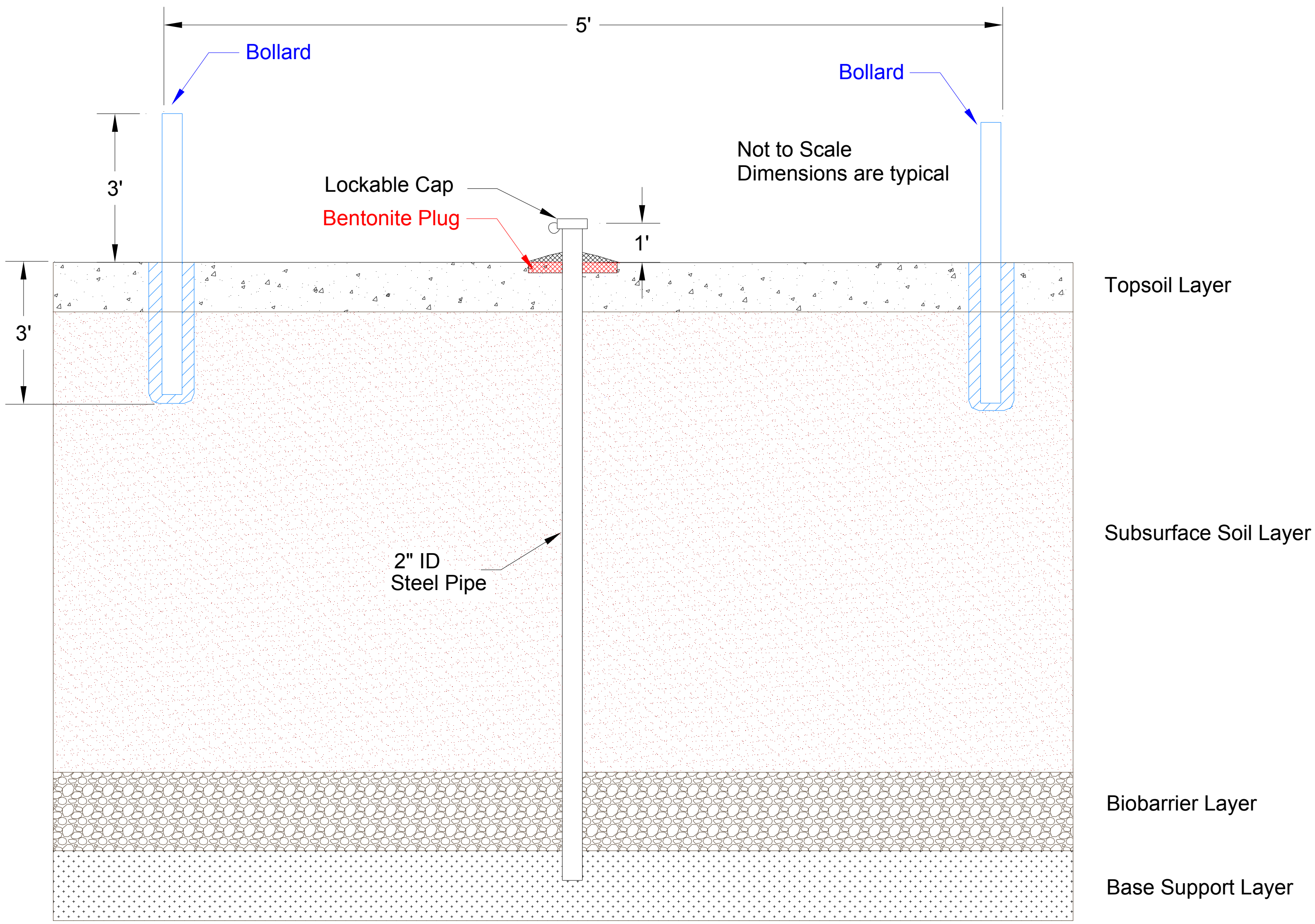


Figure 4-6 Typical Soil Moisture Neutron Access Tube Construction

The agencies concurred with these recommendations in late 2008. Furthermore, the agencies concurred that the actions associated with designating NRF-18A as a No Action site was consistent with the selected remedies in the NRF OU8-08 Final ROD. The demolition of the spray pond structure was performed under the INL Action Memorandum as a Non-Time Critical Removal Action and the project was completed in 2009, including the disposal of the waste to the ICDF.

Since NRF-18A has been re-designated to a no action status, there are no longer any institutional controls or reporting requirements applicable to this site.

4.2.7.2 NRF-80 Removal Action

Similar to Site NRF-18A, it was anticipated that construction activities associated with the new office building would encroach upon NRF-80 (A1W/S1W Radioactive Lines); therefore, conditions at NRF-80 were also re-evaluated in 2008. Recommendations pertaining to NRF-80 (A1W/S1W Radioactive Lines) were included in *The Recommended Course of Action for NRF-18A* (BBI, 2008). Even though the remediation of NRF-80 in 1999 met the remedial action objectives, the Recommended Course of Action recommended the removal of residual contaminated soil in order to release the area from institutional controls and disposal of the soil at the ICDF. The agencies concurred with this recommendation along with recommendations for NRF-18A in late 2008. The agencies likewise concurred that the further removal of residual contaminated soil at NRF-80 was consistent with the NRF OU8-08 Final ROD (where the removal of contaminated soil at NRF-80 as part of the selected remedy was presented in the ROD and in the Phase 1 Remedial Design/Remedial Action Work Plan).

The excavation and removal of residual contaminated soil from both the west and east portion the NRF-80 (see Figure 1-3) site was initiated in late 2009 and completed in early 2010. The residual contaminated soil primarily contained cobalt-60 with small amounts of cesium-137. Analytical data associated with the removal of contaminated soil from NRF-80 showed that remaining activity in the soil left in place was less than 0.5 pCi/g cobalt-60 and no detectable levels of cesium-137.

The 2010 Institutional Controls Monitoring Report (BMPC, 2010) summarized the removal of contaminated soil from NRF-80. The report stated that "ICs at NRF-80 were no longer required after the residual contaminated soil was removed". There are no longer any reporting requirements associated with this site.

4.2.7.3 NRF-43A Removal and Disposal Action

The source of contaminants at NRF-43 is the radioactive effluent pumped to the area from site NRF-21A (Old Sewage Basin) in 1958. NRF-43 is currently designated a NFA site. The primary contaminant of concern associated with NRF-43 is cesium-137. In 2009, a sample result from the annual sampling conducted in support of the NRF Environmental Monitoring Program was above the remediation goal for cesium-137 of 16.7 pCi/g as established in the NRF OU 8-08 Final ROD. Additional sampling of the area was performed. This sampling showed three areas of elevated contamination within or directly adjacent to NRF-43 (see Figure 4-7). Based on the results from this sampling, a Recommended Course of Action (BMPC, 2011) was proposed and approved to remove and dispose of contaminated soil above the ROD remediation goal at NRF-43. The selected action is consistent with the ROD and a minor change to the ROD was issued.

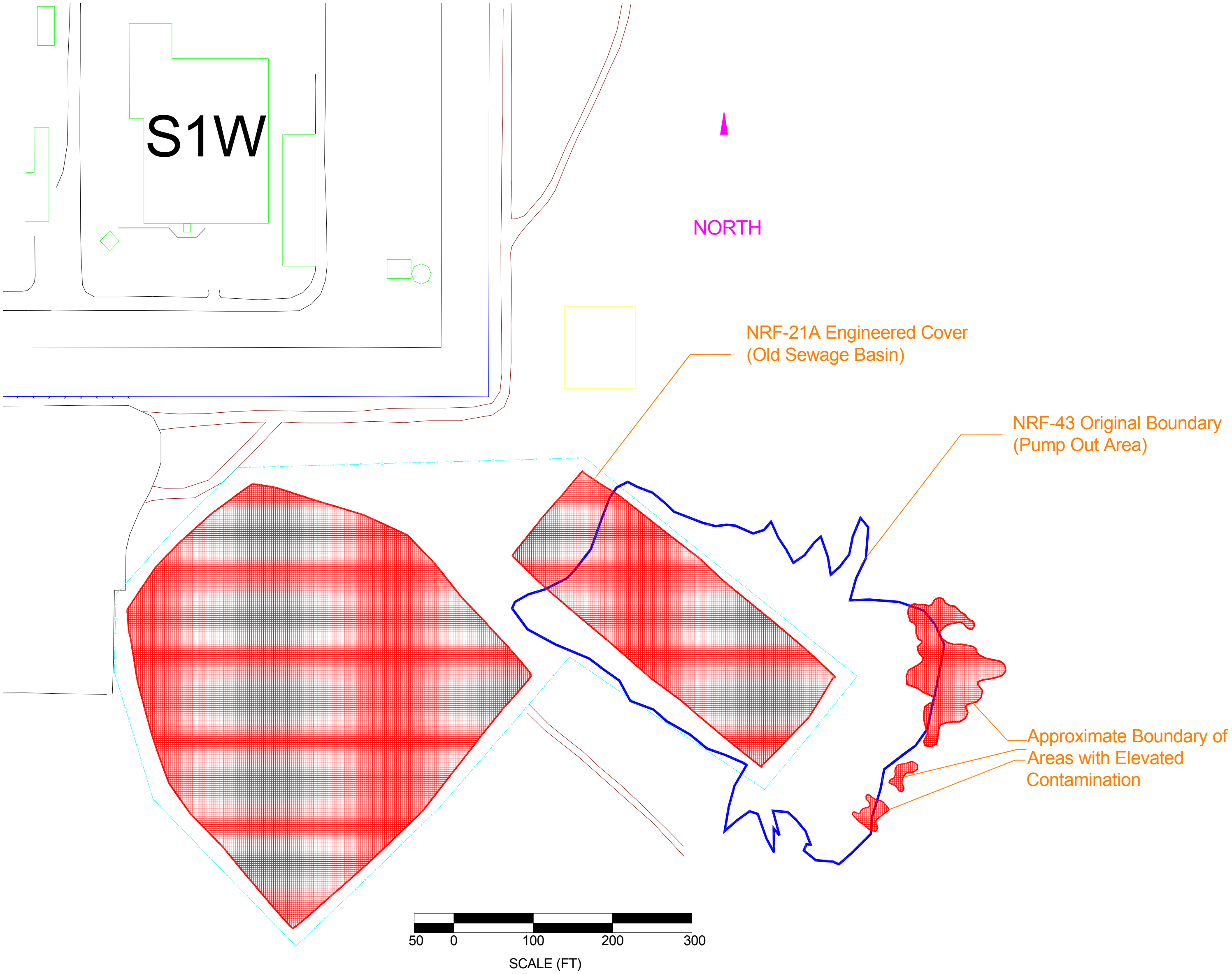


Figure 4-7 Three Areas of Elevated Contamination in NRF-43

The removal option for the NRF-43 site specifically included the following actions:

- Removal of contaminated soil until soil radioactivity levels are less than the cleanup level (16.7 pCi/g for cesium-137);
- Transporting and disposing of contaminated soil at the INL ICDF (a facility away from NRF);
- Collecting verification samples to ensure soil with contamination above the cleanup level has been removed.
- Performing radiological surveys throughout the remediation process;
- Performing site restoration by backfilling the excavated areas with clean fill material and then revegetating the area.

After these actions are complete, the site will retain the NFA designation and will be maintained under institutional controls since residual contamination would remain in the soil less than the CERCLA cleanup level but above levels that would allow unrestricted use. These actions are scheduled to begin in the spring of 2012.

5.0 Progress Since Last Review

The following sections summarize issues identified in the 2006 Five-Year Review and their resolutions.

5.1 2006 Review of Inactive Landfill, NFA and OU 8-08 Remedial Action Sites

5.1.1 Protectiveness Statement

Protectiveness statements were presented in the 2006 Five-Year Review for the NRF OU 8-08 Sites. These protectiveness statements confirmed that visual inspections, soil gas data, and groundwater data indicated that the selected remedies for the Inactive Landfill Areas, the OU 8-08 Remedial Action and the NFA sites appeared to be effective at limiting unauthorized access and excavation, have been effective in achieving RAOs, and appear to successfully limit the migration of contaminants that may be present. Based on this assessment it was concluded that the selected remedies remain protective of human health and the environment.

5.1.2 Issues, Recommendations, and Proposed Actions

The 2006 NRF Five-Year Review provided recommendations pertaining to the landfill covers, the groundwater monitoring network, and the soil gas monitoring probes. These are summarized below.

- Based on data presented in the 2006 Five-Year Review, specifically the relatively infrequent occurrence of organic compounds in the NRF Groundwater Monitoring Network, NRF proposed discontinuing the analysis for Total Organic Halogens (TOX).

  The 2006 Institutional Control Monitoring Report contained the following text: “TOX is used as a screening tool for the presence of halogenated organic compounds in the groundwater. Historically the TOX results have been predominately non-detect with some sample results at or slightly above the method detection limit. The 2006 results were consistent with past results. Non-detect TOX results have correlated closely with the absence of chlorinated organics in groundwater”. Based on this assessment which affirmed the recommendation contained in the 2006 Five-Year Review, TOX analysis of groundwater samples was discontinued starting in May 2008.

- The 2006 Five-Year Review noted that, if supported by future monitoring results, NRF could propose that the sampling frequency of all wells be changed from three times per year to twice per year.

  After continued review of groundwater monitoring results, it was concluded that collecting samples three times per year conservatively detected seasonal and climate based changes in the data and that adopting a bi-annual sampling frequency would not detract from this ability; therefore, the groundwater sample collection frequency was reduced to twice per year at the beginning in May 2007.

- The analysis presented in Appendix A of the 2006 Five-Year Review, indicated that the probable cause for elevated metal constituents in NRF-13 was suspended solids and possibly corrosion of well components. NRF committed to continue to assess the elevated chromium in NRF-13 by collecting additional information from NRF-13 and using this information to make future decisions concerning the well.

  After collecting additional information from NRF-13, by removing and inspecting the riser pipe, measuring line, pump and motor; video logging the well screen, and determining the depth of the borehole, the agencies agreed that a new upgradient well should be constructed to replace NRF-13, NRF-7 and USGS 12.

- NRF committed to continue monitoring NRF-6 for signs of silting, and recondition the well if this condition persisted.

  After reconditioning NRF-6 in late 2003, signs of siltation in the well abated. Between November 2003 and May 2010, the concentration of chromium in well NRF-6 rose from 26 parts per billion (ppb) to 64 ppb. At first, the rise in chromium concentration in NRF-6 occurred with minimal indications of siltation. Beginning in 2009 and continuing into 2010, the difference between filtered and unfiltered chromium results indicating that siltation and/or corrosion issues in the well potentially could be causing the unusually elevated results. This steady rise in concentration and filtered sample results prompted NRF to pull the pump, motor, riser pipe and measuring line from this well and examine the well's component (parts and screen). After performing maintenance on the well in the fall of 2010, chromium concentrations dropped by approximately 15 ppb.

- NRF noted that soil gas monitoring on a quarterly basis no longer appeared to be necessary because of the lack of variability exhibited by the data and the generally low concentrations found to date; therefore, the sampling frequency was to be reduced to semiannual beginning in 2007. NRF committed to reducing sampling frequency to annual after three years of additional sample collection provided the data supports this change.

  Beginning in 2007, soil gas sampling frequency was reduced to twice per year. Recommendations for future changes in sampling frequency are included in this report.

Table 5-1 summarizes recommendations, responses and status of actions taken associated with the 2006 Five-Year Review.

Table 5-1 Summary of Actions Taken Since Last Five-Year Review

Deficiencies, Issue or Commitment from Previous Review	Recommendations /Follow-up	Responsible Party	Action Taken	Date of Action
TOX samples no longer needed	Discontinue TOX if supported by data	NRF	Discontinued collecting TOX	After May 2007
Triannual groundwater sampling frequency no longer required	Reduce sampling frequency to biannual	NRF	Began collecting groundwater samples in May and November each year	Beginning May 2007
Evaluate NRF-13	Examine pulled pump and motor and determine bottom of well	NRF/USGS	Pump and motor were pulled and examined, no problems seen; bottom of well was determined to be 2 feet above original completion depth. Some silt present	November 2006
Meet with Agencies to determine future actions	Continue collecting samples from NRF-13 until suitable upgradient well is completed	NRF/USGS	Samples collected until NRF-16 was approved	December 2010
	Construct new well	NRF/USGS	NRF-16 was constructed in 2009 and accepted for use in 2010	December 2010
	Determine future use of USGS 12 and NRF-7	NRF/Agencies	USGS 12 and NRF-7 were removed from CERCLA monitoring network	December 2010
NRF-6 has had siltation problems	Monitor NRF-6 for continued signs of siltation	NRF/USGS	Trends in constituent concentrations were tracked; Pump and motor was pulled; interior of well inspected; filtered versus unfiltered samples collected	August 2010
Quarterly soil gas sampling frequency no longer required	Reduce sampling frequency to biannual	NRF	Began collecting soil gas samples in May and November each year	Beginning May 2007

6.0 Data Review and Evaluation for Five-Year Review Process

6.1 Summary of Five-Year Review Process

This Five-Year Review is intended to determine whether the selected remedies remain protective of human health and the environment. In addition, the review reassesses the monitoring programs to ensure the correct constituents are being monitored, and to ensure the frequency of sampling and the number of wells are correct. BMPC personnel have reviewed past site information, including sampling data (groundwater, soil gas, and soil moisture), ICMRs, work plans, ARARs, and RODs, and were responsible for drafting this Five-Year Review. NR/IBO, EPA, and IDEQ personnel have also reviewed this information and approved this report. This document is available at the INL Information Repository. Public notification of the Five-Year Review and its coming availability was provided in local newspapers.

6.2 Site Inspections

6.2.1 Overview of Site Inspection Activities

Annual inspections of the various CERCLA sites are required per the O&M plans and results are reported annually in the ICMR. The ICMRs have been issued annually since 2002. In addition, routine surveillances are conducted as a matter of good practice. The following sections discuss results of inspections at the various sites.

6.2.1.1 Inspections of Inactive Landfill Areas

Annual inspections of the landfill covers are required. Annual inspections revealed mostly minor issues. These problems included observation of anthills, rodent holes, badger holes, weed growth, and a small sparse area of vegetation at Site NRF-1.

6.2.1.2 Inspections of No Further Action Sites

Annual inspections of the No Further Action Sites are required. No significant deficiencies were noted during site inspections between 2006 and 2010. Minor deficiencies (e.g., sagging fences and damaged signs) were addressed when they were noted, as soon as circumstances allowed (e.g., weather conditions).

6.2.1.3 Inspections of Remediated Radiological Sites

Formal inspections of the Remediated Radiological Sites began in 2006 and continued each year thereafter as required by the Institutional Control Plan. Most sites have been restored to near pre-work conditions. NRF-17 is presently being used as a staging area for new construction and will be restored to surrounding conditions after project completion. Warning signs for the sites have been in place or are temporarily moved to accommodate the construction work. Residual contamination at NRF-17 is at least 5 feet below the surface

6.2.1.4 Inspection of OU 8-08 Engineered Covers

Required annual inspections of the engineered covers revealed mostly minor issues, which include observation of small erosion channels, anthills, rodent holes, badger holes, and weed growth. Part of the weed growth at engineered cover area NRF-12B/14 included some noxious weeds (Musk thistle and a few Canada thistle plants). The noxious weeds were sprayed or removed during the late spring and summer of each year they were discovered. Follow-up inspections were performed to ensure no additional noxious weeds were present.

Another minor issue observed at NRF-12B/14 was an area of minor subsidence. This area was first noticed in the spring of 2006 where there was a small area of standing water estimated to be 30 ft^2. This area has been frequently inspected over the past several years with no further observance of standing water even after the occurrence of some major storms (one storm event in particular where approximately 1.5 inches of precipitation fell over a three day period at NRF). Furthermore, the area has been evaluated through multiple engineering surveys to see if the condition worsened. Based on three years of surveying data, the entire cover appears to have settled approximately 1 inch and the rate of settling in the subsidence area appears to be about the same as the rest of the cover. The current depth of the subsidence area is 2 to 3 inches.

6.2.1.5 Inspection and Maintenance of NRF Groundwater Monitoring Wells

The United States Geological Survey (USGS), the organization assisting in the collection of NRF groundwater samples, inspects wells during the sampling process. Any problems with the wells are reported to NRF personnel. Maintenance or repairs are handled through the USGS under the cognizance of NRF personnel. NRF personnel also periodically inspect well locations. Since the last Five-Year Review, inspections of the wells have revealed only minor issues (e.g., cracked paint, cracked concrete pad, etc.) which were corrected shortly after discovery. Periodically, other more serious issues (e.g., failed motors) were discovered during scheduled sampling events. In addition to the various inspections discussed above, routine maintenance is performed on one to two NRF wells annually as a best-management-practice. Both emergent and routine maintenance of the NRF wells are discussed below.

6.2.1.5.1 Refurbishment of Well USGS 97

In November 2005, the pump, motor, riser pipe and measuring line were pulled from well USGS 97. An inspection of well part led to replacing 60 feet of riser pipe and measuring line, and replacing the well screen. The well pump, motor and associated wiring were also replaced. Maintenance of USGS 97 was completed in March of 2006 prior to collecting the first trimester sample.

6.2.1.5.2 Refurbishment of Well NRF-13

In the fall of 2006 the pump, motor, riser pipe and measuring line from NRF-13 were pulled as part of an investigation that was looking for potential causes for the elevated levels of chromium found in samples collected from the well. All parts were inspected, but no signs of corrosion were seen. Indications of siltation were present on the well parts (fine film of sediment). A video inspection of the well screen revealed the presence of silt, but no corrosion. The well was reassembled with a new pump and motor.

6.2.1.5.3 Refurbishment of Well NRF-11

While attempting to collect the July 2007 groundwater sample from NRF-11, the USGS noted that the well would not produce water. Later in July, the riser pipe, measuring line, pump and motor were pulled from the well. The motor had burned out, but the rest of the well parts appeared in good condition. The screen was inspected by the USGS using a video camera and was found to be in good condition. The pump and motor were replaced along with the motor to surface wires.

6.2.1.5.4 Refurbishment of Well NRF-8

In July 2008, personnel from the USGS pulled the pump, motor, riser pipe and measuring line from well NRF-8.

Inspection of the riser pipe and measuring line indicated that the lower portion of the measuring line was beginning to show signs of rust. Several segments of both the measuring line and riser pipe were replaced. The pump and motor showed surficial signs of rust which brushed away easily; however, because of the age of both, they were replaced. The well screen looked to be in good condition and the level of the pump appeared appropriate. Rust colored deposits were present just above the pump intake level. Because of the good quality of the water being recovered from the well, no additional actions were taken.

6.2.1.5.5 Refurbishment of Well NRF-10

In July 2008, personnel from the USGS pulled the pump, motor, riser pipe and measuring line from wells NRF-10.

Inspection of the riser pipe and measuring line showed that two sections of the measuring line and one section of the riser pipe showed signs of rust and were replaced. The pump and motor also showed signs of rust and were replaced. Video inspection of the screen showed signs of the build up of silt/iron deposits. Sediments were detected in the bottom of the well but at a depth that would not affect water intake. The original completion depth of the well was 427 feet. The water level in the well was approximately 389 feet while the pump intake was set at approximately 415 feet. Two pieces of metal, probably pieces from the pump or motor were observed at the bottom of the well. The USGS could not recover the pieces; however, leaving them in place should not adversely affect the well’s functioning since the pieces are made of stainless steel and they are approximately 10 feet below the pump and motor. The pieces showed no signs of corrosion.

6.2.1.5.6 Refurbishment of Well USGS 102

During June 2009, the USGS performed routine maintenance on well USGS 102. The pump, motor, riser pipe, and measuring line were removed and inspected. The pump and motor both showed signs of corrosion and were replaced. The riser pipe was in good shape; however, the measuring line, which was composed of galvanized steel, was replaced with a 1-inch stainless steel pipe. The screen was relatively clean.

6.2.1.5.7 Refurbishment of Well NRF-9

On November 3, 2009, the USGS informed NRF that well NRF-9 had failed to operate while attempting to collect the routine second semester sample. Several days later, the USGS pulled the pump, motor, riser pipe and measuring line from the well. It was noted that bolts holding the brackets on the pump had rusted and broke allowing the pump to fall apart and separate from the motor. These components were replaced. One segment of both the riser pipe and measuring line were corroded and were replaced. The screen was found to be in good condition.

6.2.1.5.8 Refurbishment of Well NRF-6

Over the past 7 years, NRF-6 has been refurbished twice. The first time, which was discussed in the 2006 Five-Year Review, occurred in 2004 and was in response to elevated metal results coupled with a failed pump motor. Information gathered from sample results and maintenance activities indicated that sedimentation and corrosion by products (high suspended solids) were the likely cause for the unusually high chromium sample results. To prevent future failure of the pump motor and entrainment of sediments into water samples the pump and motor assembly was placed five feet above its original position when reinserted in the well. Samples collected immediately after refurbishing the well showed results at or below historical levels.

The second refurbishment occurred in 2010. Shortly after the 2004 refurbishment of NRF-6, the concentration of chromium began to rise and hit a maximum in May 2010 as shown in Figure 6-1. During this apparent upward trend in chromium concentrations, NRF began collecting a series of filtered and unfiltered samples to determine if suspended solids entrained in the water samples could account for the apparent increase. The evidence supporting corrosion or siltation as a cause for the observation was inconclusive. In July 2010, the USGS pulled the pump, motor, riser pipe and measuring line from the well again to see if a cause for the trend could be determined. An inspection revealed that all well components were generally in good shape. Although the pump and motor were covered with a thin film of sediment or precipitate, the underlying metal was not corroded. The ends of the stainless steel riser pipe, measuring line sections, and the couplers holding them together were in good shape. Although the pump and motor were generally in good condition, they were replaced.

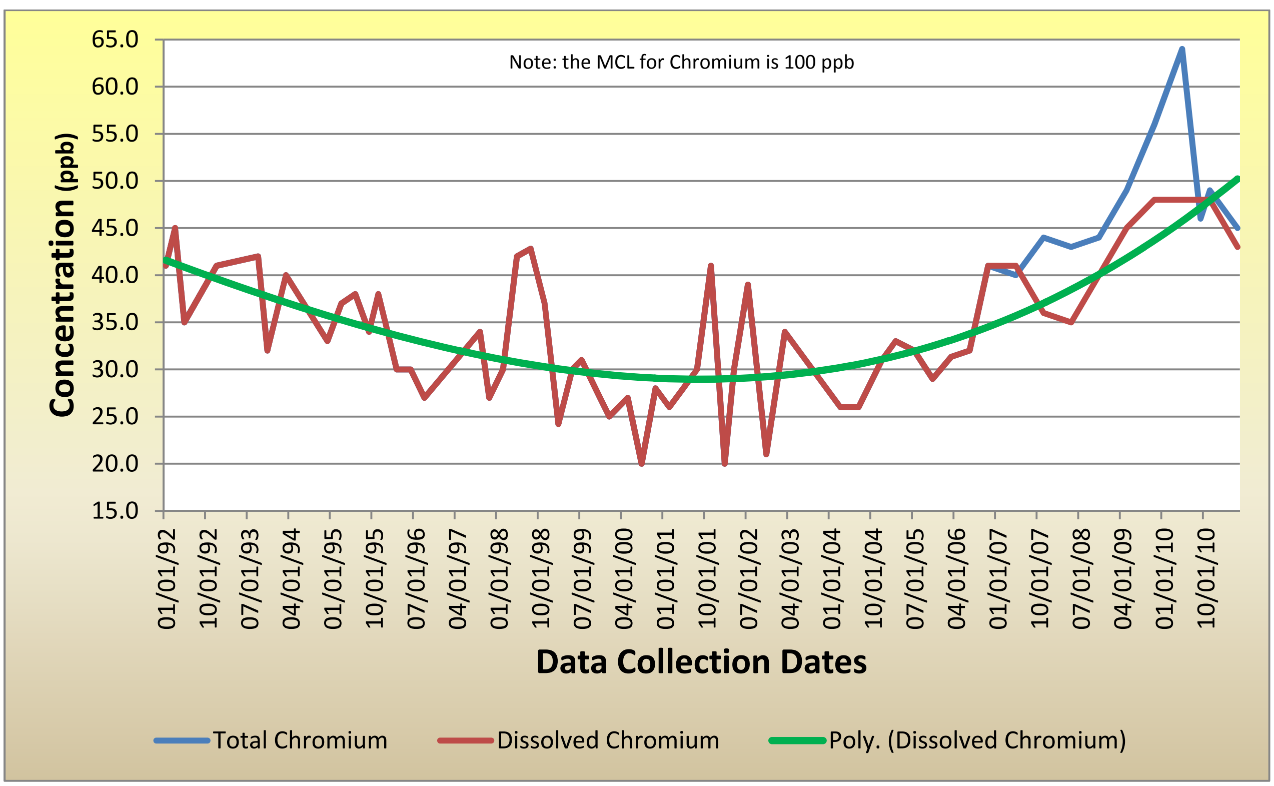


Figure 6-1 Comparison of Dissolved and Total Chromium in NRF-6

The inside of the well was inspected using a video camera. The camera was inserted into the well via a wire-line to a depth of 414 feet, which is three feet above its original completion depth of 417 feet. A rust colored build-up covering portions of the well screen both above and below the water table was visible. This build-up should not diminish the well's effectiveness to monitor the aquifer at this location. No evidence of corrosion of the well screen could be seen.

The USGS brought a drill rig to NRF-6 and brushed the screen. Air and water was used to surge the well and remove sediment built-up in the bottom of the borehole and material removed from the screen. After several hours of surging, the well was reassembled and a sample collected. The post reconditioning samples and routine samples collected in November 2010 and May 2011 showed a slight drop in chromium concentration.

6.2.1.6 Inspections of Soil Gas Monitoring Probes

No problems were noted with any of the soil gas monitoring probes during annual inspections.

6.2.1.7 Inspections of Soil Moisture Neutron Access Tubes

No deficiencies were noted with the soil moisture neutron access tubes with the exception of occasional stiff locks on some of the access tube covers. The padlocks were either lubricated or replaced as necessary. In addition, padlock covers have been installed to minimize the entry of dust and precipitation into the padlock.

6.3 Data Review

6.3.1 Monitoring Program Overview

NRF collects various types of data including groundwater, soil gas, surface soil gas emissions, and soil moisture. These data are used to assess the effectiveness of remedies that have been implemented and to determine if operations at NRF are having an adverse effect on the environment. Surface soil gas emissions data for the three inactive landfill cover areas are acquired during an annual survey using a portable meter. No volatile organic compounds have been detected from these surveys. The following sections discuss the results of the other monitoring performed at NRF. A summary of yearly monitoring results is included in the annual NRF Environmental Monitoring Report (BBI, 2006 to 2010).

6.3.2 Groundwater

6.3.2.1 Analysis of Groundwater Monitoring Data

Groundwater monitoring data collected from monitoring wells located around NRF were analyzed. This analysis covers the period from the well's construction or initial inclusion into the monitoring network through November 2010.

Since the last Five-Year Review, the configuration of the NRF Groundwater Monitoring Network has changed. Through November 2006, NRF collected groundwater data from 13 groundwater wells located around the site as shown in Figure 3-7. After November 2006, groundwater samples from NRF-13 were no longer used to evaluate NRF groundwater quality for CERCLA compliance. The same was true for samples collected from USGS 12 and NRF-7 after November 2010 when NRF-16 replaced these wells. Between 2007 and November 2010 data from the various NRF monitoring wells were placed into one of four groups to facilitate evaluation. These included the Regional Upgradient Group representing upgradient background water quality; Local Downgradient and Regional Downgradient Groups representing downgradient water quality and the Effluent System Group representing water quality associated with discharges to the IWD (Refer to Table 3-1).

Historically, upgradient water quality relative to NRF was not well defined. In 1991, NRF-7 was constructed at a location intended to monitor water released from the IWD. In 1996, however, based on water quality characteristics, the data obtained from NRF-7 were included with USGS 12 to become the Regional Upgradient Group. Since 1991, NRF-7 was not considered to be an ideal upgradient monitoring well, because it produced water at only 1 to 3 gallons per minutes, which makes samples collected from this well susceptible to sediment cross-contamination. During the sampling process, the water level in the well falls to near the intake depth. This in turn allows water to cascade down the well bore from the level of the regional aquifer to the level of the pump (approximately 20 feet). The cascading water creates turbulence which in turns loosens sediments lodged in fractures and pores in the aquifer material. Some of the dislodged fines potentially can be pulled into the pump along with the water being sampled. If the sediment is analyzed along with the water, anomalously high results can be generated. Additionally, this well is not hydraulically located upgradient to NRF. Finally, NRF-7 is believed by NRF and USGS scientists to contain mostly "old water", because it is nearly unaffected by anthropomorphic influences, (e.g., tritium produced by past above ground nuclear testing at the Nevada Test Site and other world sites) unlike other nearby wells, including upgradient wells, which are affected by anthropomorphic influences. The concentrations of key ionic constituents (e.g., calcium, chloride, sodium, nitrates, etc.) are anomalously low compared to corresponding concentrations from other area wells. Although the exact age of the water is not known, it is believed to be greater than 50 years old and maybe much older.

USGS 12 is not considered an ideal upgradient well because it is not hydraulically upgradient to NRF, it is completed at a depth that may not represent water sampled at NRF, and the well was not completed using modern construction standards. With the construction of NRF-16 to replace NRF-7 and USGS 12, the Regional Upgradient Group now consists of NRF-16 only; however, because this well was not completed until late 2009 and accepted as a CERCLA monitoring well until late 2010, the evaluation presented in this review uses data from NRF-7 and USGS 12 to calculate background concentrations.

Until November 2006, NRF-6 and NRF-13 were part of the Effluent System well group. NRF-6 is known to monitor effluent from the IWD. Although NRF-13 was originally constructed as an upgradient well, it was included as an Effluent System well because its results did not reflect upgradient quality water, but rather properties similar to NRF-6 results. Because of the problems with NRF-13 noted in the 2006 Five-Year Review, NRF-13 was removed as a CERCLA monitoring well and data from this well are not used nor discussed in this report except for very limited and specific purposes (e.g., creation of water table maps).

6.3.2.2 Inorganic Data Review

Analysis of inorganic data included evaluating monitoring results for trends, and comparing upgradient background water quality to downgradient and Effluent System water quality. Because organic constituents were seldom detected in the groundwater, they are discussed separately in Section 6.3.2.3.

For purposes of this groundwater analysis, several key constituents were considered. Key constituents included in the assessment were based on the following criteria:

- Contaminants of concern (COCs) as described in the RODs for the OUs 8-05/06 and 8-08 sites that are routinely measured due to the potential for detection.
- Constituents detected in the soil during confirmation sample analysis that were also consistently detected in groundwater samples and were known to have been released at NRF in the past. These constituents include chromium.
- Constituents that are good geochemical indicators. This group includes calcium, chloride, sodium, and tritium. These constituents generally do not interact with the aquifer matrix material, and therefore reflect important aquifer properties such as dispersion and groundwater flow paths.
- Constituents that are consistently present in NRF groundwater samples and act as geochemical indicators. This group includes aluminum, iron, manganese, and nickel. These constituents may interact with the aquifer matrix.

This groundwater analysis compared long-term monitoring results to two benchmarks. These benchmarks were Federal drinking water guidelines and local background concentrations. The purpose of comparing the results to Federal drinking water guidelines was to determine potential impacts to aquifer with respect to known Federal standards. Comparison of NRF groundwater quality to local background concentrations was intended to assess the relative impact that NRF operations have had on the aquifer. The results of these comparisons were used to assess whether the selected remedies are functioning correctly and effectively.

Regional background (or regional upgradient) concentrations were estimated using data from the former Regional Upgradient wells NRF-7 and USGS 12. For this report, all data except for the statistical outliers from NRF-7, were averaged with corresponding data from USGS 12 for all constituents. If a given constituent result was reported as less than the method detection limit (MDL), the corresponding MDL value was used to calculate the average. The excluded outliers included data with a high MDL compared to other values for that constituent. For example, data reported as less than the MDL of 10 parts per billion (ppb) for antimony, were considered outliers since other results from the wells reported antimony at a much lower concentrations or at lower MDLs (e.g., 0.07 ppb). If included, the higher MDL of 10 ppb would bias the calculated background concentration. This method of calculating background concentrations produces more conservative results. Similar outliers were found with arsenic, beryllium, cadmium, copper, lead, manganese, nickel, silver, and thallium. In addition, NRF-7 data collected from November 2002 to March 2004 were considered outliers for aluminum, chromium, iron, manganese, calcium, potassium, and magnesium due to sediments in the samples as indicated by elevated turbidity measurements (see Appendix A of the 2006 Five-Year Review for additional discussion of this event). Table 6-1 shows the most current estimate of regional background concentrations. In general, the background concentrations calculated for this Five-Year Review compare very favorably with those calculated in the 2006 Five-Year Review, except that the statistical uncertainty (i.e., standard deviations) associated with the 2011 background concentrations are generally lower, and in some cases, significantly lower (e.g., calcium, magnesium, sodium and chloride).

The mean concentrations for each well and well group for all NRF inorganic groundwater constituents were compared to background concentrations and Maximum Contaminant Levels (MCLs; 40 CFR 141, 143) in Table 6-2. None of the constituent concentrations exceeded primary Federal MCLs, and with the exception of iron in two wells (NRF-6 and 7) and chloride in one well (NRF-6), none of the mean concentrations exceeded secondary Federal MCLs.

NRF-6 is located immediately downgradient of the IWD; therefore, sample results from this well reflect contributions from the IWD effluent. NRF-7 is a low producing well (1 to 3 gallons per minute), that produces results that sometimes can be influenced by the presence of fine sediments, hence the elevated iron results.

The values in Table 6-2 are color coded with respect to regional upgradient concentrations. Values highlighted in yellow exceed background concentrations by 1 to 2 standard deviations. Values highlighted in red exceed background concentrations by greater than 3 standard deviations. Orange values are mid way between these two.

A quick glance at this table reveals that red values are associated with specific conductance and ionic salt constituents including calcium, chloride, magnesium, potassium, sodium and sulfate in NRF-6 and other wells which are elevated compared to upgradient concentrations. The causes for these observations are discussed below.

Sodium chloride is used to create the regeneration solution for current water softening processes at NRF. As a result of the softening cycle, the solution discharged to the IWD contains elevated levels of calcium, chloride, magnesium, and sodium ions compared to upgradient (background) groundwater. These elevated concentrations of calcium, chloride, magnesium, and sodium ions are reflected in the groundwater after the IWD effluent percolates through the ground to the aquifer below. The elevated concentration of potassium ions in the aquifer is likely due to exchange reactions occurring between calcium ions and magnesium ion-rich IWD effluent as it percolates through sediments and rocks to the aquifer below. In this process, IWD effluent (now groundwater recharge) is slightly enriched in potassium ions while the surrounding aquifer material is enriched in calcium and magnesium ions.

Prior to the mid-1990s, NRF used sulfuric acid as the regeneration solution for the water softening process such that elevated levels of neutralized sulfate ion-rich wastewater was discharged to the IWD. This resulted in the perched water located below the IWD containing a sulfate ion concentration in excess of 350 milligrams per liter (mg/L). The concentration of sulfate ions that is currently present in perched water beneath the IWD is believed to still contain elevated levels of residual sulfate ions. The fact that the concentration of sulfate ions currently in NRF-6 water samples is higher than the concentration being discharged to the IWD suggests that water containing elevated concentrations of sulfate ions is slowly being released as perched water drains to the aquifer below.

The concentrations of ionic constituents discussed above, including chloride and sulfate in the Downgradient wells are slightly elevated compared to corresponding concentrations in the Upgradient wells reflecting the extended influence from the IWD.

Downgradient wells USGS 97, -98, and -99 contain zinc concentrations that are elevated compared to background but are significantly below the MCL. Zinc levels in these wells are associated with well construction issues rather than groundwater issues. This conclusion is supported by the observation that the mean zinc concentration in USGS 98 was approximately 150 ppb prior to the replacement of the pump, motor, and well screen in this well early in 2005 compared to a mean of approximately 11 ppb after the refurbishment. Well components and construction history for USGS 97 and USGS 99 are similar to that of USGS 98.

Table 6-2 shows tritium averages since the collection of data began (historical) and the tritium averages for the past five years (Five-Year). The historical levels of tritium in NRF-9, NRF-10, and NRF-11 were elevated with respect to background, although significantly lower than the

MCL. These wells are located downgradient of the S1W Leaching Beds/Pit (NRF-14 and NRF-12B). It is believed that residual contamination from historical releases to these sites is responsible for the elevated tritium. Because of these three wells, the historical average in the Local Downgradient Group is also elevated. The Five-Year tritium averages for NRF-9, NRF-10, and NRF-11 are significantly lower than their historical counterparts and are only slightly above background concentrations reflecting the results of the natural decay of the tritium.

The presence of elevated nitrate levels in most of the downgradient wells indicates the influence of the NRF sewage lagoons. These lagoons are nearly 50 years old and are known to leak. All nitrate concentrations are significantly below primary MCL levels.

The average concentration of chromium in NRF-6 exceeded the upgradient concentration by a factor of approximately four. The observed trend of chromium concentration in NRF-6 has been investigated and is discussed in greater detail in Section 6.3.2.4.

6.3.2.3 Organic Data Review

During the 2006 to 2011 period, groundwater samples were analyzed for selected volatile and semi-volatile compounds once each year (refer to Table 4-1). Most of the organic compounds that were analyzed for were not detected in NRF water samples. Many of the compounds that were detected occurred at very low concentrations and were likely due to cross-contamination. Included in this list are bis(2-ethylhexyl)phthalate (related to plastics); butylated hydroxytoluene (a preservative for food and cosmetics); acetone (a laboratory solvent); and benzene, naphthalene and toluene (combustion by-products). Of the remaining compounds detected during 2006 through 2011, only bromocil and tetrachloroethylene found consistently in NRF-6 samples at low concentrations (see Table 6-3), could be related to past operations at NRF. Bromocil is an herbicide that is used at NRF for weed control. Tetrachloroethylene is a solvent used in industry and is detected as soil vapor from all three abandoned NRF landfills. The reason for its presence in NRF-6 is unknown, but historically, it may have been inadvertently disposed of in drains connected to the IWD. No hydrologic connection between the abandoned landfills and groundwater sampled by NRF-6 is known to exist. There is no evidence of a pattern of consistent or wide-spread contamination of the aquifer associated with any organic compound.

6.3.2.4 Data Trends and their Implications

Table 6-4 compares water quality averages between the four well groups for ten key inorganic constituents (a total of 40 comparisons) for the periods 1996 through 2000, 2001 through 2005, and 2006 through 2010. These comparisons are intended to provide an overview of trends in constituent concentrations at NRF. Table 6-4 shows that group mean concentrations for many of the key constituents have dropped since 1996 (e.g., the Regional Upgradient aluminum concentration of 103 ppb compared to a concentration of 39 ppb). Of the 40 comparisons made (four well groups times 10 constituents), the mean concentrations for 26 comparisons have declined (a few more than in previous reviews), seven rose (two only slightly), and seven remained unchanged.

Where increases were noted, they were relatively small with the exception of calcium, chromium, sodium, and chloride in the Effluent System well group. The increase in the ionic salt concentrations is primarily due to water softening operations at NRF as discussed in Section 6.3.2.2 coupled with a decrease in the volume of water discharged to the IWD from other sources which are not associated with water softening operations. A recent change to more efficient water softening units is expected to reduce the overall amount of salt used during future operations at NRF. In summary, this table shows that the relative magnitude of mean constituent concentrations is nearly the same (or slightly lower) compared to those described in the 2001 Five-Year Review (1996 to 2001) and supports the conclusion that past or present operations at NRF do not substantially impact the quality of the SRPA. Table 6-4 also shows that the average activity levels for tritium in all wells is lower over the past five years compared to historical averages demonstrating the effects of radioactive decay.

Table 6-1 Estimated NRF Background Groundwater Concentration

Constituent	pH	Spec. Cond.	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium
Units		µS/cm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
MCL	6.5 to 8.5 (a)	(b)	200(a)	6	10	2000	4	5	100
Mean	8.0	397	<(c) 63	<<(c) 0.44	<(c) 3	< 101	<<(c) 0.9	<<(c) 0.5	9
Std. Dev	0.2	11	43	0.31	1	21	0.7	0.4	3
Max	8.7	265	200	<< 1.10	5	100	2.0	<< 1.0	15
Min	8.0	210	< 27	0.17	1	51	< 0.5	0.1	1

Constituent	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium
Units	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
MCL	1000(a)	300 (a)	15(d)	50 (a)	2	(b)	50	100 (a)	2
Mean	<<(c) 3	138	<(c) 1.8	< 6	<<(c) 0.1	<(c) 5.9	< 4	<<(c) 1.1	<<(c) 0.1
Std. Dev	2	171	0.9	5	0.0	2.7	2	0.3	0.2
Max	10	620	4.0	20	0.2	13.0	5	1.0	<< 0.5
Min	1	<70	0.4	3	0.0	1.0	1	0.2	0.0

Constituent	Zinc	Calcium	Potassium	Magnesium	Sodium	Chloride	Sulfate	NO_2	$NO_2 + NO_3$
Units	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
MCL	5000 (a)	(b)	(b)	(b)	(b)	250000 (a)	250000 (a)	1000	10000
Mean	<<(c) 12	44210	2583	14614	11659	17152	22766	<< 3	1115
Std. Dev	8	2530	199	382	1056	548	3511	1	72
Max	37	31500	3300	9800	11500	6700	35000	3	720
Min	3	21000	2720	8300	4500	4000	13000	2	380

Constituent	Strontium-90	Nickel-63	Cesium-137	Cobalt-60	Tritium
Units	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L
MCL	8.0	(b)	(b)	(b)	20000
Mean	0.09	0.31	0.14	0.44	27
Std. Dev	0.11	0.74	0.34	1.28	16
Max	0.34	1.90	0.71	3.60	57
Min	0.00	-1.20	-0.55	-2.00	-29

< A significant portion of the data used to create this value are at or below the MDL
<< Most of the data used to create this value are at or below the MDL
(a) Secondary MCL (this is not an enforceable value, but rather a recommendation)
(b) MCL not determined
(c) Two or more MDLs were used in the creation of this number

The 2006 to 2010 Local Downgradient Group average is lower in concentration for nine of the ten key constituents compared to the 1996 to 2000 Local Downgradient Group average for the same constituents. The only exception is sodium. These observations suggests that water quality downgradient of NRF is generally improving.

Data derived from individual NRF groundwater monitoring wells contained within the various groups for ten selected key constituents (discussed above) were evaluated for trends. This evaluation shows that a majority of the key constituents are stable or trending downward in the

Table 6-2 Comparison of MCL and Background Groundwater Concentrations to Individual Wells and Well Groups

Constituent / Units	pH	Spec. Cond. µS/cm	Aluminum ppb	Antimony ppb	Arsenic ppb	Barium ppb	Beryllium ppb	Cadmium ppb	Chromium ppb
MCL	6.5 to 8.5 (a)	(b)	200(a)	6	10	2000	4	5	100
Background	8.0 ± 0.2	397 ± 11	63 ± 43	0.44 ± 0.31	3.0 ± 1.4	101 ± 21	0.9 ± 0.7	0.5 ± 0.4	9 ± 3
NRF-6	7.8 ± 0.2	1589 ± 350	52 ± 37	0.49 ± 0.47	4.2 ± 0.9	106 ± 39	0.9 ± 0.7	0.5 ± 0.3	34 ± 9
NRF-7	8.3 ± 0.2	246 ± 9	114 ± 97	0.44 ± 0.35	3.1 ± 1.5	70 ± 21	0.9 ± 0.7	0.4 ± 0.4	12 ± 2
NRF-8	7.8 ± 0.2	569 ± 19	51 ± 39	0.48 ± 0.84	3.3 ± 1.5	127 ± 8	0.9 ± 0.7	0.4 ± 0.2	8 ± 1
NRF-9	7.8 ± 0.2	615 ± 19	58 ± 38	0.51 ± 1.02	3.3 ± 1.5	137 ± 7	0.9 ± 0.7	0.4 ± 0.2	11 ± 1
NRF-10	7.8 ± 0.2	582 ± 22	140 ± 102	0.63 ± 1.35	3.5 ± 1.7	136 ± 8	0.9 ± 0.7	0.4 ± 0.2	14 ± 3
NRF-11	7.8 ± 0.2	603 ± 24	55 ± 35	0.46 ± 0.75	4.9 ± 3.0	138 ± 15	0.9 ± 0.6	0.5 ± 0.2	17 ± 4
NRF-12	7.8 ± 0.2	624 ± 51	56 ± 37	0.40 ± 0.51	3.3 ± 1.5	149 ± 14	0.9 ± 0.6	0.4 ± 0.2	18 ± 4
USGS-12	7.8 ± 0.1	545 ± 43	49 ± 41	0.43 ± 0.33	3.0 ± 1.4	129 ± 18	0.9 ± 0.6	0.5 ± 0.3	7 ± 1
USGS-97	7.9 ± 0.1	584 ± 18	54 ± 39	0.49 ± 0.56	2.9 ± 1.4	127 ± 16	0.9 ± 0.6	0.6 ± 0.3	7 ± 1
USGS-98	7.9 ± 0.1	415 ± 21	54 ± 37	0.41 ± 0.35	2.9 ± 1.5	51 ± 8	0.9 ± 0.7	0.5 ± 0.3	6 ± 1
USGS-99	7.9 ± 0.1	526 ± 13	51 ± 42	0.41 ± 0.35	4.1 ± 3.2	105 ± 6	0.9 ± 0.7	0.6 ± 0.3	6 ± 1
USGS-102	7.9 ± 0.1	568 ± 20	48 ± 36	0.41 ± 0.34	2.9 ± 1.4	114 ± 10	0.9 ± 0.6	0.5 ± 0.3	7 ± 1
Regional Upgradient	8.0 ± 0.3	404 ± 153	79 ± 79	0.44 ± 0.34	3.0 ± 1.4	101 ± 36	0.9 ± 0.6	0.5 ± 0.3	9 ± 3
System Effluent	7.8 ± 0.2	1589 ± 350	52 ± 37	0.49 ± 0.47	4.2 ± 0.9	106 ± 39	0.9 ± 0.7	0.5 ± 0.3	34 ± 9
Local Downgradient	7.8 ± 0.2	591 ± 35	66 ± 60	0.48 ± 0.86	3.6 ± 2.0	133 ± 15	0.9 ± 0.6	0.5 ± 0.2	12 ± 5
Regional Downgradient	7.9 ± 0.1	509 ± 72	53 ± 39	0.44 ± 0.43	3.4 ± 2.4	97 ± 32	0.9 ± 0.6	0.5 ± 0.3	6 ± 1

Constituent / Units	Copper ppb	Iron ppb	Lead ppb	Manganese ppb	Mercury ppb	Nickel ppb	Selenium ppb	Silver ppb	Thallium ppb
MCL	1000(a)	300 (a)	15(d)	50 (a)	2	(b)	50	100 (a)	2
Background	3 ± 2	138 ± 171	1.8 ± 0.9	6 5	0.1 ± 0.0	5.9 2.7	4 2	1.1 0.3	0.15 0.2
NRF-6	3 ± 2	465 ± 474	1.8 ± 0.9	6 ± 4	0.1 ± 0.1	11.5 ± 7.8	4 ± 1	1.0 ± 0.7	0.39 ± 1.4
NRF-7	4 ± 4	310 ± 293	1.8 ± 1.0	8 ± 6	0.1 ± 0.1	8.3 ± 3.5	4 ± 2	1.1 ± 0.7	0.14 ± 0.2
NRF-8	4 ± 3	69 ± 44	2.1 ± 1.0	3 ± 4	0.1 ± 0.1	4.5 ± 3.3	5 ± 0	1.1 ± 0.9	0.11 ± 0.2
NRF-9	3 ± 3	78 ± 43	2.0 ± 0.9	4 ± 4	0.1 ± 0.1	4.3 ± 3.4	5 ± 1	1.1 ± 0.9	0.11 ± 0.2
NRF-10	3 ± 3	236 ± 215	2.1 ± 0.9	6 ± 4	0.1 ± 0.1	12.4 ± 8.3	5 ± 1	1.1 ± 0.9	0.10 ± 0.1
NRF-11	4 ± 3	79 ± 53	2.0 ± 0.9	4 ± 4	0.1 ± 0.1	7.1 ± 2.8	5 ± 1	1.2 ± 0.9	0.26 ± 0.9
NRF-12	4 ± 3	86 ± 54	2.0 ± 0.9	4 ± 4	0.1 ± 0.1	8.0 ± 5.9	4 ± 1	1.1 ± 0.9	0.10 ± 0.2
USGS-12	2 ± 1	59 ± 42	1.7 ± 0.9	5 ± 5	0.1 ± 0.1	3.2 ± 3.1	4 ± 1	0.8 ± 0.2	0.15 ± 0.2
USGS-97	3 ± 2	66 ± 55	2.2 ± 0.9	6 ± 5	0.1 ± 0.1	3.2 ± 3.1	4 ± 1	1.1 ± 0.7	0.18 ± 0.2
USGS-98	3 ± 2	131 ± 110	3.9 ± 2.4	7 ± 4	0.1 ± 0.1	2.9 ± 3.1	4 ± 2	1.1 ± 0.7	0.16 ± 0.2
USGS-99	3 ± 1	109 ± 89	2.2 ± 0.9	5 ± 5	0.1 ± 0.1	3.1 ± 3.0	4 ± 2	1.1 ± 0.7	0.14 ± 0.2
USGS-102	3 ± 3	86 ± 91	1.7 ± 0.9	5 ± 5	0.1 ± 0.1	3.1 ± 3.0	4 ± 1	1.1 ± 0.8	0.13 ± 0.2
Regional Upgradient	3 ± 3	179 ± 239	1.8 ± 0.9	7 ± 5	0.1 ± 0.1	5.8 ± 4.2	4 ± 2	0.9 ± 0.5	0.15 ± 0.2
System Effluent	3 ± 2	465 ± 474	1.8 ± 0.9	6 ± 4	0.1 ± 0.1	11.5 ± 7.8	4 ± 1	1.0 ± 0.7	0.39 ± 1.4
Local Downgradient	3 ± 3	104 ± 116	2.0 ± 0.9	4 ± 4	0.1 ± 0.1	6.5 ± 5.8	4 ± 1	1.1 ± 0.9	0.14 ± 0.4
Regional Downgradient	3 ± 2	102 ± 91	2.8 ± 1.8	6 ± 5	0.1 ± 0.1	3.1 ± 3.0	4 ± 2	1.1 ± 0.7	0.16 ± 0.2

(a) Secondary MCL (this is not an enforceable value, but rather a recommendation)
(b) MCL not determined
(d) Action Level

Between 1 and 2 std. dev. greater than background
Between 2 and 3 std. dev. greater than background
Greater than 3 std. dev. from background

Group Configuration –

Regional Upgradient Group	USGS 12 and NRF-7
Effluent System Group	NRF-6
Local Downgradient Group	NRF-8 through 12 and USGS 102
Regional Downgradient Group	USGS 97, -98, and -99

Note: Table constituents are arranged by metals, salts, nutrients, and then radionuclides.
Averages are for the period 1989 to present for wells USGS 12, 97, 98, 99, and 102; 1991 to present for NRF-6 and 7; and 1996 to present for NRF-8, 9, 10, 11, 12, and 13.

Table 6-2 Comparions of MCL and Background Groundwater Concentrations to Individual Wells and Well Groups (Continued)

Constituent Units	Zinc ppb	Calcium ppb	Potassium ppb	Magnesium ppb	Sodium ppb	Chloride ppb	Sulfate ppb	NO_2 ppb	$NO_2 + NO_3$ ppb
MCL	5000 (a)	(b)	(b)	(b)	(b)	250000 (a)	250000 (a)	1000	10000
Background	12 ± 8	44210 ± 2530	2583 ± 199	14614 ± 382	11659 ± 1056	17152 ± 548	22766 ± 3511	3 ± 1	1115 ± 72
NRF-6	12 ± 8	130144 ± 25441	5208 ± 1009	34431 ± 5190	123192 ± **47366**	301485 ± 133391	150094 ± 61593	3 ± 2	1834 ± 173
NRF-7	13 ± 9	26174 ± 2807	3067 ± 276	9213 ± 447	8962 ± 780	5017 ± 283	13967 ± 776	3 ± 1	464 ± 45
NRF-8	11 ± 7	68267 ± 3936	2291 ± 185	21923 ± 1411	15307 ± 987	32902 ± 3352	33431 ± 1984	3 ± 2	1913 ± 210
NRF-9	12 ± 7	72273 ± 4184	2485 ± 265	22496 ± 1334	18187 ± 1281	44702 ± 3965	42188 ± 3793	3 ± 2	2183 ± 180
NRF-10	11 ± 8	68254 ± 4516	2497 ± 206	21953 ± 1551	15773 ± 1543	41951 ± 3787	38898 ± 3286	4 ± 2	1802 ± 170
NRF-11	12 ± 7	69423 ± 4384	2541 ± 223	21883 ± 1381	18779 ± 1564	43117 ± 3878	40349 ± 3756	4 ± 3	1923 ± 213
NRF-12	12 ± 7	70717 ± 5903	2582 ± 231	22138 ± 2076	20177 ± 2516	48243 ± 9025	45672 ± 8886	4 ± 3	1893 ± 221
USGS-12	12 ± 6	62135 ± 5418	2037 ± 226	19829 ± 1832	14251 ± 2189	28074 ± 8992	30444 ± 5029	3 ± 2	1672 ± 406
USGS-97	5 ± 1	68104 ± 4347	2157 ± 234	22308 ± 1451	15181 ± 1791	33189 ± 2742	34283 ± 1898	3 ± 2	2012 ± 162
USGS-98	11 ± 4	47452 ± 3701	2142 ± 233	18198 ± 1463	9915 ± 1123	14369 ± 777	21533 ± 822	3 ± 1	1124 ± 120
USGS-99	113 ± 26	61586 ± 3093	1818 ± 185	21652 ± 907	14023 ± 1677	22008 ± 1899	26854 ± 1428	3 ± 1	1683 ± 145
USGS-102	13 ± 8	67814 ± 4491	2228 ± 233	21671 ± 1467	14443 ± 1635	31880 ± 2948	33286 ± 2322	3 ± 3	1892 ± 174
Regional Upgradient	12 ± 8	44722 ± 18579	2546 ± 575	14746 ± 5500	11742 ± 3133	17485 ± 13285	22747 ± 9041	3 ± 2	1118 ± 674
System Effluent	12 ± 8	130144 ± 25441	5208 ± 1009	34431 ± 5190	123192 ± 47366	301485 ± 133391	150094 ± 61593	3 ± 2	1834 ± 173
Local Downgradient	12 ± 7	69456 ± 4836	2437 ± 259	22009 ± 1562	16914 ± 2683	39822 ± 7847	38520 ± 6360	3 ± 3	1929 ± 223
Regional Downgradient	81 ± 53	59002 ± 9385	2037 ± 268	20737 ± 2217	13078 ± 2739	23528 ± 7950	27880 ± 5390	3 ± 1	1608 ± 392

Constituent Units	Strontium-90 pCi/L	Nickel-63 pCi/L	Cesium-137 pCi/L	Cobalt-60 pCi/L	Tritium (Historical) pCi/L	Tritium (Five-Year) pCi/L
MCL	8	(b)	(b)	(b)	20,000	20,000
Background	0.09 ± 0.11	0.31 ± 0.74	0.14 ± 0.34	0.44 1.28	26.56 ± 16.20	26.56 16.20
NRF-6	0.11 ± 0.18	0.17 ± 1.13	0.17 ± 0.53	0.01 ± 0.91	60.20 ± 19.30	40.66 ± 9.11
NRF-7	0.10 ± 0.15	0.22 ± 0.87	0.08 ± 0.39	0.23 ± 0.42	2.67 ± 2.99	2.56 ± 3.11
NRF-8	0.10 ± 0.16	0.39 ± 0.69	0.08 ± 0.43	-0.66 ± 1.07	44.45 ± 10.50	35.48 ± 8.81
NRF-9	0.12 ± 0.18	0.34 ± 0.85	0.10 ± 0.54	-0.10 ± 0.44	79.37 ± 27.52	48.98 ± 14.88
NRF-10	0.07 ± 0.11	4.08 ± 2.01	0.10 ± 0.41	-0.05 ± 0.96	109.49 ± 33.87	72.08 ± 16.62
NRF-11	0.07 ± 0.10	1.89 ± 0.95	0.07 ± 0.33	0.23 ± 0.29	139.27 ± 86.55	42.87 ± 13.17
NRF-12	0.09 ± 0.17	-0.10 ± 0.39	0.22 ± 0.41	-0.14 ± 1.13	49.66 ± 14.67	32.26 ± 8.30
USGS-12	0.06 ± 0.12	0.39 ± 0.60	0.17 ± 0.33	-0.10 ± 0.91	49.67 ± 16.03	31.27 ± 7.21
USGS-97	0.08 ± 0.17	-0.18 ± 1.01	0.10 ± 0.35	-0.44 ± 1.28	43.04 ± 12.38	28.76 ± 6.82
USGS-98	0.03 ± 0.12	0.34 ± 0.66	-0.07 ± 0.27	0.00 ± 0.22	15.20 ± 6.43	10.10 ± 4.99
USGS-99	0.05 ± 0.15	0.64 ± 1.03	0.05 ± 0.32	0.86 ± 1.03	26.93 ± 8.12	21.83 ± 12.92
USGS-102	0.09 ± 0.11	0.14 ± 0.52	0.30 ± 0.60	0.39 ± 2.26	45.51 ± 13.16	33.54 ± 10.84
Regional Upgradient	0.08 ± 0.13	0.30 ± 0.74	0.12 ± 0.36	0.07 ± 0.71	28.50 ± 26.40	18.35 ± 15.69
System Effluent	0.11 ± 0.18	0.17 ± 1.13	0.17 ± 0.53	0.01 ± 0.91	60.20 ± 19.30	40.66 ± 9.11
Local Downgradient	0.09 ± 0.14	1.26 ± 1.87	0.15 ± 0.47	-0.04 ± 1.22	77.80 ± 54.24	44.20 ± 18.32
Regional Downgradient	0.06 ± 0.15	0.28 ± 0.96	0.03 ± 0.32	0.17 ± 1.14	28.27 ± 14.62	19.09 ± 9.77

(a) Secondary MCL (this is not an enforceable value, but rather a recommendation) — Between 1 and 2 std. dev. greater than background
(b) MCL not determined — Between 2 and 3 std. dev. greater than background
(d) Action Level — Greater than 3 std. dev. from background

Group Configuration –

Regional Upgradient Group	USGS 12 and NRF-7
Effluent System Group	NRF-6
Local Downgradient Group	NRF-8 through 12 and USGS 102
Regional Downgradient Group	USGS 97, -98, and -99

Note: Table constituents are arranged by metals, salts, nutrients, and then radionuclides.
Averages are for the period 1989 to present for wells USGS 12, 97, 98, 99, and 102; 1991 to present for NRF-6 and 7; and 1996 to present for NRF-8, 9, 10, 11, 12, and 13.

individual NRF groundwater monitoring wells. Furthermore, when trends in individual wells are examined, different conclusions are developed compared to conclusions derived from the well group analysis discussed above. These individual trend comparisons do not undermine the overall conclusion that water quality at NRF is improving, but rather provide important information pertaining to the hydrogeologic conditions (mechanisms) at NRF. Data trends in individual NRF wells and their hydrogeologic implications are discussed below. Information gathered during this trend analysis is used to explain the hydrogeologic conditions that cause the variations observed in NRF wells particularly chromium in both NRF-6 and the wells in the Local Downgradient Group.

The concentrations of chloride, sulfate, and to a lesser extent, calcium have been trending upward for the past 8 to 10 years in NRF-8, 9, 10, 11, and USGS 102. In NRF-12, the concentration fell steeply between 1996 and 2005 and then has been relatively flat since then. Figure 6-2 shows the chloride time versus concentration graphs for the Local Downgradient wells. These graphs are also representative of the trends exhibited by sulfate. The calcium graphs for all wells seem to mimic the overall trends exhibited by chloride and sulfate, but are bunched together within 5,000 ppb of each other.

Table 6-3 Occurrence of Organic Compounds in NRF Wells from 2006 to 2011

	MDL	NRF-6 (Concentrations in ppb)					
		2006	2007	2008	2009	2010	2011
Bromocil	0.1	Not Detected	1.2	0.99	1.2	Not Detected	Not Detected
Tetrachloroethylene	0.2	0.28	0.28	0.37	0.35	0.37	Not Detected

A more in-depth trend and hydrogeologic analysis was performed for chloride, chromium, and tritium compared to the other groundwater constituents. These three constituents were chosen because they exemplify various aspects of NRF operations and are therefore considered to be key constituents. Chloride was released in quantity at NRF in the past (primarily at the IWD in the form of the ionic salt sodium chloride). Chloride is also a naturally occurring constituent in groundwater and is a good tracer because it is relatively unaffected by common retardation mechanisms associated with the aquifer system, thus allowing flow path and contaminant distribution analyses to be performed. Chromium, a contaminant that is known to have been discharged to the IWD prior to 1980, is consistently detected in both soil and groundwater and is the main constituent of concern in NRF-6 (which monitors IWD effluent impacts to the aquifer). Tritium was evaluated because it was released at NRF in the past at the S1W Leaching Bed/Pits (NRF 12B/14); therefore, its flow path is different than for chloride which has a different source location. Like chloride, tritium generally does not interact with the aquifer matrix and therefore is also a good indicator of dispersion and groundwater flow paths.

The time versus concentration graphs created using data from the Local Downgradient Group wells for chloride can be divided into three sub-groups based on the relative concentration of the constituents and the shape of the graphs – NRF-12 (subgroup 1); NRF-9, 10, 11 (subgroup 2); and NRF-8 and USGS 102 (subgroup 3 - see Figure 6-2). Although not part of the Local Downgradient Group of wells, the graph from USGS 97 also fits in with subgroup 3. The NRF-12 graph (subgroup 1) starts out 12,000 ppb higher in concentration than the graphs for subgroup 2, but between 2002 and 2005 the concentration drops below the subgroup 2 graph and end up 7,000 ppb lower in concentration.

This cross-over period corresponds to a span of time associated with an anomalous rise in the NRF-11 tritium time versus concentration graph and other hydrologic events that are discussed later. The NRF-12 (subgroup 1) concentration is currently at or near an historical minimum.

The concentrations depicted by the subgroup 2 graphs start out between 45,000 and 50,000 ppb but drops quickly to a low in 2001 between 36,000 and 38,000 ppb; thereafter they rise to between 47,000 and 50,000 ppb. The concentrations from NRF-9, with several minor exceptions, are consistently the highest of subgroup 2 followed by NRF-11, and then by NRF-10. The subgroup 2 graphs are currently at or near their historical maximum concentrations.

The subgroup 3 graphs generally mimic the changes that are exhibited in the subgroup 2 graphs, but are from 10,000 ppb to 15,000 ppb lower in concentration. Like the other two subgroups, the graphs for approximately the past 10 years show a modest increasing trend (2,000 to 3,000 ppb). All of the graphs for the individual wells included in subgroups 1, 2, and 3 (Figure 6-2) show a steep drop in concentration between the end of 1999 and the beginning of 2000. This same drop is evident in time versus concentration graph for USGS 12 (one of the upgradient wells), but this drop begins around the middle of 1996, which in turn corresponds almost precisely to the beginning of a four year rise in water level in the well as shown in Figure 6-3. A similar correlation is evident in NRF-6 and to a lesser extent in NRF-8, NRF-10 and NRF-12.

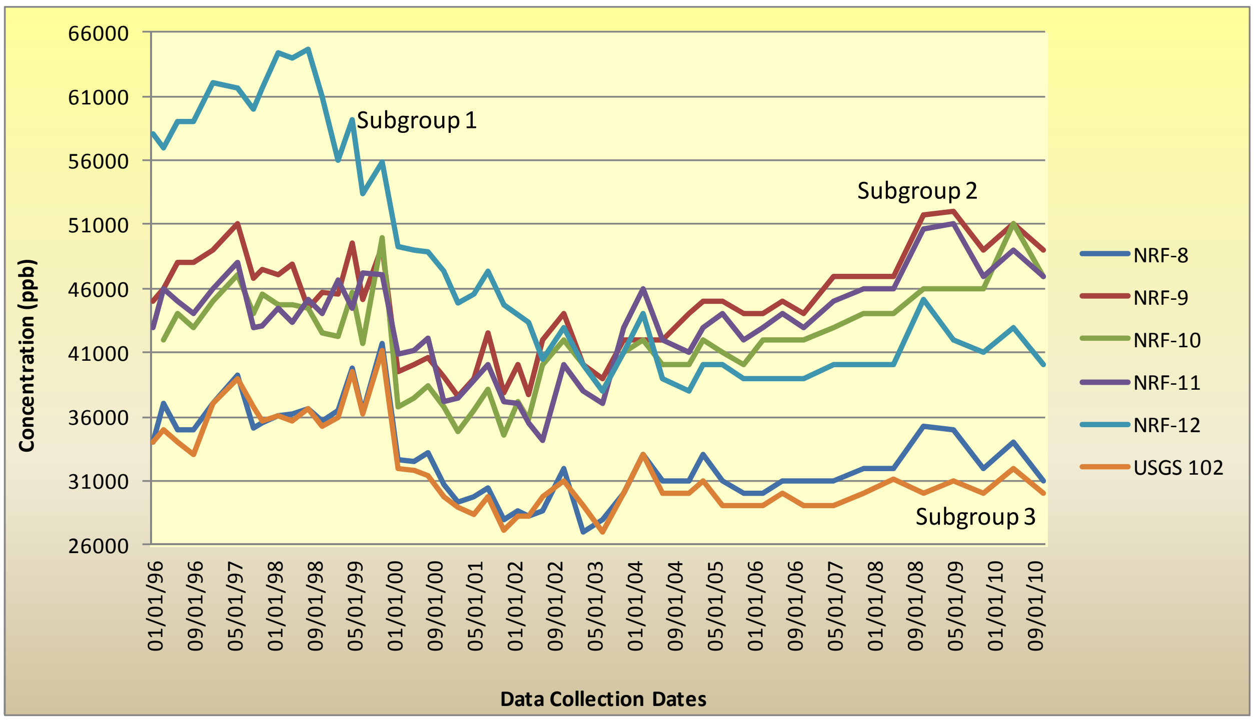


Figure 6-2 Chloride Concentration in NRF Local Downgradient Wells

These observations suggest that the shapes (trends) exhibited in the time versus concentration graphs from USGS 12, NRF-6 and the Local Downgradient Group wells are strongly influenced by the elevation of the water table (and whether it is rising or falling).

The specific concentration of a given constituent is primarily determined by the source of the constituent (e.g., the IWD) and the well's position relative to flow paths that transport the specific constituent. For example, the shape of the NRF-12 graph is explained by an eastward flow path (relative to NRF) that has migrated westward over time. Surprisingly, the concentration of the constituents in NRF-6 do not appear to exert as much of an influence on the trends observed in the Local Downgradient Group wells as might be expected.

Table 6-4 Comparison of MCL and NRF Background Groundwater Concentrations to Individual Wells and Well Groups

Period	Constituent ►	Aluminum	Calcium	Chromium	Iron	Manganese	Nickel	Sodium	Chloride	Sulfate	Tritium
	Units ►	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	pCi/L
	MCL ►	200(a)	(b)	100	300 (a)	50 (a)	(b)	(b)	250000 (a)	250000 (a)	20000
2006 to 2010	Regional Upgradient	39 ± 33	43955 ± 19810	10 ± 2	97 ± 75	3 ± 2	7.2 ± 4.0	12809 ± 3603	17699 ± 13173	23350 ± 9457	26 ± 25
	System Effluent	19 ± 4	153939 ± 13810	43 ± 8	73 ± 40	1 ± 1	4.8 ± 2.9	192727 ± 22843	514545 ± 40091	104909 ± 7778	41 ± 14
	Local Downgradient	35 ± 43	68606 ± 3666	12 ± 3	63 ± 84	2 ± 2	4.8 ± 2.9	18098 ± 1972	40374 ± 7299	36448 ± 3337	76 ± 46
	Regional Downgradient	23 ± 14	56438 ± 10519	7 ± 1	92 ± 117	3 ± 3	4.2 ± 3.3	14639 ± 2567	23306 ± 7358	27521 ± 4974	28 ± 13
2001 to 2005	Regional Upgradient	68 ± 56	45448 ± 18212	9 ± 3	186 ± 320	4 ± 4	8.3 ± 5.1	11156 ± 2441	13700 ± 9227	20759 ± 7207	25 ± 24
	System Effluent	69 ± 34	131329 ± 25103	31 ± 8	566 ± 479	5 ± 4	9.2 ± 6.3	133335 ± 51918	349647 ± 138921	94118 ± 3878	40 ± 14
	Local Downgradient	79 ± 79	66768 ± 3402	13 ± 6	123 ± 153	3 ± 4	6.6 ± 5.1	16823 ± 1911	36822 ± 5780	36259 ± 3943	72 ± 43
	Regional Downgradient	62 ± 35	59014 ± 8668	6 ± 1	91 ± 84	4 ± 5	2.8 ± 1.3	13794 ± 2860	23024 ± 6873	27600 ± 4710	27 ± 13
1996 to 2000	Regional Upgradient	103 ± 86	44468 ± 18698	9 ± 3	177 ± 210	8 ± 6	6.6 ± 3.4	11862 ± 3368	15374 ± 12632	21145 ± 8413	37 ± 30
	System Effluent	61 ± 39	116050 ± 20782	30 ± 6	646 ± 520	7 ± 3	16.2 ± 7.9	100120 ± 16698	220450 ± 34810	156095 ± 43451	58 ± 21
	Local Downgradient	76 ± 40	72250 ± 4950	12 ± 6	112 ± 92	6 ± 4	8.9 ± 7.2	17240 ± 2932	43545 ± 8258	42464 ± 7623	100 ± 65
	Regional Downgradient	72 ± 41	60769 ± 9093	6 ± 1	92 ± 74	7 ± 4	4.9 ± 4.1	13226 ± 2756	23884 ± 8909	27786 ± 5654	32 ± 15

(a) Secondary MCL (this is not an enforceable value, but rather a recommendation)
(b) MCL not determined

Group Configuration:

Regional Upgradient Group	USGS 12 and NRF-7
Effluent System Group	NRF-6
Local Downgradient Group	NRF-8 through 12 and USGS 102
Regional Downgradient Group	USGS 97, 98, and 99

Even though the concentration of chloride in NRF-6 has more than doubled in the past 10 years, there is no evidence yet of a corresponding response in the Local Downgradient wells. And even though the chloride concentrations in some of these wells appear to be trending upward, this same trend is present in the upgradient wells USGS 12, which does not support the conclusion that the increases are being caused by the effluent released to the IWD.

Figure 6-4 shows generalized time versus concentration graphs for chromium in the NRF wells. Data from wells NRF-6, NRF-7, and NRF-9 through NRF-12 are represented by poly-trend lines. The composite time versus concentration graph includes an average of wells NRF-8, USGS 12, 97, 98, 99, and 102 and collectively are represented by a single composite poly-trend line. In this way, random variations in the data are removed and a clearer comparison can be made. Chromium is a naturally occurring constituent in both groundwater and soil; however, past hydrogeological investigations demonstrated that sediments beneath the IWD contain elevated chromium concentrations from historic releases from NRF. These sediments are the primary source of the chromium which are detected above background concentrations (but significantly below the MCLs) in NRF-6 and some of the downgradient monitoring wells.

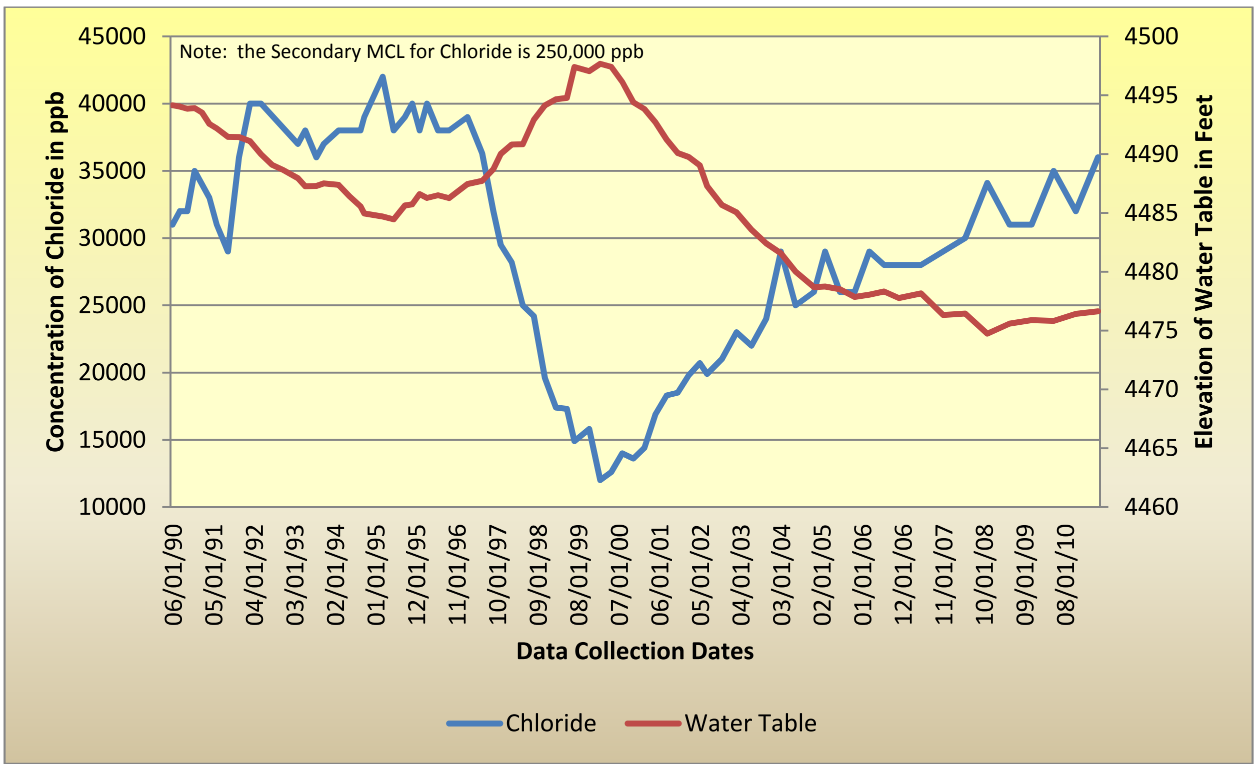


Figure 6-3 Chloride Concentration versus Water Table Elevation in USGS 12

The average chromium concentration detected in the IWD effluent since 1998 is 7.43 ppb. This concentration is slightly below the groundwater background level of 9 ± 3 ppb. Chromium concentrations are currently trending upward in five of twelve NRF groundwater monitoring wells. NRF-6 is the only well in which a significant increasing trend in chromium concentrations is present. The trends in the remaining wells are either slightly upward (three to four ppb over 14 years), downward or relatively flat and represent small changes in chromium concentrations and are probably more reflective of changes in local flow directions than changes in the amount of chromium being released to the aquifer by any past or current activity at NRF.

The trend lines shown in Figure 6-4 can be placed into several subgroups (similar to chloride graphs discussed above). The highest chromium levels are found in well NRF-6, which is located immediately downgradient of the IWD. In the 2006 Five-Year Review, the chromium concentration in this well was reported to be trending downward with an explanation that the observed trend likely reflected decreased discharge to the IWD. It was further explained that since leaching of chromium is a process limited by solubility, the amount of chromium entering the aquifer is sensitive to the infiltration rate. Since the last Five-Year Review, the downward trend observed at the time ceased and an upward trend began. As noted in Section 6.2.1.5.5, an investigation of the data coupled with information gathered during maintenance on the well indicated that a portion of the apparent increase in chromium concentration was due to either well corrosion or sedimentation issues. The time versus concentration graph shown in Figure 6-1 for NRF-6 used filtered data since May 2007 in order to remove the bias associated with the suspended particles. Even with this, the increase in chromium concentration is clearly visible. Since the 2006 Five-Year Review, annual discharge volume to the IWD has remained nearly constant at approximately 10,000,000 gallons per year.

Figure 6-5 is a time versus concentration graph showing normalized IWD chromium concentrations versus the normalized IWD effluent concentrations. Although the correlation between the shapes of the graphs is good, the fact that IWD concentrations are consistently 3 to 4 times lower than the NRF-6 groundwater concentrations suggests that if changes in the concentration of chromium in IWD effluent affect the concentration of chromium in NRF-6 this effect appears to be minor compared to other factors.

As indicated by the discussion of salts above, what appears to be more important is groundwater hydraulics. More specifically, the direction of groundwater flow beneath NRF (coupled with rising and falling aquifer levels) appears to influence the concentration of groundwater constituents more than the concentration of the constituents at their source. These observations explain the apparent trends in the local downgradient wells as well as the apparent rise in chromium concentration in NRF-6.

Figure 6-6 shows that prior to 2004, the chromium concentration in the Local Downgradient Group wells decreased from the eastern most to the western most placement (NRF-12, to NRF-11, to NRF-10 etc.). After 2004, the highest concentration occurred in NRF-10 as shown in Figure 6-7. Successive concentration peaks can be seen in the graphs for NRF-12, NRF-11, NRF-10, and NRF-7 (see Figure 6-4). In NRF-12 the peak occurs during mid-2000 and in NRF-11 it occurs during late-2003. In NRF-7, peak occurs in January of 2004 while in NRF-10, the peak occurs during early 2005. The pattern depicted by the three local downgradient wells and well NRF-7 is consistent with a chromium plume (water with chromium levels above background concentrations but significantly below federal MCLs) that is moving through the wells clockwise from the northeast to the southwest carried by an aquifer undergoing a change in flow directions. This hypothetical chromium plume appears to be located just southwest of NRF-10 at the present time indicating a flow path that is currently passing beneath NRF in a west-southwesterly direction (again, refer to Figure 6-7).

Figure 6-8 compares time versus water table elevation graphs derived from data collected from NRF-6 and NRF-7. The figure shows that the water table in NRF-7 was generally higher than in NRF-6 between September 1991 and September 1997 and again between February 2002 and the present. As this shows, the period where the water elevation in NRF-6 was higher than in NRF-7 straddles a peak in water table elevation for both wells, which in turn corresponds to a wetter than normal period that was discussed in Section 2.3.3.6. This phenomenon can be explained by the physical properties of the aquifer that surrounds NRF. Aquifer pump tests have demonstrated that the aquifer at NRF-6 has a much higher hydraulic conductivity that the aquifer near NRF-7 and NRF-13. Modeling indicates that a large area north and east of NRF possesses generally lower hydraulic conductivities. Because of the differences in the physical properties of the aquifer, NRF-6 can produce 30 to 40 times more water in a given time period than either NRF-7 or NRF-13. When the water table in the area was rapidly rising, the aquifer near NRF-6 "filled" more quickly than the aquifer near NRF-7 thus producing the first cross-over in November 1997 shown in Figure 6-8.

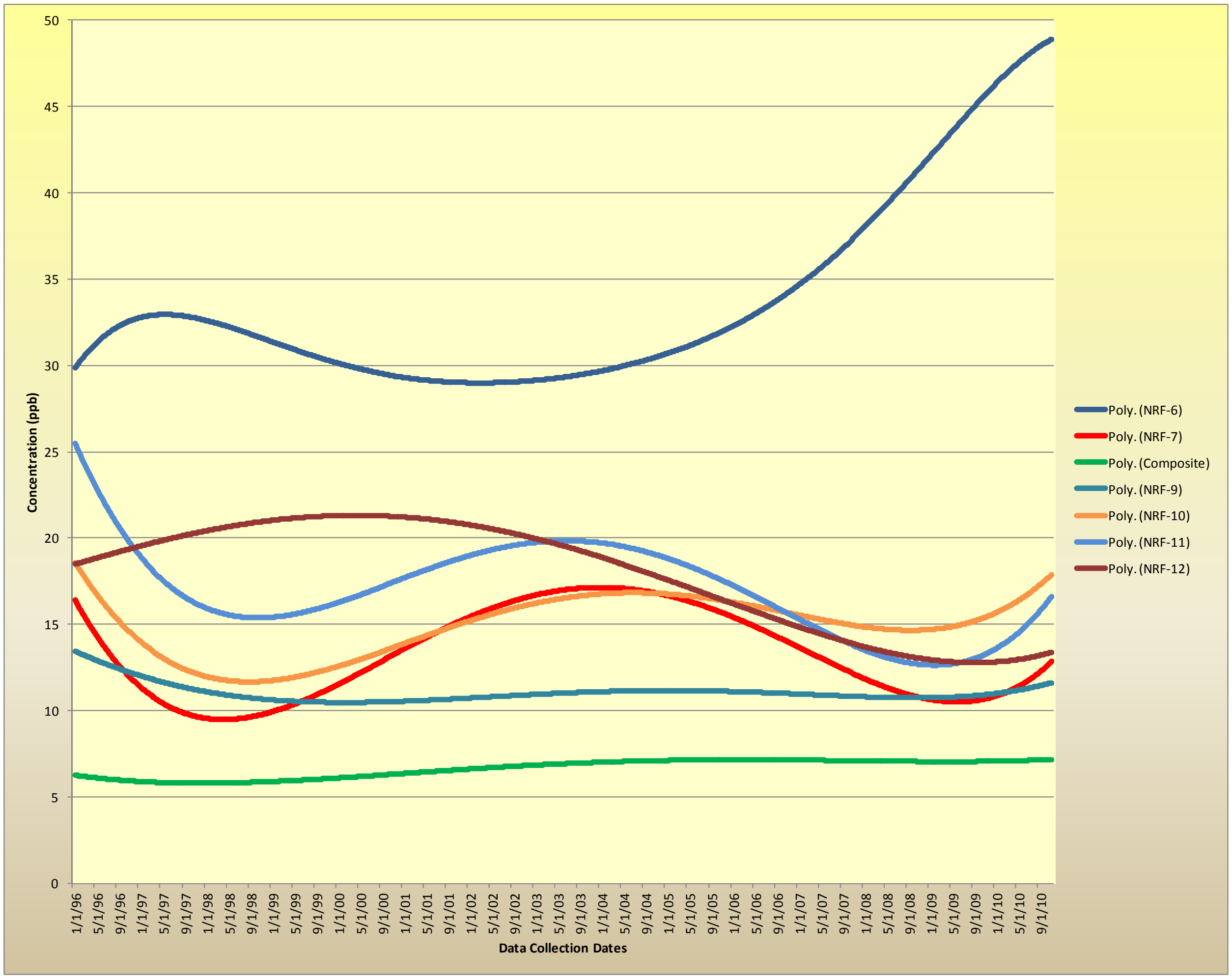


Figure 6-4 Chromium Concentration in Selected NRF Wells

When the water table began to rapidly decline as it did after late-2000, the aquifer near NRF-6 drained more quickly than the aquifer near NRF-7 thus producing the second cross-over. Groundwater data indicate that when the water table in NRF-7 is higher than in NRF-6, the flow direction at NRF in general, and specifically at the IWD, tends to be more northwest to southeast. When the opposite is true, the flow direction becomes more southerly. Hence, in May of 2000, at the water table elevation peak, and when the differences between the water table elevations in the two wells were at their maximum, the chromium concentration in NRF-12 also reached its maximum.

With time, as the aquifer water levels continued to decline, and the differences in elevations between NRF-7 and NRF-6 increased, the aquifer flow direction progressively became more southerly carrying with it elevated chromium concentrations (plume). The differences in the chromium concentration in NRF-6 and the Local Downgradient wells is explained in part by dispersion mechanisms and in part by the fact that the aquifer flow direction beneath the IWD, which is a source for chromium in the aquifer, can change over time. When the aquifer flow direction is more perpendicular with respect to the IWD, a greater portion of the aquifer is exposed to the contaminants originating in the IWD resulting in lower concentrations of chromium in the aquifer. When the aquifer flow direction is more parallel with respect to the IWD (more southerly), a smaller portion of the aquifer is exposed to the contaminants and aquifer chromium concentrations are higher. As the plume successively passes through the various wells, the peak concentration is progressively lower primarily due to the increased distance from the source (and therefore the effects of dispersion are greater).

The shape of the chromium graph in NRF-6 is explained by the same mechanism discussed above. In January 2002, when the NRF-6 chromium concentration as shown by the graph in Figure 6-4 was at its minimum, the water table elevation in NRF-6 was at its maximum, and so too was the most easterly extent of the chromium plume in NRF-12. As the flow direction beneath the IWD resumed a more southerly flow pattern, the concentration of chromium in NRF-6 began rising. The higher concentrations are a least partially due to the aquifer flow beneath the IWD being more parallel with the length of the IWD and thus the chromium exposure cross-section is greater. As discussed in the 2006 Five-Year Review, the release of chromium from IWD sediment is believed to be a solubility controlled process. The apparent increasing chromium trend in NRF-6 likely does not indicate that more chromium is being released from the IWD sediment, but rather the observed chromium concentrations in NRF-6 were (are) approaching the static concentration being released from the sediments.

Climatic data indicate that eastern Idaho has entered a cooler and wetter climatic pattern. This condition is confirmed by the graphs in Figure 6-8 which show that the rapid decline in water table elevation in NRF-6 and NRF-7 (and in other area wells) has slowed and may be on the verge of an increasing cycle. If the rate of increase in the water table is rapid like before, the aquifer flow direction beneath the IWD should again become more easterly, and the chromium concentration in NRF-6 will once again trend downward. If conditions stay as they are now, the chromium concentrations in NRF-6 should remain somewhat static as they have been for the past year. Although the chromium concentration released from the IWD sediments under static conditions is not known for certain, it is very doubtful that it is much higher than what has already been seen in NRF-6 sample results.

The green poly trend line in Figure 6-4 which was derived from data from wells, NRF-8, USGS 97, 98, 99 and USGS 102 reflects chromium near background concentrations. These wells lie either west or substantially downgradient of NRF. This pattern can be interpreted to mean that the flow direction at NRF seldom if ever will be so extreme as to substantially impact these wells. The shape of the NRF-9 graph in Figure 6-4 is very similar to the shape of the composite graph but the concentration of the former is consistently 5 to 8 ppb higher. This indicates that this well is on the outer fringes of the chromium plume impact zone. If the water level in NRF-7 continues to be significantly above the water level in NRF-6 for a sufficiently long time, the chromium concentration in this well may rise in response to the approaching plume from the east.

The tritium activity levels in all wells but NRF-7 are trending downward. The tritium activities in this well have consistently been near the detection limits. The long-term average tritium activities in most NRF wells are above background levels, with wells NRF-10 and NRF-11 being the most elevated. The activity levels in these two wells are still significantly lower than MCLs. These wells are located downgradient of the S1W Leaching Beds/Pit. It is likely that residual contamination from historical tritium releases to this area is responsible for these elevated concentrations, as water with any appreciable amounts of tritium has not been released from NRF since 1978.

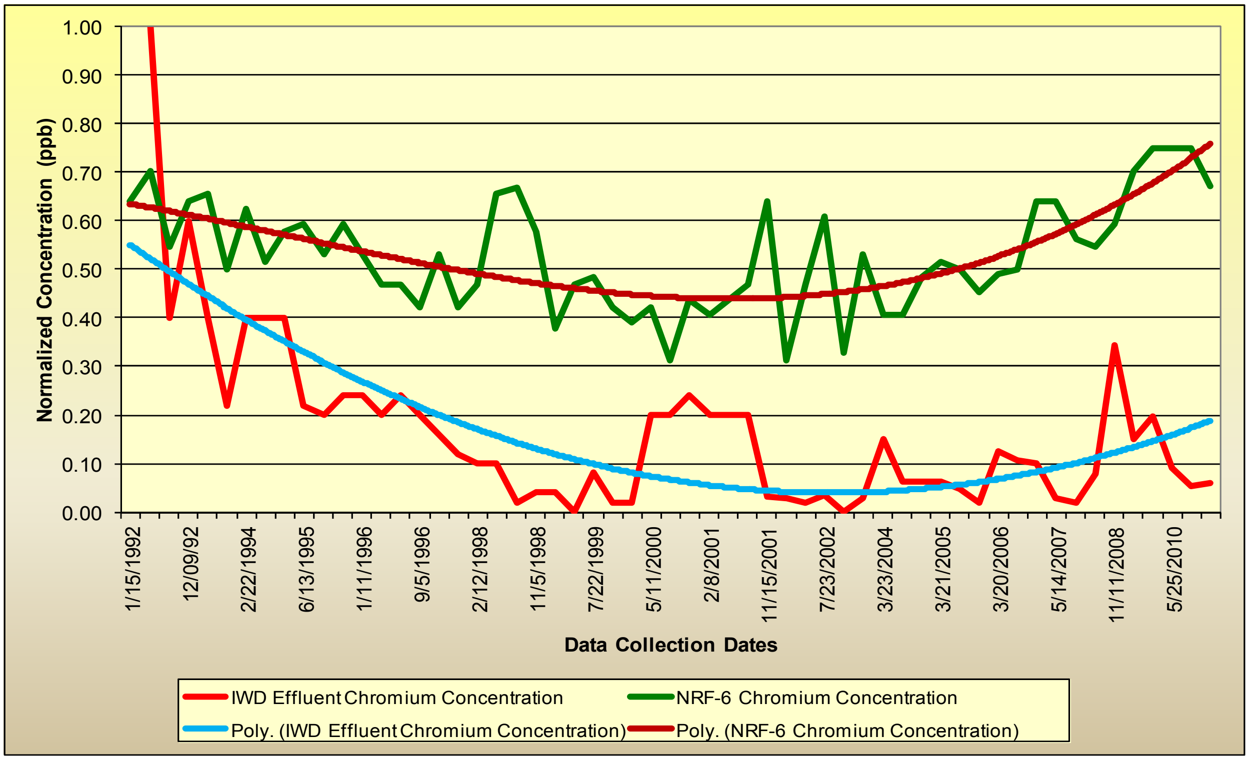
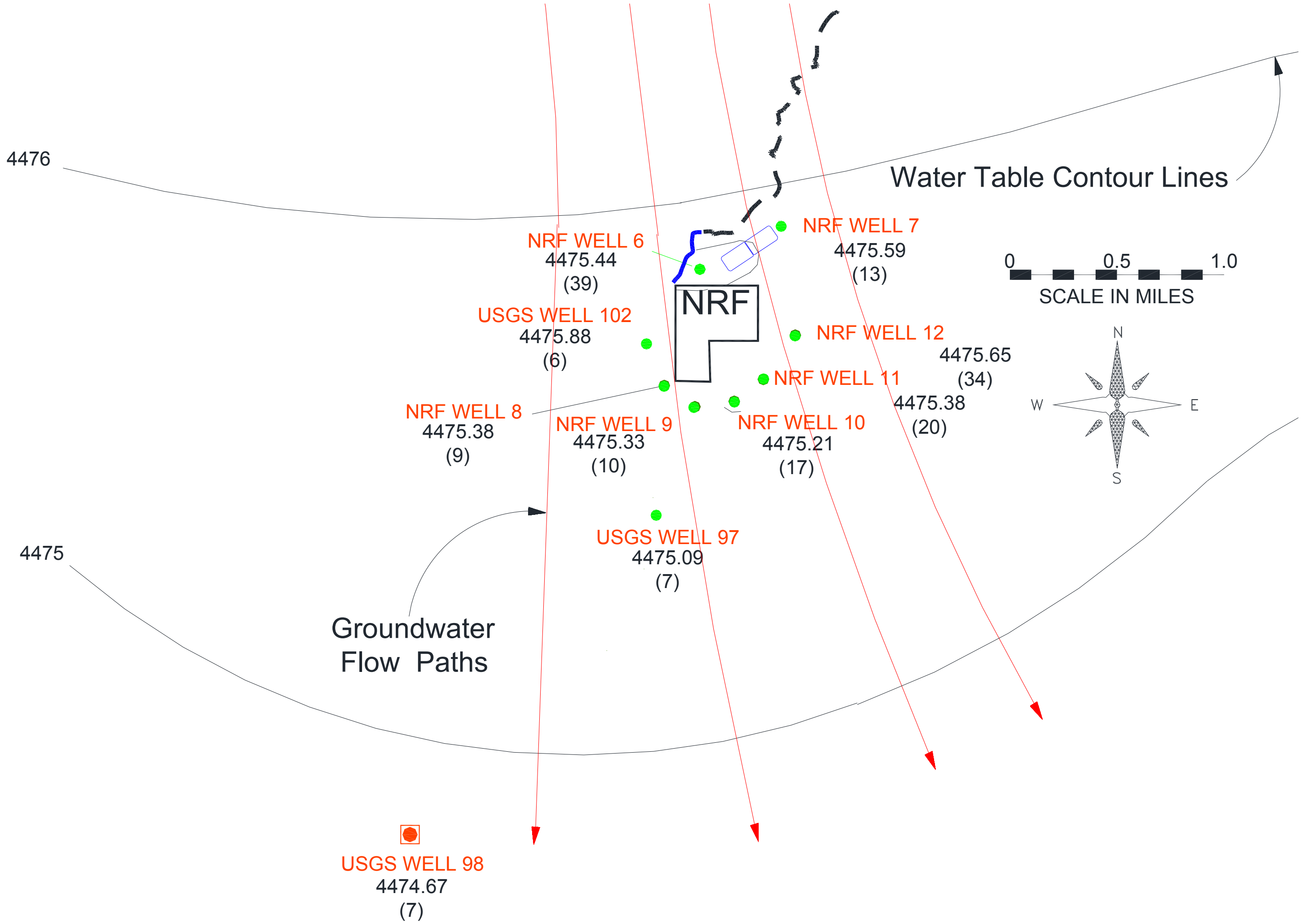


Figure 6-5 Comparison of Chromium Concentrations in IWD Effluent to Chromium Concentrations in NRF-6

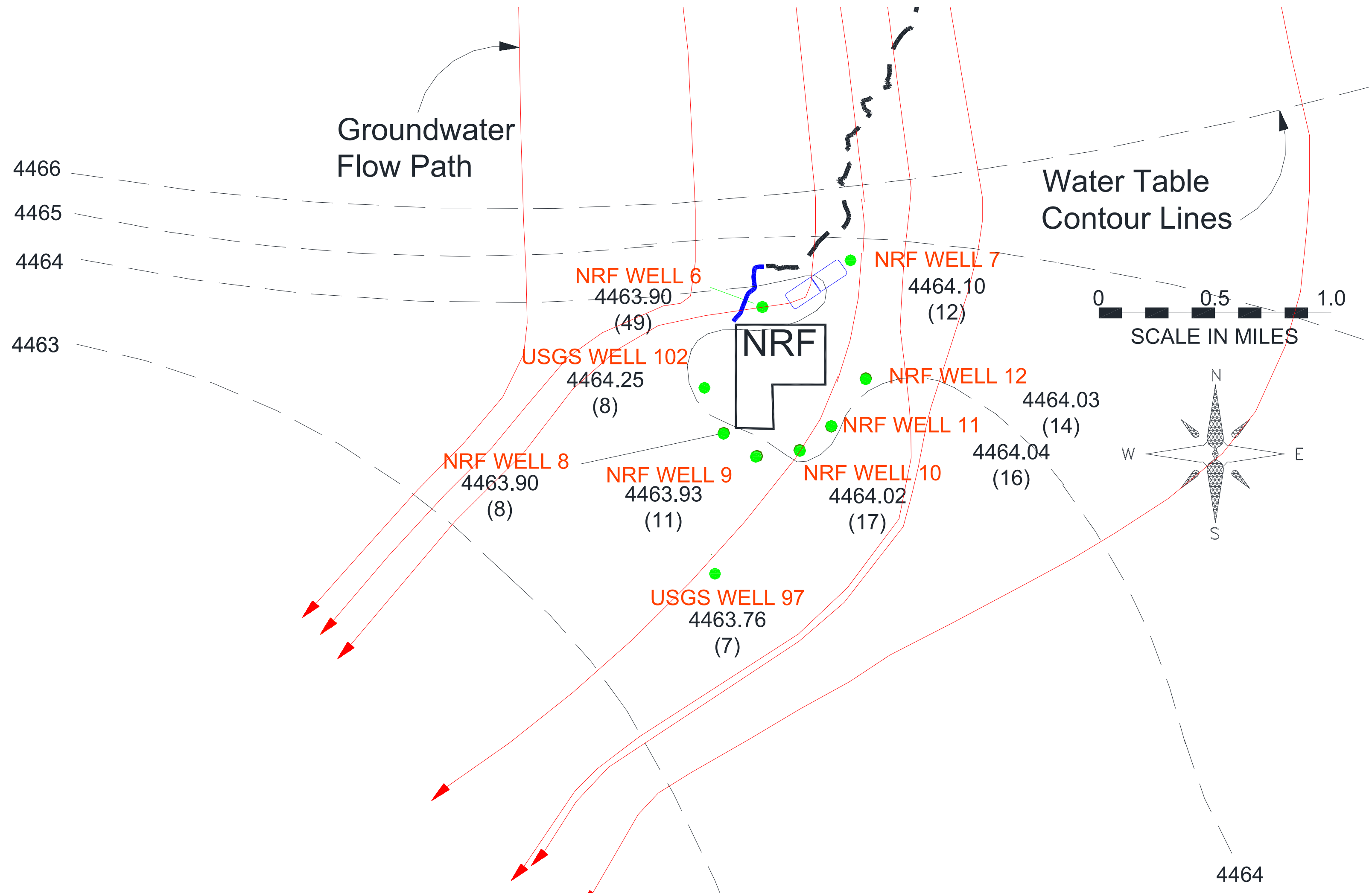
A residual perched water zone, which is releasing small quantities of water to the aquifer, is suspected as one possible mechanism causing the current elevated tritium activities. The observed downward trends in tritium activities at NRF are expected given normal radioactive decay. Figure 6-9 is a time versus concentration graph of data from NRF-11. This graph demonstrates the general downward trend in tritium data and shows the anomaly discussed previously. For NRF-11, the rise in concentration occurred between 2000 and 2004. This time period corresponds to a similar “bump” in the graph for chromium data in NRF-11 shown in Figure 6-4 and supports the conclusions discussed above (i.e., changing flow directions and plume passing through various wells).

Overall, most measured contaminants are trending downward. Samples representing regional upgradient and regional downgradient water quality are statistically similar, thus, indicating that past and present operations at NRF have had no significant impact on water quality.



Water table elevations are shown in black numbers under the wells names
Chromium concentrations are shown in parentheses under the water table elevation values

Figure 6-6 Groundwater Flow Lines and Chromium Concentrations for 2002



Water table elevations are shown in black numbers under the well names
Chromium concentrations are shown in parentheses under the water table elevation values

Figure 6-7 Groundwater Flow Lines and Chromium Concentrations for 2010

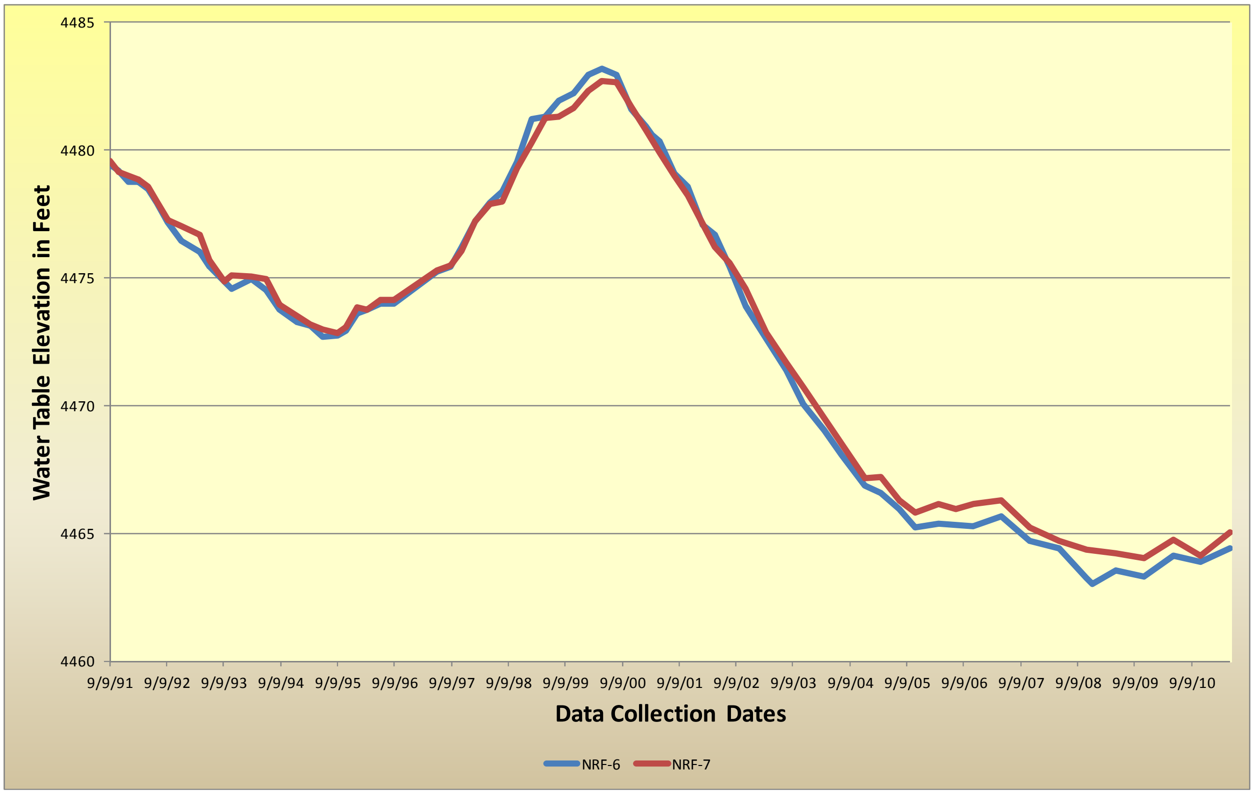


Figure 6-8 Comparison of Water Table Elevations in Wells NRF-6 and NRF-7

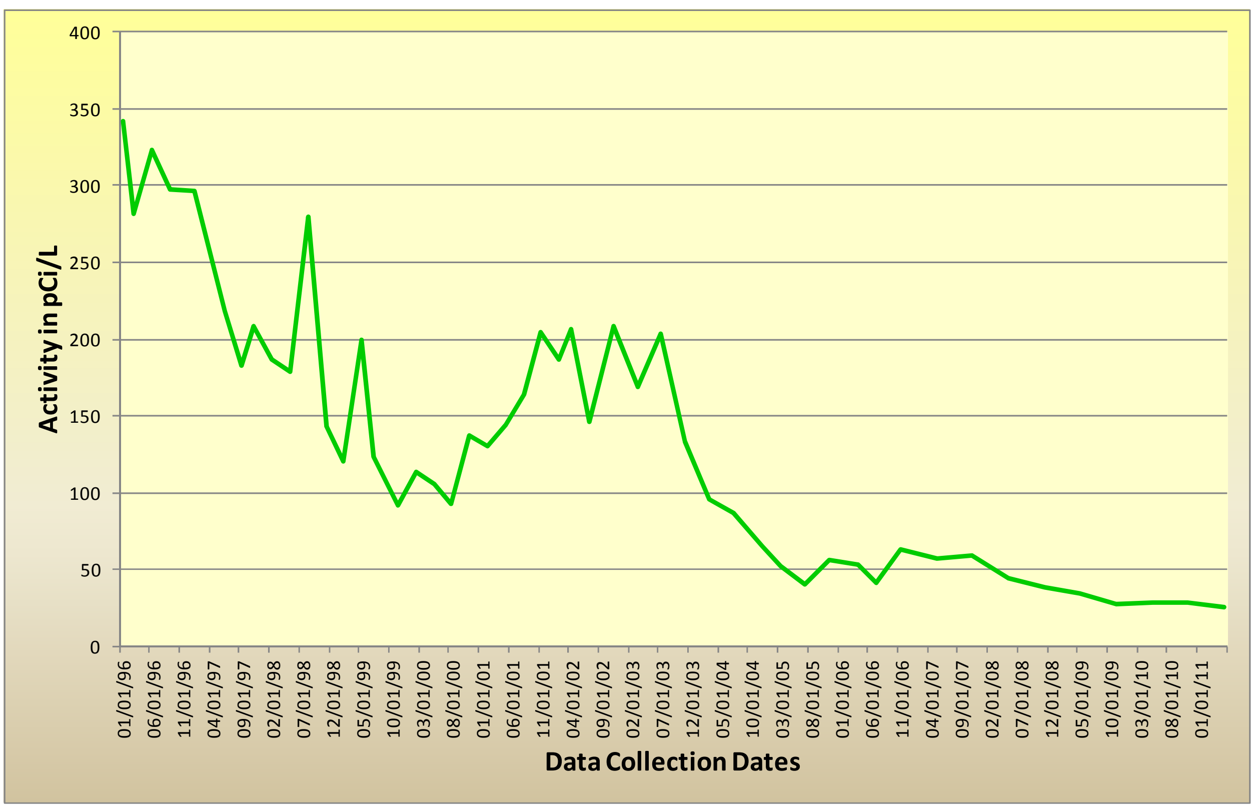


Figure 6-9 Tritium Concentration in NRF-11 Showing Anomaly

6.3.3 Soil Gas

6.3.3.1 Analysis of Soil Gas Data

Soil gas monitoring data collected from monitoring probes around the perimeter of the three NRF Inactive Landfill Areas were analyzed by an off-site laboratory. The following are the VOCs that were consistently detected above the reporting limit between 1997 through 2010: dichlorodifluoromethane (Freon 12); trichlorofluoromethane (Freon 11); 1,1,1-trichloroethane; chloroform; trichloroethylene; and tetrachloroethylene. Freon 11 and tetrachloroethylene were the two most frequently detected constituents at all of the sites. 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) that was detected above the reporting limit in previous sampling periods through 2005 was not detected at or above the reporting limit for the 2006-2010 sampling period.

The statistical review presented in this section centers on comparison of monitoring results to two different benchmarks. These benchmarks are the baseline concentrations obtained from the October 1996 initial sampling event (baseline data for each individual probe) and the overall maximum concentrations obtained during the Track 2 Investigations for these three landfill areas (the overall maximum data occurring at NRF-53). Such a comparison also presents a relative risk picture associated with NRF landfills. Ultimately, the results of these comparisons are used to re-evaluate risk associated with the selected remedies and to determine the overall effectiveness of the remedies. In addition, comparisons between the data collected from 1997 through 2010 will also be made where appropriate. A summary of data collected from 1997 through 2010 and baseline data are presented in Table 6-5, Table 6-6, and Table 6-7.

6.3.3.2 Statistical Review

6.3.3.2.1 Dichlorodifluoromethane (Freon 12)

Since 1997, Freon 12 has been detected at only one site (NRF-1), and has been detected consistently above the reporting limit at only one sample location (MW1-4) with a maximum concentration of 43 parts per billion on a volumetric basis (ppbv) or 212.2 micrograms per cubic meter (μg/m^3). This maximum concentration, detected in June 2001, exceeded the baseline concentration of 5.3 ppbv (26.2 μg/m^3); however, the levels detected since June 2001 are less than the maximum concentration. Since 1997, Freon 12 has been detected only three times above the reporting limit at MW1-3 with a maximum concentration of 5.1 ppbv (25.2 μg/m^3), in December 2001. Freon 12 was not detected at any of the three landfill areas during the Track 2 Investigations. However, the concentrations recently observed are relatively low in comparison with other halogenated organic compounds detected at the three landfill areas.

6.3.3.2.2 Trichlorofluoromethane (Freon 11)

Since 1997, Freon 11 has been detected at all three landfill areas, but most consistently at NRF-1. At sample locations MW1-2 and MW1-3, Freon 11 has been detected frequently above the reporting limit and, at sample locations MW1-1 and MW1-4, it has been detected primarily just below the reporting limit. During the 1997-2010 sampling period, the overall maximum concentration detected at NRF-1 was 7.1 ppbv (39.8 μg/m^3) at sample location MW1-3 in 2000. During the 2006-2010 sampling period, the maximum concentration detected at NRF-1 was 2.7 ppbv (47.7 μg/m^3) in 2006.

Freon 11 has been consistently detected at all four sample locations at NRF-51 since 1997. During the 1997-2010 sampling period, the overall maximum concentration detected at NRF-51 was 15 ppbv (84 μg/m^3) at sample location MW51-2 in 1997. During the 2006-2010 sampling period, the maximum concentration detected at NRF-51 was 3.5 ppbv (19.6 μg/m^3) in 2006.

At NRF-53, Freon 11 has been detected occasionally only at locations MW53-2 and MW53-4 since 1997. During the 1997-2010 sampling period, the overall maximum concentration detected at NRF-53 was 3.5 ppbv (19.6 μg/m^3) at sample location MW53-2 in 1997. During the 2006-2010 sampling period, Freon-11 was only occasionally detected at NRF-53 at a maximum concentration of 1.1 ppbv (6.2 μg/m^3).

The maximum concentration detected at all three sites during the 2006-2010 sampling period was 3.5 ppbv (19.6 μg/m^3), which is below the overall baseline concentration of 16 ppbv (89.7 μg/m^3). These concentrations are low in comparison with other halogenated organic compounds detected at the three landfill areas.

6.3.3.2.3 Chloroform

Since 1997, chloroform has been consistently detected at NRF-1 at one sample location (MW1-1; replacement sample probe location). Chloroform has been detected at NRF-51 but below the reporting limit. Chloroform has never been detected at NRF-53 above the reporting limit. During the 2006-2010 sampling period, chloroform was detected at a maximum concentration of 4.9 ppbv (23.9 μg/m^3) in 2007, which is less than the overall maximum concentration of 7.6 ppbv (37.0 μg/m^3) detected at this location in 2004.

6.3.3.2.4 1,1,1-Trichloroethane

1,1,1-Trichloroethane has been consistently detected at NRF-1 at only sample location MW1-3 since 1997 with an overall maximum concentration of 4.0 ppbv (21.8 μg/m^3) in 2000. During the 2006-2010 sampling period, the detected concentrations at NRF-1 were all below the reporting limit. 1,1,1,-trichloroethane has not been detected at NRF-1 since 2008 (at a concentration below reporting limit).

1,1,1-Trichloroethane has been consistently detected at NRF-51 at all sample locations. The overall maximum concentration detected at NRF-51 was 8.4 ppbv (45.7 μg/m^3) at sample location MW51-2 in 1997. During the 2006-2010 period, 1,1,1-trichloroethane was only detected three times above the reporting limit at levels below the overall maximum concentration.

1,1,1-Trichloroethane was not detected at NRF-53 during the 2006-2010 sampling period. Historically, 1,1,1-Trichloroethane has been detected only four times above the reporting limit at NRF-53.

During the 1997-2010 sampling period, the highest maximum concentration for all three sites was 8.4 ppbv. This concentration is less than the overall maximum concentration of 83 ppbv (452.0 μg/m^3) detected during the Track 2 Investigation.

6.3.3.2.5 Tetrachloroethylene

Tetrachloroethylene was the constituent most commonly detected above the reporting limit at all three landfill areas. Also, tetrachloroethylene was detected at the highest concentration of all the constituents detected at the three areas (excluding the outlier discussed in the following section). Since 1997, the overall maximum concentration detected was 616 ppbv (4170 µg/m^3) at NRF-1 sample location MW1-3 in 1998 which is less than the overall maximum concentration of 1400 ppbv (9477 µg/m^3) detected during the Track 2 Investigation. The maximum tetrachloroethylene concentration for the 2006-2010 sampling period was 560 ppbv (3790.9 µg/m^3) at the MW1-4 sample location, which occurred in 2009 and 2010. Tetrachloroethylene was detected at much lower concentrations at sample locations MW1-1 and MW1-2.

Since 1997, tetrachloroethylene has been consistently detected above the reporting limit at all four sample locations at NRF-51. The overall maximum concentration was detected in 1997 at 29 ppbv (196.3 µg/m^3) at sample location MW51-1. The maximum tetrachloroethylene concentration for the 2006-2010 sampling period was 13 ppbv (88.0 µg/m^3) at sample locations MW51-1 and MW51-2.

Tetrachloroethylene has been routinely detected above the reporting limit at NRF-53 at most of the sample locations. The overall maximum concentration detected at NRF-53 was 27 ppbv (182.8 µg/m^3) at sample location MW53-2 in 2002. The maximum tetrachloroethylene concentration for the 2006-2010 sampling period was 18 ppbv (121.8 µg/m^3) at sample location MW53-2 in 2007.

6.3.3.2.6 Trichloroethylene

Since 1997, trichloroethylene has been detected predominately at NRF-1 and occasionally at NRF-51 and NRF-53. Trichloroethylene is a natural degradation product of tetrachloroethylene. The overall maximum trichloroethylene concentration detected during the 1997-2010 sampling period was 250 ppbv (1341 µg/m^3) at NRF-1 sample location MW1-1 in 2004 and 2005. This concentration is greater than the overall maximum concentration of 16 ppbv (86 µg/m^3) detected during the Track 2 Investigation; however, the concentrations of trichloroethylene are considered low in comparison with tetrachloroethylene detected at all three landfill areas. The maximum trichloroethylene concentration during the 2006-2010 sampling period was 220 ppbv (1180 µg/m^3) at sample location MW1-1, which occurred three times during this period, the latest in 2009. Trichloroethylene has been detected at much lower concentrations at the other NRF-1 sample locations.

At NRF-51, trichloroethylene has been detected only twice at sample location MW51-4 and once at sample locations MW51-2 and MW51-3 at or above the reporting limit since 1997. The maximum concentration detected at NRF-51 was 94.0 ppbv (504.1 µg/m^3) at sample location MW51-4 in 2003. Since this concentration (94.0 ppbv) is significantly greater than the concentration of 2 ppbv (10.7 µg/m^3) detected for the only other occurrence at MW51-4, it appears to be an outlier. During the 2006-2010 sampling period, trichloroethylene was not detected above the reporting limit at any NRF-51 sample locations.

At NRF-53, trichloroethylene has rarely been detected since 1997. The overall maximum concentration detected at NRF-53 was 45.0 ppbv (241.4 µg/m^3) at sample location MW53-6. Since this concentration (45 ppbv) was only a single occurrence and significantly greater than the concentrations detected at the other NRF-53 sample locations, it appears to be an outlier. During the 2006-2010 sampling period, trichloroethylene was detected above the reporting limit at NRF-53 only once at sample location MW53-5 at a concentration of 8.2 ppbv (44 µg/m^3).

Table 6-5 Soil Gas Data Summary for Site NRF-1

Site	Sample Location	Statistical Parameter	Freon 12		Freon 11		Freon 113		Chloroform		1,1,1-Trichloroethane		Tetrachloroethylene		Trichloroethylene	
Overall Maximum Track 2 Data			(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3
			ND	**ND**	**10.0**	**56.1**	**5.3**	**40.5**	**19.0**	**92.6**	**83.0**	**452.0**	**1400.0**	**9477.1**	**16.0**	**85.8**
NRF-1 MW1-1		Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Mean	ND	ND	<1.7	<9.5	ND	ND	3.9	19.2	ND	ND	5.4	36.7	180.4	967.7
		Std Dev.	ND	ND	0.6	3.5	ND	ND	2.0	9.6	ND	ND	5.6	37.6	48.6	260.8
		Maximum	ND	ND	2.6	14.6	ND	ND	7.6	37.0	ND	ND	20.0	135.4	250.0	1340.8
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	97.0	520.2
		Confidence	ND	ND	0.3	1.9	ND	ND	1.1	5.2	ND	ND	3.0	20.4	26.4	141.8
NRF-1 MW1-2		Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Mean	ND	ND	2.5	13.8	ND	ND	ND	ND	ND	ND	4.6	31.5	ND	ND
		Std Dev.	ND	ND	0.5	2.6	ND	ND	ND	ND	ND	ND	1.9	12.9	ND	ND
		Maximum	ND	ND	3.4	19.1	ND	ND	ND	ND	ND	ND	11.0	74.5	ND	ND
		Minimum	ND	ND	1.7**	9.5**	ND	ND	ND	ND	ND	ND	1.5	10.2	ND	ND
		Confidence	ND	ND	0.3	1.4	ND	ND	ND	ND	ND	ND	1.0	7.0	ND	ND
NRF-1MW1-3		Baseline	ND	ND	**8.5**	**47.7**	ND	ND	**4**	**19.5**	ND	ND	**580**	**3926.2**	**29**	**155.5**
		Mean	<<	<<	<3.3	<18.7	ND	ND	<2.1	<10.1	<1.9	<10.2	342.6	2319	19.4	104.1
		Std Dev.	<<	<<	1.8	10.1	ND	ND	1.4	6.7	1.1	5.9	123.7	837.4	5.3	28.4
		Maximum	5.1	25.2	7.1*	39.8*	ND	ND	5.3	25.8	4.0	21.8	616.0	4169.9	30.0	160.9
		Minimum	ND	ND	1.2**	6.7**	ND	ND	ND	ND	ND	ND	73.0	494.2	8.1	43.4
		Confidence	<<	<<	1.0	5.5	ND	ND	0.8	3.7	0.6	3.2	67.2	455.2	2.9	15.5
NRF-1 MW1-4		Baseline	**5.3**	**26.2**	**1.7****	**9.5****	**2.2**	**16.8**	ND	ND	ND	ND	**120**	**812.3**	**2.9**	**15.6**
		Mean	13.3	65.7	<1.9	<11.6	<1.5	<11.4	<<	<<	ND	ND	249.9	1691.9	<4.3	<22.8
		Std Dev.	9.1	44.9	0.9	4.9	1.2	8.8	<<	<<	ND	ND	113.5	768.1	1.3	6.7
		Maximum	43.0	212.2	4.3	24.1	3.9	29.8	4.7	22.9	ND	ND	560	3790.9	7.5	40.2
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72.0	487.4	1.9**	10.2**
		Confidence	4.9	24.4	0.5	2.7	0.6	4.8	<<	<<	ND	ND	61.7	417.5	0.7	3.7

** = Estimated quantities above the Method Detection Limit but below the standard Laboratory Reporting Limit, * = Excludes Baseline Data, ND = Not Detected above the Method Detection Limit

< = Mean includes estimated values below the Reporting Limit, << = Most values below Reporting Limit thus no calculations were performed

Table 6-6 Soil Gas Data Summary for Site NRF-51

Site / Sample Location	Statistical Parameter	Freon 12 (ppbv)	Freon 12 µg/m3	Freon 11 (ppbv)	Freon 11 µg/m3	Freon 113 (ppbv)	Freon 113 µg/m3	Chloroform (ppbv)	Chloroform µg/m3	1,1,1-Trichloroethane (ppbv)	1,1,1-Trichloroethane µg/m3	Tetrachloroethylene (ppbv)	Tetrachloroethylene µg/m3	Trichloroethylene (ppbv)	Trichloroethylene µg/m3
Overall Maximum Track 2 Data		**ND**	**ND**	**10.0**	**56.1**	**5.3**	**40.5**	**19.0**	**92.6**	**83.0**	**452.0**	**1400.0**	**9477.1**	**16.0**	**85.8**
NRF-51 MW51-1	Baseline	ND	ND	15	84.1	ND	ND	2.7	13.2	6.3	34.3	22	148.9	ND	ND
	Mean	ND	ND	<6.3	<35.3	ND	ND	<<	<<	<2.7	<14.9	13.2	89.5	ND	ND
	Std Dev.	ND	ND	3.7	20.5	ND	ND	<<	<<	1.7	9.1	5.6	37.9	ND	ND
	Maximum	ND	ND	14*	78.5*	ND	ND	2.7	13.2	7.8	42.5	29.0	196.3	ND	ND
	Minimum	ND	ND	1.5**	8.4**	ND	ND	ND	ND	ND	ND	5.7	38.6	ND	ND
	Confidence	ND	ND	1.0	5.7	ND	ND	<<	<<	0.5	2.6	1.6	10.6	ND	ND
NRF-51 MW51-2	Baseline	ND	ND	**16**	89.7	ND	ND	**2.3**	11.2	**6.6**	35.9	23	155.7	ND	ND
	Mean	ND	ND	<6.5	<36.7	ND	ND	<1.6**	<7.7**	<3.3	<17.7	13.8	93.3	<<	<<
	Std Dev.	ND	ND	3.7	20.9	ND	ND	0.8	3.9	1.8	9.8	4.6	31.0	<<	<<
	Maximum	ND	ND	15*	84.1*	ND	ND	2.9	14.1	8.4	45.7	23.0	155.7	10	53.6
	Minimum	ND	ND	1.7**	9.5**	ND	ND	ND	ND	ND	ND	3.2	21.7	ND	ND
	Confidence	ND	ND	1.0	5.9	ND	ND	0.2	1.1	0.5	2.7	1.3	8.7	<<	<<
NRF-51 MW51-3	Baseline	ND	ND	**13**	72.9	ND	ND	ND	ND	**4.8**	26.1	19	128.6	ND	ND
	Mean	ND	ND	<3.9	<21.8	ND	ND	ND	ND	<1.6	<8.7	<9.0	<60.6	<<	<<
	Std Dev.	ND	ND	2.9	16.1	ND	ND	ND	ND	1.3	7.3	4.3	29.4	<<	<<
	Maximum	ND	ND	11*	61.7*	ND	ND	ND	ND	5.7	31.0	21	142.2	4	21.5
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Confidence	ND	ND	0.8	4.5	ND	ND	ND	ND	0.4	2.0	1.2	8.2	<<	<<
NRF-51 MW51-4	Baseline	ND	ND	**16**	89.7	ND	ND	**2.6**	12.7	6	32.7	26	176.0	ND	ND
	Mean	ND	ND	<5.1	<28.5	ND	ND	<<	<<	<2.2	<11.7	11.6	78.8	<<	<<
	Std Dev.	ND	ND	3.6	20.3	ND	ND	<<	<<	1.7	9.4	6.0	40.4	<<	<<
	Maximum	ND	ND	14*	78.5*	ND	ND	2.6	12.7	7.0	38.1	24*	162.5*	94	504.1
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Confidence	ND	ND	1.0	5.7	ND	ND	<<	<<	0.5	2.6	1.7	11.3	<<	<<

** = Estimated quantities above the Method Detection Limit but below the standard Laboratory Reporting Limit, * = Excludes Baseline Data, ND = Not Detected above the Method Detection Limit at or above the reporting limit
< = Mean includes estimated values below the Reporting Limit, << = Most values below Reporting Limit thus no calculations were performed

Table 6-7 Soil Gas Data Summary for Site NRF-53

Site / Sample Location	Statistical Parameter	Freon 12		Freon 11		Freon 113		Chloroform		1,1,1-Trichloroethane		Tetrachloroethylene		Trichloroethylene	
Overall Maximum Track 2 Data		(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3
		ND	**ND**	**10.0**	**56.1**	**5.3**	**40.5**	**19.0**	**92.6**	**83.0**	**452.0**	**1400.0**	**9477.1**	**16.0**	**85.8**
NRF-53 MW53-1	Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**5.2**	**35.2**	ND	ND
	Mean	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	<1.8**	<12.4**	<<	<<
	Std Dev.	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	0.9	5.9	<<	<<
	Maximum	ND	ND	ND	ND	ND	ND	ND	ND	2.6	14.2	4.4*	29.8*	3.5	18.8
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Confidence	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	0.5	3.2	<<	<<
NRF-53 MW53-2	Baseline	ND	ND	**6.7**	**37. 6**	ND	ND	ND	ND	ND	ND	**24**	**162.5**	ND	ND
	Mean	ND	ND	<1.6**	<9.0**	ND	ND	ND	ND	<<	<<	<15.9	<107.8	<<	<<
	Std Dev.	ND	ND	1.1	6.1	ND	ND	ND	ND	<<	<<	5.2	35.3	<<	<<
	Maximum	ND	ND	3.5*	19.6*	ND	ND	ND	ND	2.1	11.4	27.0	182.8	2.3	12.3
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1**	7.4**	ND	ND
	Confidence	ND	ND	0.6	3.2	ND	ND	ND	ND	<<	<<	2.8	19.2	<<	<<
NRF-53 MW53-3	Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Std Dev.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Maximum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Confidence	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NRF-53 MW53-4	Baseline	ND	ND	**2.1**	**11.8**	ND	ND	ND	ND	ND	ND	**3.6**	**24.4**	ND	ND
	Mean	ND	ND	<<	<<	ND	ND	ND	ND	<<	<<	<2.3	<15.4	<<	<<
	Std Dev.	ND	ND	<<	<<	ND	ND	ND	ND	<<	<<	1.0	7.0	<<	<<
	Maximum	ND	ND	2.2	12.3	ND	ND	ND	ND	4.6	25.1	5.1	34.5	6.5	34.9
	Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7**	4.7**	ND	ND
	Confidence	ND	ND	<<	<<	ND	ND	ND	ND	<<	<<	0.3	2.0	<<	<<

** = Estimated quantities above the Method Detection Limit but below the standard Laboratory Reporting Limit, ND = Not Detected above the Method Detection Limit at or above the reporting limit,* = Excludes Baseline Data
< = Mean includes estimated values below the Reporting Limit
<< = Most values below Reporting Limit thus no calculations were performed

Table 6-7 Soil Gas Data Summary for Site NRF-53 (Continued)

Site	Sample Location	Statistical Parameter	Freon 12		Freon 11		Freon 113		Chloroform		1,1,1-Trichloroethane		Tetrachloroethylene		Trichloroethylene	
			(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3	(ppbv)	µg/m3
Overall Maximum Track 2 Data			**ND**	**ND**	**10.0**	**56.1**	**5.3**	**40.5**	**19.0**	**92.6**	**83.0**	**452.0**	**1400.0**	**9477.1**	**16.0**	**85.8**
NRF-53 MW53-5		Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**6**	**40.6**	ND	ND
		Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<2.5	<16.9	<<	<<
		Std Dev.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.2	7.9	<<	<<
		Maximum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.9*	39.9*	8.2	44.0
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0**	6.8**	ND	ND
		Confidence	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	2.2	<<	<<
NRF-53 MW53-6		Baseline	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**9.9**	**67.0**	ND	ND
		Mean	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	<5.0	<33.7	<<	<<
		Std Dev.	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	2.1	14.4	<<	<<
		Maximum	ND	ND	ND	ND	ND	ND	ND	ND	29	157.9	11.0	74.5	45	241.4
		Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.9**	12.9**	ND	ND
		Confidence	ND	ND	ND	ND	ND	ND	ND	ND	<<	<<	0.6	4.0	<<	<<

** = Estimated quantities above the Method Detection Limit but below the standard Laboratory Reporting Limit
ND = Not Detected above the Method Detection Limit at or above the reporting limit
* = Excludes Baseline Data
< = Mean includes estimated values below the Reporting Limit
<< = Most values below Reporting Limit thus no calculations were performed

6.3.3.3 Trend Analysis

The baseline and 1997-2010 analytical data were plotted as concentration versus time (sample collection date) to evaluate any specific patterns, trends, or anomalies. Trends were established by analyzing the concentration of constituents over the entire sample collection period (1997-2010). The analysis of the trends was a qualitative assessment used to identify acceptable trends (stable or decreasing) or future potential problems (increasing). With reference to specific patterns in the graphical representation of the soil gas data, coincident peaks or dips may be attributed to one or more of the following factors: seasonal events (i.e., changes in precipitation or increased infiltration of water from snowmelt), effects of water infiltration within the periphery of the cover on contaminant migration, significant variations in barometric pressure, and chemical-specific characteristics affecting migration patterns. In order to explain the dissimilarity in trends between NRF-1 soil gas data and data from the other two sites, some of the factors that were explored in this section, specific to NRF-1, are the infiltration of water within the periphery of the cover, and contaminant migration.

Soil gas concentrations for all constituents for all sites except NRF-1 are trending downward. NRF-1 is the only site that experienced an overall increasing trend for tetrachloroethylene and trichloroethylene (at one location) during the 1997 through 2010 sampling period. Details related to these trends are discussed below.

Perched water has been observed at NRF-53 and NRF-1 in the past. These zones have been of limited areal extent and occur only during times of extended precipitation or periods of rapid snow melt. Pooling of storm or melt-water which occurs in low lying areas adjacent to the covers probably results from inadequate drainage. Water located at the periphery of the covers may enter the waste layer laterally from these low lying areas. Percolating water from natural precipitation may acquire soluble organic components that have been immobilized by adsorption in the soil or that are contained in the waste by processes of desorption and/or dissolution. These organic compounds can be transported a certain distance away from the original source and then become immobilized again (Everett, 1984); the organic compounds can then evaporate and become a new source for soil gases or supplement an existing source.

The depth to the top of the basalt in the general area of NRF-1 appears to increase from northeast to southwest along the southern portion of NRF-1. Thus, contaminants within the waste layer, if mobilized, could migrate toward MW1-4. From historical reviews of documents, photos, and old drawings, the bulk of the waste is located on the southern half of NRF-1 (just to the northwest of MW1-3, which is the probe closest to the waste). Because of the location of the bulk of the waste and the subsurface features, it is possible for some migration to occur in the direction of MW1-4. The discussion above would explain the increasing trends in tetrachloroethylene and trichloroethylene at this location. However, the analytical data trend for tetrachloroethylene for NRF-1 (see Figure 6-10) indicates that the tetrachloroethylene concentrations at MW1-3 (where a decreasing trend is exhibited) and MW1-4 (where an increasing trend is exhibited) have crossed and appears that MW1-4 data continues to exhibit an increasing trend whereas MW1-3 data continues to trend downward (although it appears that the concentrations at MW1-3 are leveling off beginning in 2007).

The divergent trends in the data associated with locations MW1-3 and MW1-4 indicate there could be some migration of tetrachloroethylene away from the cover area toward the southwest. This trend will be monitored in future years to see if the concentration in MW1-4 approaches the overall maximum concentration detected during the Track 2 Investigation. With regard to trichloroethylene, the concentration at MW1-4 is significantly lower than at sample locations MW1-1 and MW1-3. Trichloroethylene levels at MW1-1, where the highest concentrations have been detected of all sample locations, appear to exhibit a slight downward trend (see Figure 6-11).

NRF-51 and NRF-53 exhibit either stable or decreasing trends (both indicating that the covers are functioning as designed).

6.3.3.4 Comparison to Groundwater Data

Of the VOCs detected under the current soil gas and groundwater monitoring programs, only tetrachloroethylene was detected under both. This organic compound has been frequently detected in groundwater samples from well NRF-6 at trace levels. Well NRF-6 is located approximately 1,400 feet northwest of the inactive landfill NRF-1, 1,400 feet northeast of NRF-51 and 1,800 feet due west of NRF-53. No known migration pathway would account for the presence of the organic compounds in the well NRF-6 suggesting that organic compounds are not significantly migrating from the landfill sites at this time. See Section 6.2.3.2 for additional discussion of organic compounds detected in NRF-6.

6.3.4 Soil Moisture Monitoring

6.3.4.1 Soil Moisture Monitoring Results

Soil moisture measurements were initiated in 2005. A discussion of the soil moisture data from measurements obtained from neutron access tubes located at the OU 8-08 Engineered Cover Sites is presented below.

6.3.4.2 Analysis of Soil Moisture Data

Soil moisture content within the engineered cover at each site is estimated by obtaining measurements from a neutron probe via access tubes that were installed on the three engineered cover areas during their construction in 2004. The soil moisture data is used to assess the effectiveness of the covers in mitigating water infiltration to the contaminant zone. This is accomplished by evaluating the covers' water storage capacity; specifically, by monitoring the depth of the wetting front attributed to percolating water from precipitation. The soil moisture measurement data raw counts, obtained from the neutron probe instrumentation, have been converted to volumetric water content in percent.

For the 2006-2010 period, soil moisture measurements were typically taken in April through October. The soil moisture data obtained during the 2006-2010 period indicate that 2006 and 2010 had the highest near surface water content. In addition, 2006, 2009, and 2010 were above normal precipitation. Water content variations (caused by percolating water through the cover from precipitation and evapotranspiration) were rapidly dampened with depth as evidenced in the graphical representation of the data. The percolating water or wetting front (represented by curve separation between April and October at shallow depths) for any given year during this period, did not reach the engineered covers’ subsurface layer (as represented by relatively no separation in the curves at deeper depths, typically below 3.5 feet) and, therefore, did not migrate into the contaminant layer. Most of the soil moisture stored within the cover, from the seasonal precipitation, was removed from the soil via evapotranspiration. The graphical representation of the latest soil moisture data from 2010 are presented in Figure 6-12. Data from previous years have been documented in the annual ICMR. Data in future years will further refine any trends regarding moisture penetration.

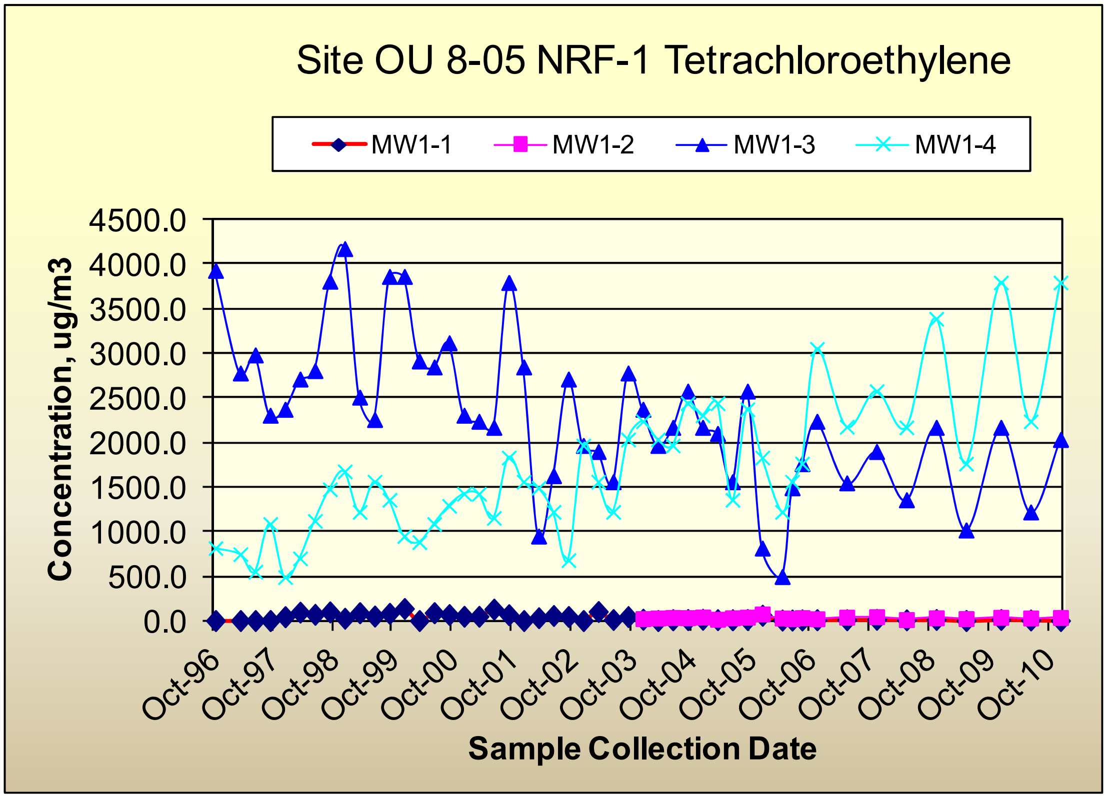


Figure 6-10 Tetrachloroethylene Concentrations for Site NRF-1

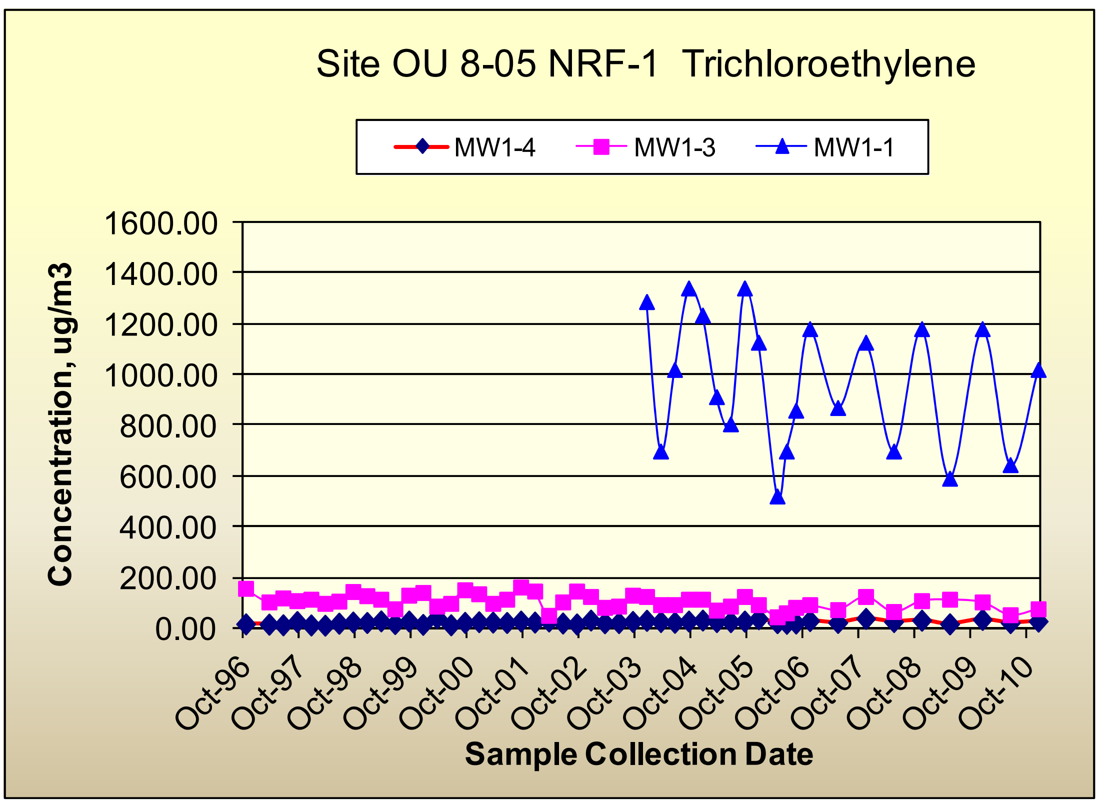
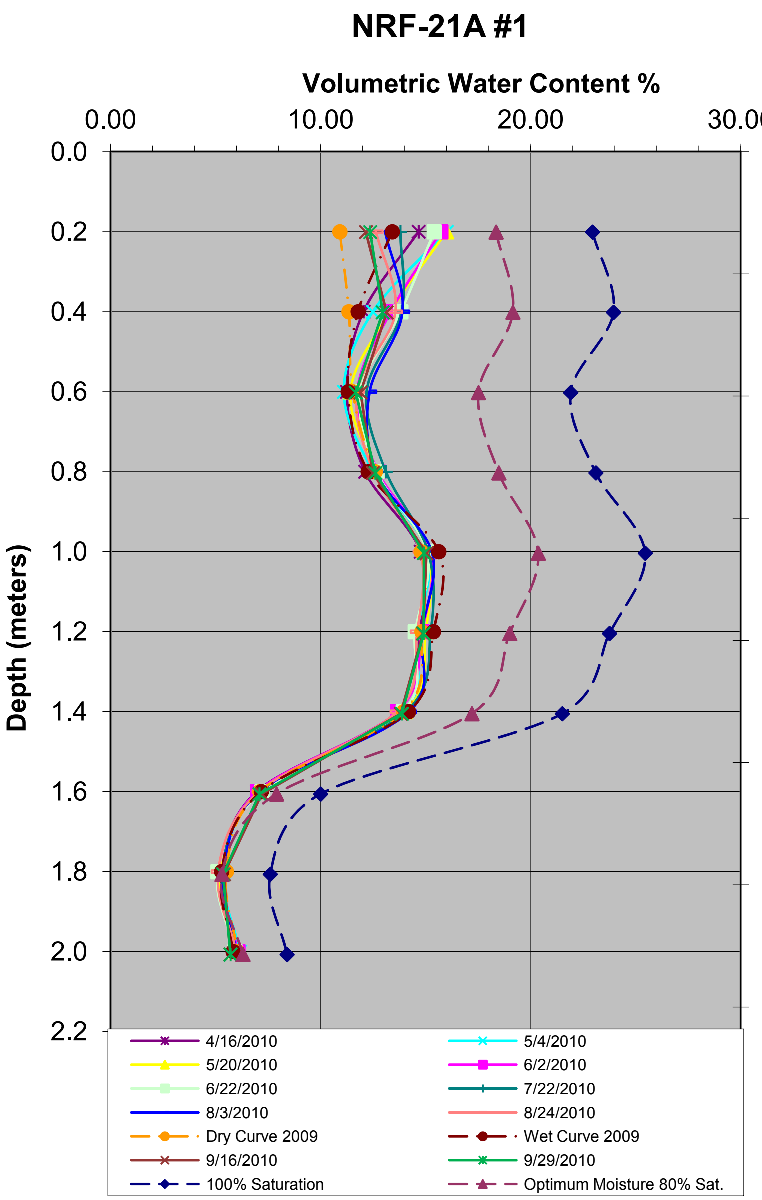
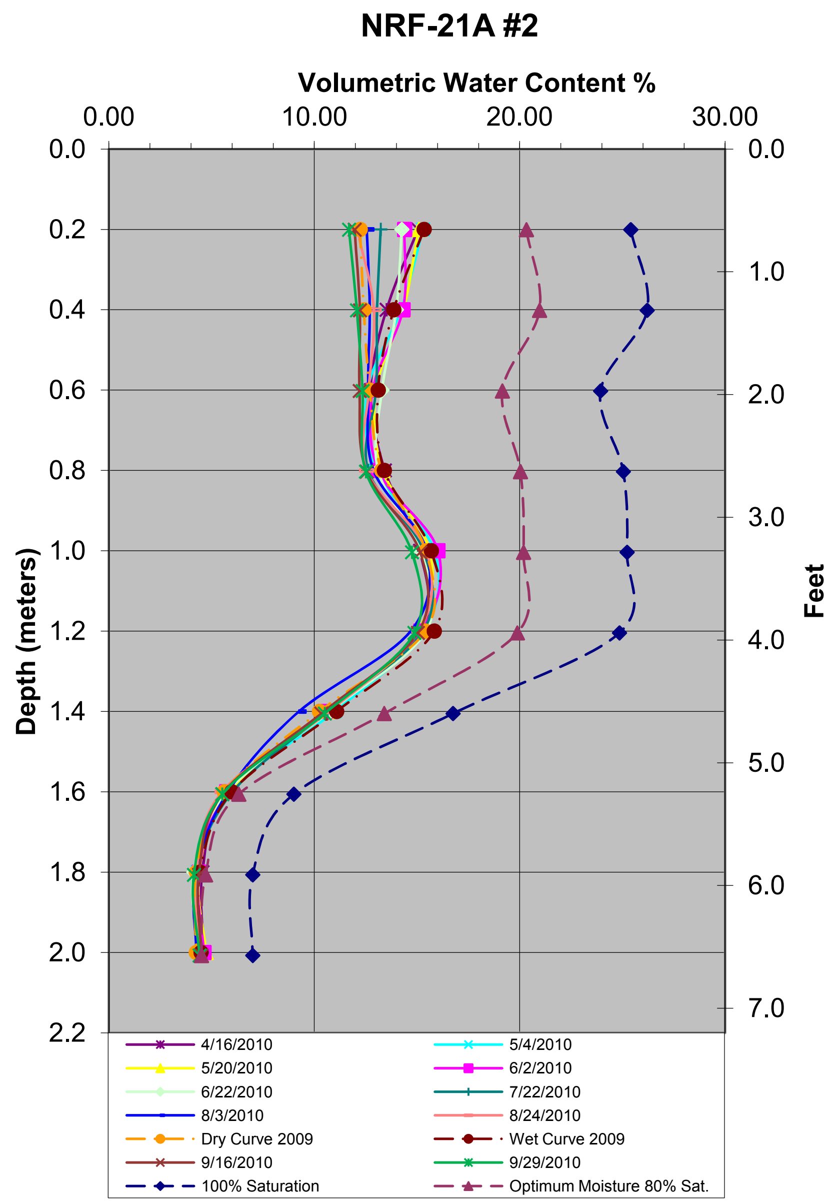
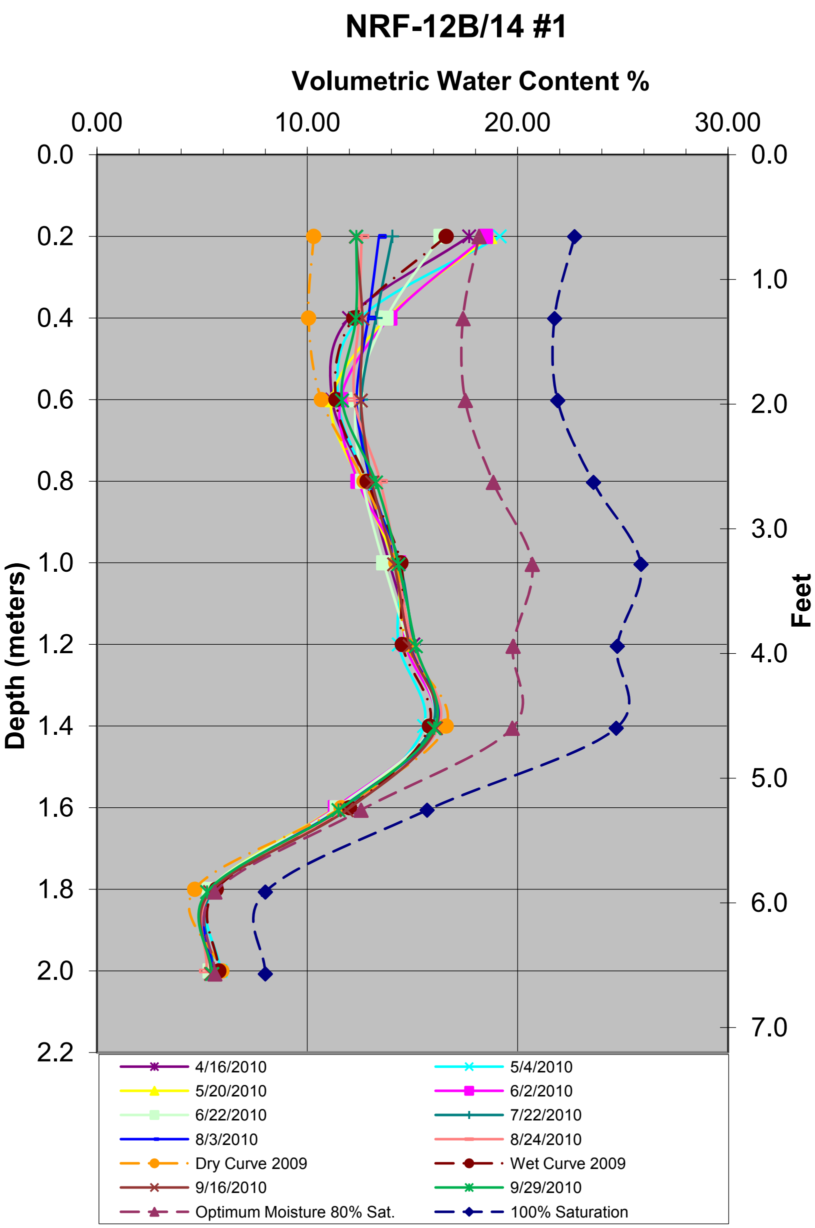
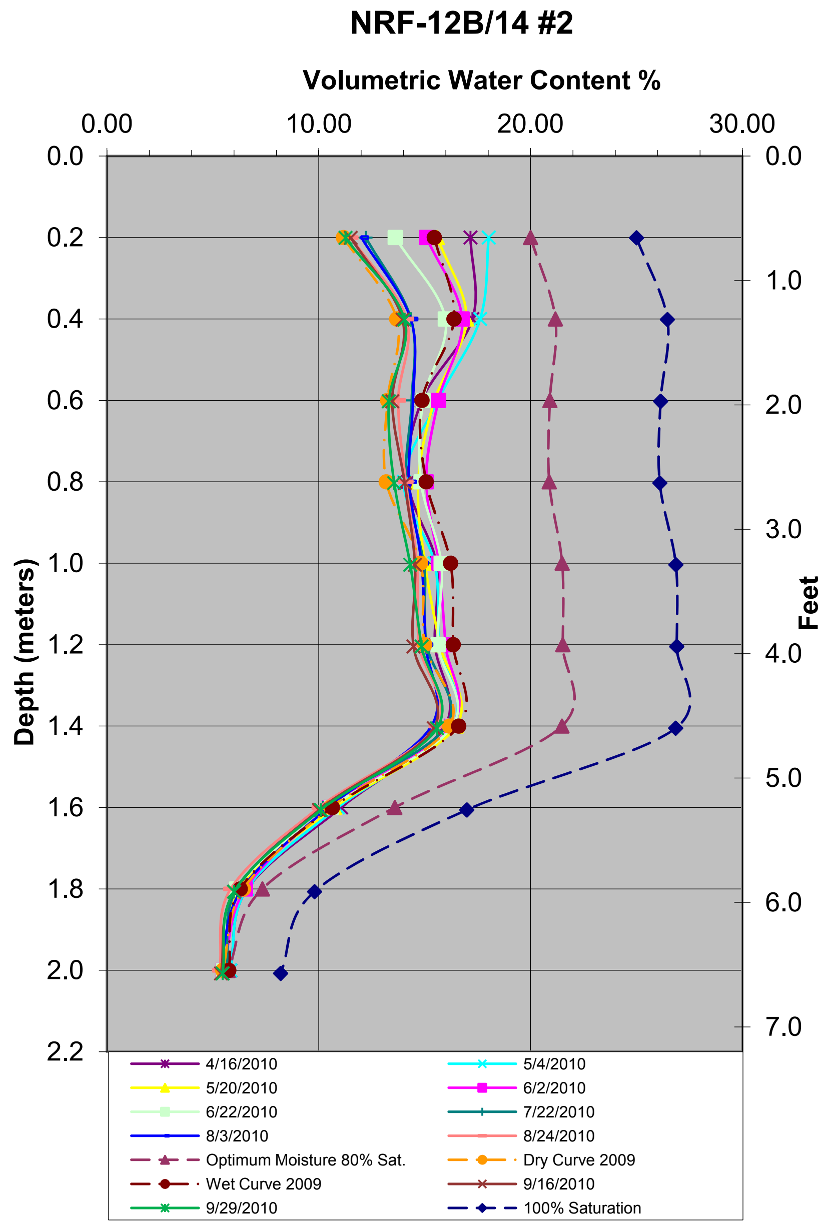


Figure 6-11 Trichloroethylene Concentrations for Site NRF-1


NRF-21A #1
Volumetric Water Content %
0.00
10.00
20.00
30.00
Depth (meters)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Feet
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
4/16/2010
5/4/2010
5/20/2010
6/2/2010
6/22/2010
7/22/2010
8/3/2010
8/24/2010
Dry Curve 2009
Wet Curve 2009
9/16/2010
9/29/2010
100% Saturation
Optimum Moisture 80% Sat.


NRF-21A #2
Volumetric Water Content %
0.00
10.00
20.00
30.00
Depth (meters)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Feet
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
4/16/2010
5/4/2010
5/20/2010
6/2/2010
6/22/2010
7/22/2010
8/3/2010
8/24/2010
Dry Curve 2009
Wet Curve 2009
9/16/2010
9/29/2010
100% Saturation
Optimum Moisture 80% Sat.


NRF-12B/14 #1
Volumetric Water Content %
0.00
10.00
20.00
30.00
Depth (meters)
Feet
4/16/2010
5/4/2010
5/20/2010
6/2/2010
6/22/2010
7/22/2010
8/3/2010
8/24/2010
Dry Curve 2009
Wet Curve 2009
9/16/2010
9/29/2010
Optimum Moisture 80% Sat.
100% Saturation


NRF-12B/14 #2
Volumetric Water Content %
0.00
10.00
20.00
30.00
Depth (meters)
Feet
4/16/2010
5/4/2010
5/20/2010
6/2/2010
6/22/2010
7/22/2010
8/3/2010
8/24/2010
Optimum Moisture 80% Sat.
Dry Curve 2009
Wet Curve 2009
9/16/2010
9/29/2010
100% Saturation

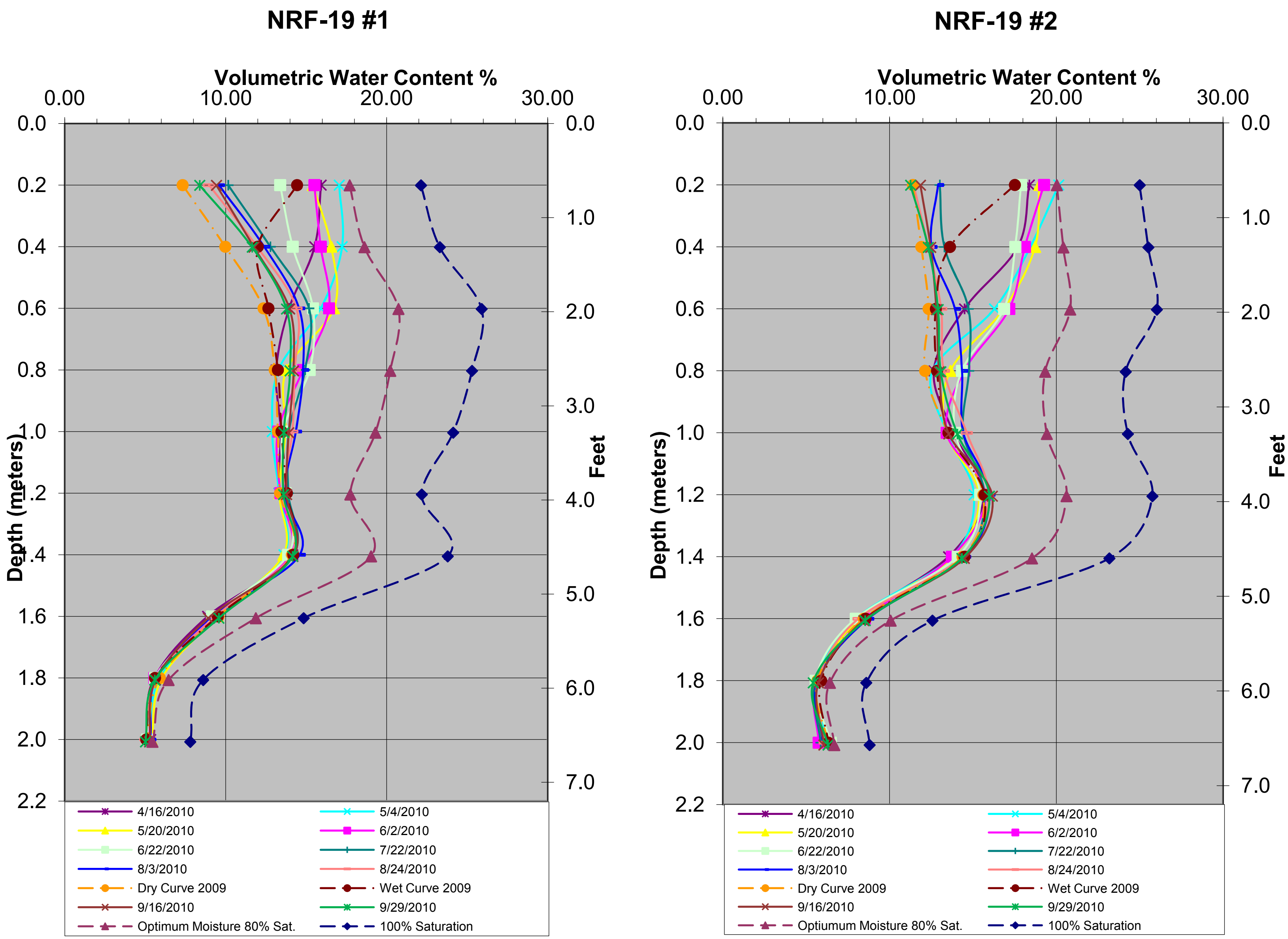


Figure 6-12 Soil Moisture Curves for OU 8-08 Engineered Cover Sites -2010

6.3.5 Ecological Monitoring

Currently, NRF obtains analytical radiological data from annual soil and vegetation samples that are collected in support of the NRF Environmental Monitoring Program. The sampling areas include uncontaminated areas, a few potentially contaminated areas, and areas where remedial actions have taken place.

Analytical data and effects data were also collected from 10 sample plots around NRF in 2007 in cooperation with the INL and by INL personnel to determine if adverse effects to plants and wildlife are occurring on the INL. Analytical data were obtained from soil, subsurface soil and vegetation samples. The types of effects data that were obtained included kidney-to-body-weight and liver-to-body-weight ratios, liver and kidney histopathology, earthworm and seedling soil toxicity testing, avian population, reptile population, plant population, small mammal population, and soil fauna. These data for 2007 are summarized and compiled in the INL Long-Term Ecological Monitoring Report (DOE/ID 2011) that covers the period 2003-2008.

The data obtained from the NRF ecological monitoring program and from the 2007 INL ecological sampling conducted in support of the INL long-term ecological monitoring program indicate that the remedies implemented at NRF are protective of the environment (which includes ecological receptors).

6.4 Review of ARARs

The selected remedies for the OU 8-05/06 and 8-08 Sites were designed to meet substantive aspects of the Applicable or Relevant and Appropriate Requirements (ARARs) identified in the ROD. The following are the pertinent ARARs that were defined for the selected remedies, and which were reviewed for changes that could affect protectiveness:

- 40 CFR 61.92, NESHAPS for Emissions of Radionuclides Other than Radon, (Applicable)
- IDAPA 58.01.01.585 & .586, Toxic Air Pollutants, Non-Carcinogenic and Carcinogenic, (Applicable to work where potential release of these substances exists)
- IDAPA 58.01.11.200.01(a), Idaho Groundwater Quality Standards, (Relevant and Appropriate)
- IDAPA 58.01.05.006.01(40 CFR 262.1), Standards Applicable to Generators of Hazardous Waste, (Applicable to work generating hazardous waste) IDAPA 58.01.05.005 (40 CFR 261), Identification and Listing of Hazardous Waste, (Applicable to work generating hazardous waste)
- IDAPA 58.01.05.011 (40 CFR 268.7, .9, .40, .45, .48) Land Disposal Restrictions, (Applicable to work generating hazardous waste)
- IDAPA 58.01.01.651, Rules for Control of Fugitive Dust, (Applicable)
- IDAPA 58.01.05.008 (40 CFR 264.309(a), 40 CFR 264.310(a)(1)(2)(3)(4)(5), and .310.(b)(1)(4)(5)(6)), Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (Surveying, Closure, and Post Closure Care for Landfills), Relevant and Appropriate
- 40 CFR 300.440, Procedures for Planning and Implementing Off-site Response Actions (Applicable to work that involves off-site transfer of CERCLA waste)
- 16 USC 470, National Historic Preservation, (Applicable to any site where cultural, historical artifacts are found)

These ARARs have not become more stringent since the signing of the ROD.

6.5 Risk Information Review

Based on the EPA five-year review guidance, risk parameters (toxicity values) used in the risk assessment at the time of the remedy selection should be reviewed for changes to determine whether the selected remedy is still protective. Therefore, an evaluation of the toxicity data was conducted to see whether any changes had occurred and whether the changes were significant enough to affect the remedy selection.

Toxicity values (slope factors and reference doses) and risk-based concentrations (RBCs, also known as preliminary remediation goals (PRGs)) used in the initial risk assessments performed for the CERCLA sites were reviewed for any updated values that may have been published since the time the remedy selection was implemented. Slope factors are used to calculate PRGs for use in screening and developing cleanup goals.

The PRGs and the methodology used to develop them are presented at the following website: http://epa-prgs.ornl.gov/radionuclides/. The original toxicity values and PRGs were compared to the newest values available from published sources (e.g., Integrated Risk Information System, the Health Effects Assessment Summary Table, and other sources).

For this review, the toxicity values and the PRGs for the contaminants of concern were evaluated. Only cesium-137, which was the primary risk driver for remedial actions and implementation of institutional controls at NRF, is discussed since the other contaminants of concern at NRF (e.g., plutonium-238, uranium-235, Aroclor-1242, etc.) were found in insignificant quantities, not detected during site cleanup operations, or the selected remedy for the site was containment by using an engineered native soil cover.

The slope factor and EPA PRG for cesium-137 have changed since the remediation goal of 16.7 pCi/g was established in the Final NRF ROD. The EPA calculations for PRGs include the use of a gamma-shielding factor and an area correction factor that provides for a more realistic assessment of exposure. Because of this improved approach, the new slope factor and PRG should provide a more accurate evaluation of risk. These changes could also affect when an area can be released from institutional controls for unrestricted use.

The revised EPA PRG for cesium-137 for the current residential scenario at the 1E-04 risk level is 6.15 pCi/g (based on the 2010 radionuclides table at the epa-prgs.ornl.gov website). This would represent a present day remediation goal for cesium-137 of 42 pCi/g, which is the level cesium-137 would have to be remediated today to allow a site to be free released for unrestricted use in 2095 (the assumed timeframe that NRF would remain under government control). The NRF remediation goal of 16.7 pCi/g established in the ROD is much more conservative. The 6.15 pCi/g cesium-137 would also represent the present day value that would allow removal of institutional controls from those sites where residual cesium-137 exists (assuming there are no other risk drivers). At NRF, several NFA sites require institutional controls due to the presence or possible presence of cesium-137. Because of the changes identified above, several NFA sites at NRF are re-evaluated in Appendix A with recommendations based on the re-evaluation provided in Section 9.0.

7.0 Data Assessment

7.1 Conditions External to the Remedy

Certain conditions external to a selected remedy can have a far-reaching influence on the applicability and the ultimate success of a chosen remedy. These conditions are discussed below.

7.1.1 Changes in Land Use or Projected Land Use

NRF does not anticipate that the land area within WAG 8 will be subject to leasing or property transfer through at least the year 2095 (100 years from initial risk assessments performed at NRF).

ICs are required as long as land use or access restrictions are necessary to maintain protection of human health and the environment. The adequacy of, and need for, the continued use of ICs for each controlled area will be evaluated during the annual inspections and the Five-Year Review process. ICs will not be changed or terminated unless NR/IBO, IDEQ, and EPA have concurred.

7.1.2 New Contaminants, Sources, or Pathway

New contaminants have not been observed in groundwater since the 2006 Five-Year Review.

Climatic changes (e.g., more or less precipitation) and changes in local discharge contribute to changing groundwater flow paths beneath NRF. For example, reduced flow to the IWD may be contributing to a reduction in elevation of a local groundwater high east of NRF, which was identified in past hydrogeological investigations. These changes could potentially impact groundwater flow paths; however, if any of these changes lead to new contaminant pathways, the current groundwater monitoring network should be capable of detecting them.

7.2 Remedy Implementation and System Operations

7.2.1 Access and Institutional Controls

Access to NRF remedial action areas is restricted from the general public as enforced by the INL security program (e.g., badges required for site access). Furthermore, NRF security personnel monitor access within the NRF fence and monitor actions in nearby areas outside the fence. A number of the NRF CERCLA sites, which are located both inside and outside the NRF fenced compound, are contained within specific fenced areas with locked gates. Other sites are marked by warning signs. Excavation controls are enforced by use of formal excavation permits which are required before any excavation, both inside and outside of the NRF security fence may begin. These permits require the review and formal approval of Environmental Personnel prior to performing the excavation.

ICs used at NRF preserve the underlying assumptions of RI/FSs developed for WAG 8 that will protect human health and the environment. The ICs are selected remedies for the NFA Sites, and are part of the selected remedies for the NRF Inactive Landfill Areas and the RA Sites. ICs are reviewed annually and the results of the reviews are documented in the ICMR. Table 7-1 summarizes Land Use Controls applicable to the NRF CERCLA sites. Land Use Controls which may include Institutional Controls are discussed in more detail in the Institutional Control Plan (Attachment E to the NRF OU 8-08 Remedial Action Report (BBI, 2006)).

7.2.2 Remedy Performance

7.2.2.1 Landfill Covers

The performance of the landfill covers was indirectly measured in several ways. First, visual inspections confirmed the physical integrity of the covers. These inspections were intended to identify the following problems: occurrence of soil erosion, establishment of adequate and appropriate vegetative cover, penetration of the cover by various burrowing animals, or formation of cracks in the cover due to temperature extremes, drought, or subsidence. The results of past inspections showed that the integrity of the landfills was maintained, thus indicating that the covers were performing as designed. Minor deficiencies are occasionally noted, as identified in ICMRs, such as rodent holes and/or anthills at all three sites. Deficiencies related to the landfill covers are addressed in more detail in Section 8.2.

The second measure of performance was gauged by results of surface soil gas monitoring. If the landfill covers are working as designed, then little or no organic vapors will be detected at the surface of the landfill covers. A number of soil gas surface emissions surveys have been performed since the construction of the landfill covers. No VOCs have been detected, thereby indicating the landfill covers are performing as designed.

Finally, several other indirect indicators were used to assess the performance of landfill covers. The soil gas monitoring probes measure the concentration of soil gas at the bedrock interface adjacent to the covers. The concentrations of soil gas constituents are on a decreasing trend or essentially stable in all soil gas monitoring probes locations with the exception of one soil gas monitoring probe location where some constituents are exhibiting an upward trend. To date, no unusual levels of organic compounds have been detected in soil gas probes, and no appreciable concentrations of organic compounds have been detected in groundwater samples. Based on survey results contained in the annual ICMRs, and soil gas and groundwater monitoring data, this Five-Year Review concludes that the landfill covers are functioning as designed.

7.2.2.2 Groundwater Monitoring System

Four aspects of the current groundwater monitoring system are assessed to determine its overall performance. These aspects include fitness of the wells, monitoring network fitness, constituents monitored, and sampling frequency. The data collected by the NRF groundwater monitoring program are used to assess remedy performance of all remedial actions at NRF and insure that these remedies remain protective of human health and the environment.

7.2.2.2.1 Well Fitness

NRF has 11 wells in its groundwater monitoring network (NRF-6, 8, 9, 10, 11, 12, 16, USGS 97, 98, 99, and 102). Eight of these wells have been constructed within the past 20 years (all but USGS 97, 98, 99) using modern drilling and construction techniques. These wells were built with environmentally inert materials (e.g., stainless steel) and were designed to target the upper 50 feet of the aquifer. The older wells (constructed between 1950 and 1980) still provide usable data; however, they are not optimally constructed for specifically monitoring the upper 50 feet of the aquifer (wells USGS 97, 98, and 99). Additionally, problems such as inadequate grouting and carbon steel in contact with aquifer water may be encountered. Some of these problems were addressed when USGS 98 was refurbished in 2005 and USGS 97 was refurbished in 2006.

Well NRF-6 was refurbished in 2004 and then again in 2010. The first refurbishment was in response to sedimentation and corrosion issues as well as mechanical failure of the pump motor. As a result, the pump and motor were raised by five feet in the well when it was replaced. Although there currently is ample water over the pump intake (approximately 20.5 feet), with falling water levels in the SRPA, care must be taken so that this well does not go dry in the future. The second refurbishment was in response to rising chromium concentrations in water samples, only part of which was attributable to sedimentation issues. Additional care will be taken to ensure that any signs of future silting around the pump/motor assembly are noted and responded to as needed. Signs may include muddy purge water, over-amperage indications at the generator while running the motor, or abnormal or erratic sample results.

Early in 2007, in response to issues associated with NRF-13, NRF proposed constructing a new upgradient monitoring well. This well was to be placed in a location that was both upgradient to, and as close to NRF as possible without being affected by NRF activities. Because of uncertainty in hydrogeological processes at NRF, a phased approach was chosen to locate the well. The initial location for the new well (designated NRF-15) was rejected because water samples contained elevated levels of chloride and sulfate indicating influence by the IWD. A new location approximately one mile north of NRF-15 was chosen for the upgradient well. The new location was designated NRF-16. Work at the alternate upgradient well location (NRF-16) began in early August 2009 and was competed prior to the collection of the second semester samples in November 2010.

Samples were collected from NRF-16 starting in November 2009 on a quarterly basis. NRF-16 was accepted as the upgradient monitoring well for NRF in November 2010 and samples were then collected semi-annually. Results collected from NRF-16 through May 2011 were compared to background and MCL concentrations. All data collected from NRF-16 have been consistent since its construction and with few exceptions (e.g., magnesium, potassium, selenium, and nitrite), all NRF-16 average values are less than the regional background concentrations that were calculated using USGS 12 and NRF-7 data. A completion report for this well was issued by the USGS in mid 2010 (SIR 2010-5101). Information contained in the completion report and sample results indicate that NRF-16 is a suitable replacement well for USGS 12 and NRF-7.

NRF routinely inspects the NRF wells and performs required maintenance. Currently, NRF plans to inspect and refurbish wells on a routine basis. Regulatory agencies will be notified whenever significant modifications appear appropriate, such as deepening wells or changing the intake depth.

7.2.2.2.2 Network Fitness

The locations of the Local Downgradient wells, NRF-8, -9, -10, -11, and -12, exclusive of USGS 102 (already in place prior to construction of the other wells), which are the core of the NRF groundwater monitoring network, were designed using computer based modeling. Groundwater results as well as hydrogeologic evidence collected over the past several years indicate these wells adequately and effectively monitor for potential groundwater contaminants. For example, these wells have detected contamination (below MCLs) in locations where it is logical to do so (e.g., low levels of tritium in NRF-10 and -11, which are downgradient of OU 8-08 sites). Also, the results from the Regional Downgradient wells (USGS 97, -98, and -99) substantiate the results from the Local Downgradient wells (NRF-8, -9, -10, -11, -12, and USGS 102). Furthermore, as discussed in Section 6.3, the timing and distribution of peaks in concentrations of various constituents confirm these assertions.

Historically, the upgradient groundwater quality relative to NRF was not well defined. In the past, NRF averaged NRF-7 data with the data collected from USGS 12 and referred to these data as “Regional Upgradient”. The regional background results shown in Table 6-1 of this report also use data from these wells. NRF now uses data from NRF-16 to provide upgradient water quality results for comparison to downgradient results.

7.2.2.2.3 Adequacy of Monitored Constituents

The NRF groundwater monitoring system is designed to search for constituents that potentially could be released to the environment because of operations at NRF. This monitoring network also searches for constituents that are characteristic groundwater indicators (e.g., calcium and chloride) or provide valuable predictive data (e.g., tritium). All constituents that are believed to be potential contaminants to the environment or provide valuable predictive or characteristic data are currently monitored by NRF.

7.2.2.2.4 Adequacy of Sampling Frequency

Beginning in May 2007, the USGS on behalf of NRF began collecting groundwater samples biannually instead of triannually. Based on the analysis of groundwater data presented in Section 6.3, the current semester sampling frequency meets and in some instances appear to exceed the level of groundwater monitoring required at NRF.

All individual programmatic goals of accounting for short-term fluctuations in groundwater flow direction, short-term variations in local recharge, and longer-term trends due to known or unknown factors have likewise been met or exceeded. Furthermore, the current semester sampling frequency is more than adequate in providing near-term data that can be used for assessing the effectiveness of the remedial actions completed in 2004 at the OU 8-08 RA Sites. Based on these observations, the current sampling frequency appears to meet and in some cases exceed the NRF groundwater monitoring needs at this time. A decrease in sampling frequency from biannual to once per year in some wells would meet future monitoring needs.

7.2.2.3 Soil Gas Monitoring System

Four aspects of the soil gas monitoring system are assessed to determine its overall performance. These aspects include fitness of the probes, monitoring network fitness, constituents monitored, and sampling frequency. The data collected by the soil gas monitoring program are used to assess remedy performance at the inactive landfill sites at NRF and insure that these remedies remain protective of human health and the environment.

7.2.2.3.1 Probe Fitness

The soil gas probes are inspected during sample collection and as part of the formal annual inspections. Physically, all probes have functioned as designed.

Table 7-1 Summary of Land Use Controls at NRF

Site	Description	Objectives	Exposure Threat	Land Restrictions	Controls
CERCLA Sites					
Group 1 (Inactive Landfill Areas)					
NRF-1	**Field Area North of S1W**	**Prevent unauthorized access and excavation**	VOC, metal leacheate	• Industrial • Lease Restriction • Transfer Restrictions	• Fencing • Excavation Controls • Signs • Inspections
NRF-51	**West Refuge Pit #4**	**Prevent unauthorized access and excavation**	VOC, metal leacheate	• Industrial • Lease Restriction • Transfer Restrictions	• Fencing • Excavation Controls • Signs • Inspections
NRF-53	**East Refuge Pit and Trenching Area**	**Prevent unauthorized access and excavation**	VOC, metal leacheate	• Industrial • Lease Restriction • Transfer Restrictions	• Fencing • Excavation Controls • Signs • Inspections
Group 2 (No Further Action Sites)					
NRF-2	**Old Ditch Surge Pond**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Excavation Controls • Signs • Inspections
NRF-16	**Radiography Building Collection Tank Area**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Existing fence also within NRF Fenced Area • Excavation Controls • Inspections
NRF-22	**A1W Painting Locker French Drain**	**Prevent unauthorized excavation**	Lead, mercury	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area also Beneath Existing Structure • Excavation Controls • Inspections
NRF-23	**Sewage Lagoons**	**Prevent unauthorized excavation**	VOC, metals, low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Existing Fencing • Signs • Excavation Controls • Inspections
NRF-42	**Old Sewage Effluent Ponds**	**Prevent unauthorized excavation**	VOC, metals, low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Excavation Controls • Signs • Inspections

Table 7-1 Summary of Land Use Controls at NRF

CERCLA Sites

Site	Description	Objectives	Exposure Threat	Land Restrictions	Controls
Group 2 (No Further Action Sites) - Continued					
NRF-43	**Seepage Basin Pumpout Area**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Excavation Controls • Signs • Inspections
NRF-61	**Old Radioactive Materials Storage and Laydown Area**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Excavation Controls • Signs • Inspections
NRF-66	**Hot Storage Pit**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Signs • Excavation Controls • Inspections
NRF-81	**A1W Processing Building Area Soil**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-82	**Evaporator Bottoms Tank Release**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-83	**ECF Hot Cells Release Area**	**Prevent unauthorized excavation**	Radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Inspections
Group 3 (Remediated Radiological Sites)					
NRF-11	**S1W Tile Drainfield and L-Shaped Sump**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-12A	**Underground Piping to Leaching Pit**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Portion within NRF Fenced Area • Excavation Controls • Signs • Inspections

Table 7-1 Summary of Land Use Controls at NRF (continued)					
CERCLA Sites					
Site	Description	Objectives	Exposure Threat	Land Restrictions	Controls
Group 3 (Remediated Radiological Sites) – Continued					
NRF-14	**Underground Piping to Leaching Bed**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-17	**S1W Retention Basin**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-19	**Underground piping to A1W Leaching Bed**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-21A	**Underground piping to Old Sewage Basin**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Portions within NRF Fenced Area • Excavation Controls • Signs • Inspections
NRF-21B	**Sludge Drying Bed**	**Prevent unauthorized excavation**	Low-level radioactivity	• Industrial • Lease Restriction • Transfer Restrictions	• Within NRF Fenced Area • Excavation Controls • Signs • Inspections
Group 4 (8-08 Engineered Cover Sites)					
NRF-12B	**S1W Leaching Pit**	**Prevent unauthorized access and excavation**	Radioactivity, lead	• Industrial • Lease Restriction • Transfer Restrictions • Radiologically Controlled Area	• Fencing • Excavation Controls • Engineered Cover • Signs • Inspections
NRF-14	**S1W Leaching Beds**	**Prevent unauthorized access and excavation**	Radioactivity	• Industrial • Lease Restriction • Transfer Restrictions • Radiologically Controlled Area	• Fencing • Excavation Controls • Engineered Cover • Signs • Inspections

Table 7-1. Summary of Land Use Controls at NRF (continued)

Site	Description	Objectives	Exposure Threat	Land Restrictions	Controls
CERCLA Sites					
Group 4 (8-08 Engineered Cover Sites) - Continued					
NRF-19	**A1W Leaching Bed**	**Prevent unauthorized access and excavation**	Radioactivity	• Industrial • Lease Restriction • Transfer Restrictions • Radiologically Controlled Area	• Fencing • Excavation Controls • Engineered Cover • Signs • Inspections
NRF-21A	**Old Sewage Basin**	**Prevent unauthorized access and excavation**	Radioactivity	• Industrial • Lease Restriction • Transfer Restrictions • Radiologically Controlled Area	• Fencing • Excavation Controls • Engineered Cover • Signs • Inspections

7.2.2.3.2 Network Fitness

Each Inactive Landfill Site is monitored by a network of probes designed for that site. Data gathered from these networks of probes provide detailed information about the site such that migration of constituents, if it were occurring, could be detected. Based on the analysis presented in Section 6.4, the configuration of the networks appears sufficient to effectively monitor the Inactive Landfill Sites.

7.2.2.3.3 Adequacy of Monitored Constituents

The current list of analytes and analytical methods used for the soil gas monitoring program includes all of the potential organic chemicals of concern, with adequate minimum detection levels; however, the current contract laboratory is updating its analytical equipment for implementing the use of EPA Method TO-15 as the primary method for the analysis of soil gas/air samples. The advantage of the TO-15 method is that it incorporates a better moisture management technique than the TO-14A method (the method currently used by NRF) since moisture in the sample can bias the analytical results. Therefore, the use of EPA Method TO-15 would provide more accurate results compared to results generated using the current method, EPA Method TO-14A.

7.2.2.3.4 Adequacy of Sampling Frequency

NRF currently collects soil gas samples biannually. Based on the analysis of soil gas data presented in Section 6.4, the current semester sampling frequency meets and in many instance appears to exceed the level of monitoring required at NRF. This frequency has been sufficient to capture seasonal fluctuations and identify trends in the data. Furthermore, the current semester sampling frequency is more than adequate in providing near-term data that can be used for assessing the effectiveness of the remedial actions. A decrease in sampling frequency from biannual to once per year for some sites would meet future monitoring needs.

7.2.2.4 No Further Action Sites

The primary remedy selected for the OU 8-08 NFA Sites is ICs. These controls are intended to prevent unauthorized intrusion and excavation and to control land use and transfer. Annual inspections are performed to ensure that conditions at the sites remain the same and to ensure that ICs are effective. As discussed in Section 5.2, inspections provide evidence that the remedy is performing as intended.

7.2.2.5 Remedial Action Sites

The selected remedies (e.g., removal actions, construction of the covers) for the OU 8-08 RA Sites appear to be functioning as expected. Formal annual inspections have been performed. Based on analysis of the data presented in the OU 8-08 RA Report, inspections of the various sites, and groundwater monitoring results, the selected remedies for the RA Sites appear to meet performance standards.

Specific requirements to maintain cover integrity against erosion, and to monitor for the potential release of contaminants from the sites, are identified in the O&M Plan, the current revision of which is a part of the RA Report. The current revision of the Institutional Control Plan, which discusses ICs for limiting land use and access, is also part of the RA Report.

7.2.2.6 Operation and Maintenance Costs

7.2.2.6.1 Groundwater Monitoring Costs

During 2006, NRF collected three groundwater samples per year from 13 wells. Between 2007 and 2010 (after NRF-13 was removed from the network), NRF collected two samples per year from 12 wells. During each sampling period, one blank sample and one duplicate sample were collected and analyzed with the routine samples. Samples were analyzed by the contracted laboratories as shown previously in Table 4-1. Once received by NRF, sample results were sent to an independent contractor for data validation. A representative from NRF coordinated the collection (by USGS personnel), analysis, validation, and interpretation of all groundwater samples. The breakdown of the actual costs from 2006 through 2010 associated with the groundwater monitoring portion of the selected remedies for the inactive landfills and the OU 8-08 sites are summarized in Table 7-2. The total cost during this review cycle is lower ($521,345) than the previous five years ($549,150). This is due primarily to fewer total samples collected, from fewer wells. The lower sampling and analysis costs were somewhat offset by higher maintenance costs.

Table 7-2 Yearly Operational Costs for Groundwater Monitoring Network

Time Period	Analysis Costs	Sample Collection Costs	Validation Costs	Maintenance	Yearly Total
2006[1]	$54,230	$35,010	$6,525	$21,000	$116,765
2007	$48,790	$46,740	$4,825	$7,000	$107,355
2008	$39,660	$39,750	$4,340	$14,000	$97,750
2009	$42,170	$41,150	$4,725	$14,000	$102,045
2010	$32,000	$53,410	$5,020	$7,000	$97,430
Subtotal	$216,850	$216,060	$25,435	$63,000	
				Five Year Total	**$521,345**

1-Based on a trimesterly sampling schedule

7.2.2.6.2 Soil Gas Monitoring Costs

The specific O&M activities associated with soil gas monitoring of the three inactive landfill cover areas includes sampling a total of fourteen soil gas monitoring probes, analytical costs, data validation, and any maintenance costs. The soil gas monitoring probe locations were sampled on a quarterly basis until 2007 and then biannually thereafter. This includes samples from all of the soil gas monitoring probes, one duplicate, one field air blank, and one field equipment blank. The samples were sent off-site and analyzed by the NRF contract laboratory. The analytical results were then submitted for data validation. After the results were validated, NRF evaluated the data for any problems and for trends. The breakdown of the costs from 2006 through 2010 associated with the soil gas monitoring tasks are tabulated in Table 7-3. The total cost ($70,380) is lower than the cost from the previous five year period ($146,900). This is due primarily to the collection and analysis of fewer samples and the absence of the replacement costs (shown as $29,900 in the 2006 Five-Year Review) for two soil gas monitoring probes in 2003.

Table 7-3 Yearly Operational Costs for Soil Gas Monitoring				
Time Period	Analysis Costs	Validation Costs	Maintenance	Yearly Total
2006	$21,0800	$2,380	$0	$23,460
2007	$10,540	$1,190	$0	$11,730
2008	$10,540	$1,190	$0	$11,730
2009	$10,540	$1,190	$0	$11,730
2010	$10,540	$1,190	$0	$11,730
Subtotals	$63,240	$7,140	$0	
			Five Year Total	$70,380

7.2.2.6.3 Soil Moisture Monitoring Costs

The specific O&M activities associated with soil moisture monitoring of the three OU 8-08 engineered cover areas includes obtaining soil moisture measurements from a total of six access tubes and any maintenance costs. Soil moisture measurements from 2006 through 2010 were obtained by subcontractor personnel (currently Gonzales-Stoller Survey) with coordination and observation by NRF personnel. The soil moisture measurements from these access tube locations may be collected up to a maximum of 12 times per year from early spring through the fall. NRF personnel evaluated the data for any problems (e.g., water infiltrating below the engineered cover). The breakdown of the costs from 2006 through 2010 associated with the soil moisture monitoring tasks are tabulated in Table 7-4. The total cost ($17,373) represents the first full five years of collection of these data.

Table 7-4 Yearly Operational Costs for Soil Moisture Monitoring				
Time Period	Analysis Costs	Validation Costs	Maintenance	Yearly Total
2006	$3,120	$0	$0	$3,120
2007	$3,208	$0	$0	$3,209
2008	$3,293	$0	$0	$3,293
2009	$3,379	$0	$0	$3,379
2010	$4,372	$0	$0	$4,372
Subtotals	$17,373	$0	$0	$17,373
			Five Year Total	$17,373

7.2.2.7 Technical Assessment

In the EPA guidance for Five-Year Reviews, the EPA provided three questions to aid in assessing remedy performance. These questions and their answers are summarized in Table 7-5.

7.2.2.7.1 Technical Assessment Summary

As noted in Table 7-5, only one potential deficiency, i.e., siltation in NRF-6, was identified as a result of the technical assessment performed as part of the Five-Year Review. This potential deficiency does not affect the protectiveness of the selected remedies, although follow-up actions may be warranted. Institutional controls were assessed and were determined to be adequate and protective of the selected remedies.

Table 7-5 Technical Assessment - Answers to Guidance Questions

Questions:	Answers:			
	Inactive Landfill Areas	**No Further Action Sites**	**Remediated Radiological Sites**	**Engineered Cover Sites**
A: Is the remedy functioning as intended by the decision documents?	Yes. Data reviews and site inspections indicate that the remedies are functioning as intended. Silt found in monitoring well NRF-6 is considered a potential deficiency; however, this does not affect the protectiveness of the overall remedy. Institutional Controls for the OU 8-05/06 Landfill Covers have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the Inactive Landfill Cover Areas.	Yes. Data reviews and site inspections indicate that the remedies are functioning as intended. Institutional Controls for the OU 8-08 No Further Action Sites have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the No Further Action Sites.	These remedies were performed in accordance with the Phase I Work Plan. Relevant data, ARARs presented in the OU 8-08 ROD, and site inspections (pre-final and final by the agencies) indicate that the remedies are functioning as intended, and thus protective of human health and the environment. Institutional Controls indicated for the OU 8-08 Remediated Radiological Sites summarized in Table 7-1 have been evaluated and have been determined to be operating as intended; therefore they provide long-term protectiveness for the Remediated Radiological Sites.	These remedies were performed in accordance with the Phase II Work Plan. A review of the relevant data, ARARs presented in the OU 8-08 ROD, and site inspections (pre-final and final by the agencies) indicate that the remedies were constructed in accordance with the requirements of the Remedial Design, and that the remedies are protective of human health and the environment. Institutional Controls indicated for the OU 8-08 Engineered Cover Sites summarized in Table 7-1 have been evaluated and have been determined to be operating as intended; therefore they provide long-term protectiveness for the Engineered Cover Sites.
B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy still valid?	Yes. – All assumptions, data, cleanup levels, and RAOs used at the time of the remedy are still valid.	Yes – However, toxicity values and risk-based concentrations have changed (see Section 6-5) but values used at the time of the remedy are more conservative	Yes – However, toxicity values and risk-based concentrations have changed (see Section 6-5) but values used at the time of the remedy are more conservative	Yes – However, toxicity values and risk-based concentrations have changed (see Section 6-5) but values used at the time of the remedy are more conservative
C: Has any other information come to light that could call into question the protectiveness of the remedy?	No	No	No	No

8.0 Deficiencies

8.1 Overview

A review of prior site inspection results and data presented in the preceding sections shows only minor deficiencies associated with the NRF Inactive Landfills, NFA Sites, Remediated Radiological Sites, or OU 8-08 Engineered Cover Sites. The following sections summarize the identified deficiencies in greater detail.

8.2 Landfill/Engineered Covers

The only issues identified by the annual inspections included a ponding/minor subsidence area observed at one of the engineered cover sites, slight encroachment by weeds into areas which were previously described as sparse vegetation areas and animal intrusion (anthills and holes caused by small rodents such as mice and voles). These issues are considered minor and not considered deficiencies. Areas that showed evidence of sparse vegetation and were re-seeded in 2004 now contain strong mature plants. Animal intrusion is limited to the upper clean layers of the covers where a gravel layer is present for the purpose of preventing further intrusion into the covers. Therefore, these intrusions were not deep enough to expose buried contaminants. With regard to the small area of subsidence where ponding of water was first observed in 2006, survey elevation data over several years shows that the rate of settling in the subsidence area appears to be about the same as the rest of the engineered cover. Based on survey data and visual observation, no repairs are necessary. These issues do not affect the integrity of the landfill/engineered covers.

8.3 Groundwater Monitoring Network

Over the past five years, only one potential deficiency was identified with the Groundwater Monitoring Network and wells. The NRF-6 well has shown signs of active siltation as demonstrated in August 2010 when the pump/motor was replaced and loose sediment was partially removed by purging the well using air and clean water. An increasing trend in dissolved chromium concentration has been observed. After maintenance on the well, the chromium concentrations appear to have stabilized at approximately 47 ppb. Evaluation of the data from NRF-6 will continue. Although this issue warrants follow-up actions, it does not affect current or future protectiveness of any of the remedies discussed in this Five-Year Review.

8.4 Soil Gas Monitoring Probes

No problems were encountered with any of the soil gas monitoring probes. Water that was observed in MW-1-4 and discussed in the 2006 Five-Year Review was not observed during this review period. This may be due to a storm water system upgrade in 2007 that allowed for adequate drainage of storm water away from this probe location.

8.5 Soil Moisture Monitoring Probes

No deficiencies associated with the moisture monitoring probes have been observed.

9.0 Recommendations and Required Actions

9.1 Overview

The purpose of this section of the Five-Year Review is to evaluate the overall performance of the remedies, including the deficiencies discussed in Section 8.0, and make recommendations regarding what actions, if any, may be appropriate to correct a deficiency or to improve the overall effectiveness of the selected remedies.

9.2 Landfill Covers

With regard to the OU 8-05/06 landfill covers, no actions are recommended.

9.3 Groundwater Monitoring Network

This document represents completion of the third review of the OU 8-05 and 8-06 Inactive Landfill Sites and the second review of the OU 8-08 Remedial Action Sites. Based on data presented in this and previous reviews, the following general conclusions can be made relative to the NRF Groundwater Monitoring Network:

- No contaminants related to NRF operations have been detected in any NRF well above primary MCLs. Apparent exceedences for chromium in NRF-6 prior to 2006 are believed to be caused by sedimentation or corrosion issues.

- No significant adverse trend for any constituent in any well has been detected at NRF. An apparent upward trend in chromium concentration in NRF-6 is likely a manifestation of flow direction coupled with changes in water level in the Snake River Plain Aquifer.

- Apparent trends in key non-radiological groundwater constituents in all downgradient wells can be adequately explained by changes in groundwater flow direction and/or water table elevation.

- NRF did not release significant amounts of radionuclides to the groundwater during past operations. Tritium activities above background, but an order of magnitude below the federal primary MCL levels are still detected in some downgradient wells.

- The prominent downward trends in tritium concentrations in most wells are due primarily to the natural decay process; however, minor influences due to groundwater flow direction and/or water table elevation are also present.

- Although NRF releases elevated amounts of chloride ions to the SRPA through current operations, and small but detectable quantities of residual chromium and tritium from past operations, dilution through dispersion and other processes, reduce the concentrations of the constituents to near background levels by the time they reach the Regional Downgradient wells (USGS 97, 98 and 99).

- Over the past 22 years, evidence gathered from water table elevation and constituent concentration maps have confirmed that the direction of groundwater flow direction changes beneath NRF over time. Groundwater monitoring results indicate that the NRF groundwater monitoring wells are adequately placed to detect the potential release of constituents from any location at NRF for any flow direction that is known to be possible at NRF.

Based on NRF's minimal impact on the aquifer and its current understanding of hydrogeologic processes influencing the aquifer near the facility, NRF makes the following recommendations:

- Reduce the sampling collection frequency for the Regional Downgradient wells (USGS 97, USGS 98, and USGS 99) to once every other year (i.e., 2012, 2014 and 2016) and discuss the potential for discontinuing all sampling of these wells in the next 2016 Five-Year Review. The water level measurements will continue to be collected twice per year.

- Reduce the sample collection frequency for the Local Downgradient wells (NRF-8, NRF-9, NRF-10, NRF-11, NRF-12, and USGS 102) to once per year (annually). The water level measurements will continue to be collected twice per year.

- Continue to collect samples from NRF-6 biannually until the mechanisms influencing the chromium concentrations (including siltation issues) in this well have been confirmed. If supported by future data, reduce the sample frequency to one time per year.

- Continue to collect samples from NRF-16 biannually until at least the next Five-Year Review. NRF-16 has only been operational since the fall of 2009; therefore, a biannual sampling frequency is necessary until seasonal variations and long term trends are understood.

Since the CERCLA groundwater monitoring network is also used to fulfill the monitoring requirements contained in the Industrial Reuse Permit issue by IDEQ, any recommendations for reductions in sampling frequency must also support sampling needs identified in the NRF Industrial Reuse Permit.

9.4 Soil Gas Monitoring Probes

No problems exist concerning the soil gas monitoring probes (regarding functionality and physical defects). The concentrations of soil gas constituents are essentially stable or trending downward in all probes for all constituents with one exception at NRF-1, where two constituents exhibit increasing trends at one sample location.

Based on analysis of the data, NRF recommends reducing the sampling frequency at NRF-51 and NRF-53 to one time per year. The sampling frequency of probes at NRF-1 should remain at twice per year until the increasing trend for the two constituents, tetrachloroethylene and trichloroethylene, is better understood.

In addition, NRF recommends the use of EPA Method TO-15 for analyzing soil gas samples instead of EPA Method TO-14A (the method currently used by NRF) because the TO-15 method incorporates a better moisture management technique than the TO-14A method since moisture in the sample can bias the analytical results.

9.5 Soil Moisture Monitoring Probes

No recommendations or required actions are necessary at this time.

9.6 General Recommendations

Based on the information presented in this Five-Year Review, the following general recommendations are presented by NRF:

- Based on the evaluation provided in Appendix A, remove institutional control requirements from No Further Action sites NRF-2, NRF-61, NRF-66, and NRF-81. Documentation of these actions could be through a minor change to the NRF Final ROD and through a revision of the NRF Institutional Control Plan.
- Update and Revise the NRF Institutional Control Plan to include NRF Response Actions for UXO.
- Update and revise the NRF Operation and Maintenance Manual to reflect changes to NRF monitoring programs.

9.7 Recommendations Summary

Table 9-1 includes a summary of recommendations that have been identified for this Five-Year Review along with any follow-up actions necessary. Table 9-1 also identifies the responsible party for implementation of the recommendations, the agency with oversight authority, the target date for implementation and completion, and the impact, if any, on protectiveness.

Table 9-1 Summary of Recommendations and Follow-up Actions

Item	Recommendation/ Follow-up Actions	Responsible Party	Oversight Agency	Targeted Date	Affects Protectiveness? (Y/N)	
					Current	Future
Potential Deficiency (see Section 8.3)						
Siltation and Rising Chromium in NRF-6	Watch well for signs of sediments in samples. Evaluate the potential cause for chromium concentration in well if they continue to rise above current levels.	NRF	IDEQ/EPA	As necessary	NO	NO
Recommendations (see Sections 9.3, 9.4 and 9.6)						
Sampling Frequency	Reduce monitoring frequency in Regional Downgradient wells to every other year	NRF	IDEQ/EPA	May 2012	NO	NO
	Reduce monitoring frequency in Local Downgradient wells to one per year	NRF	IDEQ/EPA	May 2012	NO	NO
	Maintain biannual sampling frequency for NRF-6 until data supports change to one per year	NRF	IDEQ/EPA	Continuing	NO	NO
	Maintain biannual sampling frequency for NRF-16 until next Five-Year Review	NRF	IDEQ/EPA	Continuing	NO	NO
	Reduce sampling frequency in NRF-51 and NRF-53 to one time per year	NRF	IDEQ/EPA	May 2012	NO	NO
	Maintain biannual sample frequency for Landfill Cover Site NRF-1 until data supports change to one per year	NRF	IDEQ/EPA	Continuing	NO	NO
	Continue collecting water level measurements from all wells two times per year.	NRF	IDEQ/EPA	Continuing	NO	NO
Administrative Controls	Issue minor change to ROD to remove ICs at NRF-2, 61, 66, and 81	NRF	IDEQ/EPA	March 2012	NO	NO
	Revise and update ICP	NRF	IDEQ/EPA	May 2012	NO	NO
	Revise and update O&M Manual	NRF	IDEQ/EPA	May 2012	NO	NO

10.0 Protectiveness Statements

The protectiveness of the remedies selected for the areas discussed in this NRF Five-Year Review for the OU 8-05/06 Inactive Landfill Areas and OU 8-08 Remedial Action Sites are summarized in Table 10-1.

10.1 Summary

In summary, because the individual remedies at each site are protective of human health and the environment, collectively the selected remedies for the NRF remediated CERCLA sites are protective.

Table 10-1 Summary of Protectiveness Statements for NRF CERCLA Sites

Area	Protectiveness Determination	Protectiveness Statement
OU 8-05/06 Landfill Covers	Protective	The remedy at OU 8-05/06 Landfill Covers is protective of human health and the environment. The analytical data show that the covers are effective at containing contaminants. The covers and direct contact with contaminated soils and landfill wastes are being controlled by institutional controls. Institutional Controls for the OU 8-05/06 Landfill Covers have been evaluated and determined to be operating as intended; therefore they provide long-term protectiveness for the landfill cover sites.
OU 8-08 "No Further Action" Sites	Protective	The remedy at OU 8-08 No Further Action Sites is protective of human health and the environment because the remedy has been effective in limiting unauthorized access and excavation. The data also indicate that activities at NRF have not adversely affected the groundwater, thereby supporting the No Further Action designation of the sites.
OU 8-08 Remediated Radiological Sites	Protective	The remedy at OU 8-08 Remediated Radiological Sites is protective of human health and the environment. The OU 8-08 Remedial Action (RA) report indicates that pipe removal and consolidation of contaminated soil has been successful in achieving remedial action objectives (RAOs). The data also indicate that activities at NRF have not adversely affected the groundwater, thereby supporting the protectiveness statement for the sites.
OU 8-08 Engineered Cover Sites	Protective	The remedy at OU 8-08 Engineered Cover Sites is protective of human health and the environment. The OU 8-08 RA report indicates that the construction of an engineered earthen cover has been successful in achieving RAOs. Exposure pathways that could result in unacceptable risks are being controlled by institutional controls. The data also indicate that activities at NRF have not adversely affected the groundwater, thereby supporting the protectiveness statements for the sites.

11.0 Next Review

NRF is a statutory site that requires ongoing Five-Year Reviews. The next review will be conducted within five years of this Five-Year Review, and is therefore scheduled for 2016. The next review will cover the period from September 2011 to September 2016.

Appendix A

Technical Re-evaluation

of

Various NRF

No Further Action Sites

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Introduction

The Environmental Protection Agency (EPA) has revised their preliminary remediation goals for several radionuclides to account for factors that were not included in earlier risk-based concentration models. These factors include a gamma shielding factor, an area correction factor, and an exposure time fraction. The EPA provides the revised preliminary remediation goals at the website http://epa-prgs.ornl.gov/radionuclides/. The *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site-Fiscal Years 2005-2009* discusses in more detail the basis for the EPA's modifications.

At the Naval Reactors Facility (NRF), Waste Area Group (WAG) 8, the primary contaminant of concern is cesium-137 (Cs-137). The NRF Final Record of Decision (ROD) signed in 1998 established a remediation goal for Cs-137 of 16.7 picocuries per gram (pCi/g). The remediation goal was based on risk-based values that were considered acceptable at that time and represented a level that would decay to allow unrestricted use of an area in 100 years (future residential scenario). Remedial actions were completed at several Operable Unit (OU) 8-08 sites in 2003. In addition to the OU 8-08 sites that required remedial actions, several other sites at NRF had Cs-137 present at low levels below remediation goals, but above a level that would allow current unrestricted use of the site (current residential scenario). These sites were classified as No Further Action sites and institutional controls were established to prevent disturbance of the areas and unintentional exposure to residual contamination. The ROD did not establish a time frame for when these sites could be released from institutional controls.

For Cs-137, the revised EPA preliminary remediation goal is 6.15 pCi/g for a current residential scenario at the 1E-04 risk-based level. Accounting for radioactive decay, this value would represent a present day remediation goal of 42 pCi/g for Cs-137, which assumes government control of the area until 2095 (at which time the site could be released for unrestricted use).

Because of the following factors: (1) a time frame for releasing a site from institutional controls was not established in the ROD, (2) EPA preliminary remediation goals have changed since the ROD was signed, and (3) natural radioactive decay of residual Cs-137 (the primary contaminant of concern at NRF), a re-evaluation of several No Further Action sites was warranted. Those No Further Action sites with institutional controls in place due to low levels of Cs-137 include NRF-2, NRF-61, NRF-66, and NRF-81. A technical re-evaluation of these sites is appropriate to assess whether continued use of institutional controls is warranted. The re-evaluation of each site is provided below.

NRF-2 (Old Ditch Surge Pond)

NRF-2 is an area that was originally excavated in late 1958 or early 1959 as a gravel or soil pit for construction projects at NRF. The pit was approximately 110 feet in diameter and 12 feet deep. The pit was later connected to a drainage ditch and was likely used as a storm water drainage area for heavy precipitation events. Around 1963, the pit and drainage ditch were connected to the NRF Interior Industrial Waste Ditch (IWD) system. The pit, which then acted as a pooling place for water, was used as either an overflow or settling area. The pond area and a portion of the ditch were isolated from the waste ditch system in 1985 when portions of the ditch system were replaced with underground, corrugated piping. Presently, the surge pond is a circular excavated area about 12 feet deep with a 55 foot radius (see Figure A-1). The connected ditch is estimated to be 90 feet long, 20 feet wide (from bank to bank), and 4 feet deep. The ditch runs from the pond to the northeast. Some construction debris remains visible in the pond area. The underlying basalt is about 3 to 4 feet below the bottom of the pond which is 15 to 16 feet below surrounding ground surface.

Although this site was defined as a potential radiological unit, no known radiological effluents were intentionally released to the pond. Portions of the Interior IWD became slightly contaminated with radioactivity, when water with trace amounts of cobalt-60 (Co-60) and Cs-137 was released to the ditch in the late 1960s. Accumulation of radioactivity in the ditch sediments produced levels above background. Since NRF-2 was connected to the IWD in the 1960s, the pond area may have received small amounts of radioactivity which could have accumulated in the soils above background levels. The amount of Co-60 and Cs-137 the pond received was not determined, but was expected to be small.

Surface soil samples were collected in the area from 1986 to 1993. The samples were analyzed for Co-60 and Cs-137. Co-60 was detected at a maximum activity of 11.28 picocuries per gram (pCi/g) in 1991 and Cs-137 was detected at a maximum activity of 4.7 pCi/g in 1992. Characterization sampling was performed at the pond in 1991. Samples were collected from a borehole in the middle of the ditch to a depth of three feet where the basalt was encountered. Samples were analyzed for pesticides, polychlorinated biphenyls (PCBs), organics, and metals. The only contaminants of potential concern detected from the 1991 sampling event were arsenic at 8.5 parts per million (ppm) and chromium at 90.2 ppm, which were both above background levels, in only one sample. The extent of the contamination was estimated to be limited to the pond area and attached ditch, in the upper two feet of soil.

The maximum sample result (4.7 pCi/g Cs-137) from the 1992 sampling event was below the remediation goal for the 100 year residential scenario provided in the ROD (16.7 pCi/g Cs-137) but above a level that would allow the area to be released for unrestricted use. The 4.7 pCi/g Cs-137 in 1992 has decayed to a present day value of 3 pCi/g. This decay corrected value is below the revised EPA preliminary remediation goal of 6.15 pCi/g for the release of a site for unrestricted use (current residential scenario). The Co-60 activity detected at NRF-2 would have decayed to less than one pCi/g (0.81 pCi/g), which is also below the EPA preliminary remediation goal of 3.9 pCi/g for unrestricted use (based on the 2010 radionuclides table at the epa-prgs.ornl.gov website).

Although arsenic and chromium were detected above background levels they were not considered contaminants of concern after the risk assessment was performed in the NRF comprehensive remedial investigation and feasibility study (RI/FS). Based on the evaluation presented above, it appears that institutional controls are no longer required at NRF-2.

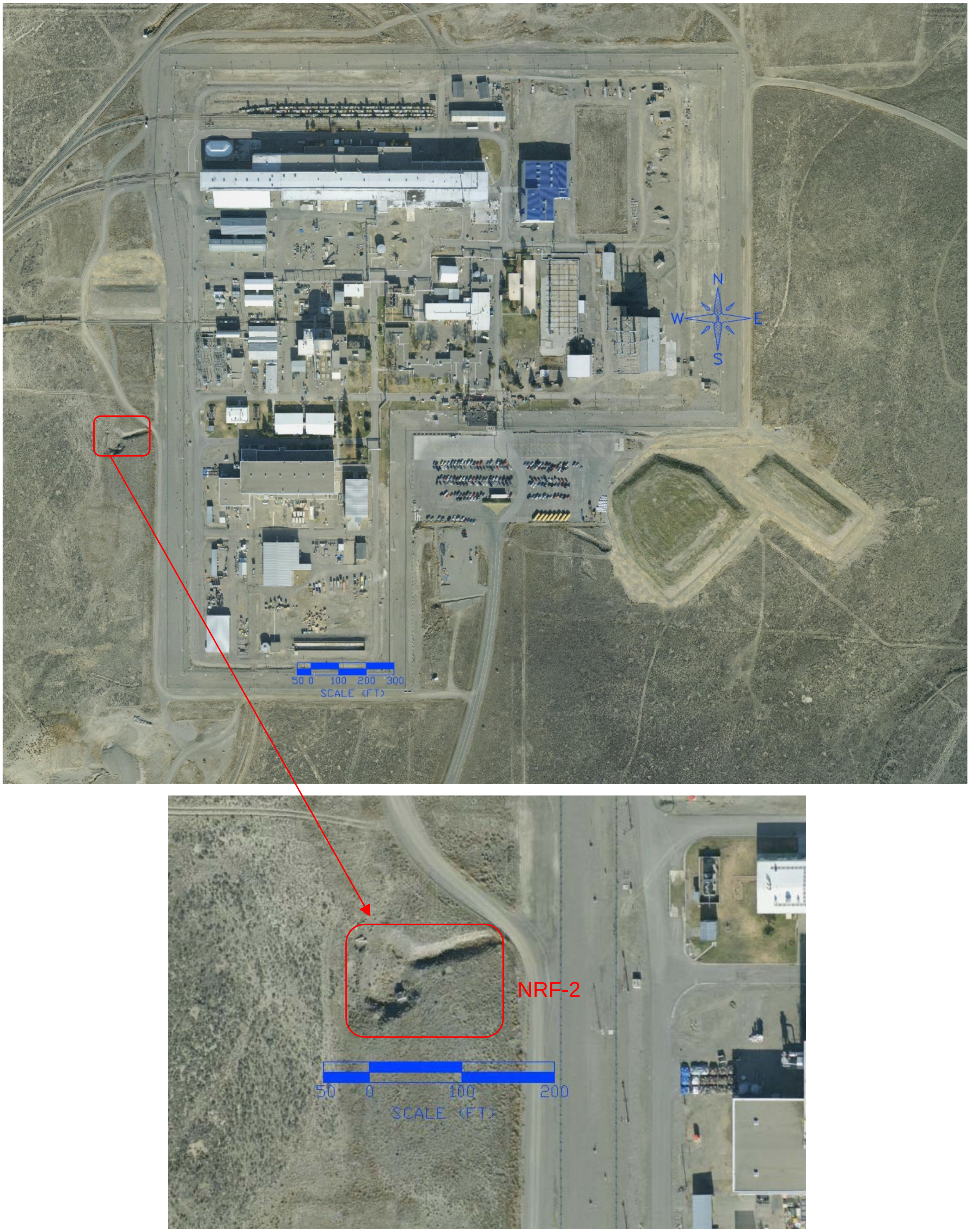

Figure A-1 NRF-2 Location

NRF-61 (Old Radioactive Materials Storage and Laydown Area)

NRF-61 is a former location of a radioactive material storage and laydown area that was used from 1954 to 1960. This area was north of the NRF perimeter fence where refueling equipment was stored (see Figure A-2). No wastes were deliberately disposed of in this area. Most of the original site was excavated during the sewage lagoon expansion project in 1972. The remaining area is approximately 90 ft by 100 feet with the south corner of the sewage lagoon berm forming the northern edge of the site (See Figure A-3). Radiation surveys were performed and soil samples were collected because potentially radioactively contaminated refueling equipment had been stored in the area. Four initial soil samples were collected in 1992 and analyzed for gross gamma activity. The results of these four samples (with a range of 3.4 - 3.7 pCi/g total gross gamma activity) were consistent with levels typically observed in soils at NRF due to naturally occurring radionuclides. Seventeen additional soil samples were collected in 1992 as well and were analyzed using the isotopic gamma spectroscopy method. These soil samples showed detectable amounts of Cs-137 with a maximum of 1.6 pCi/g.

A Track 1 evaluation was performed for this site. The contaminant of concern was Cs-137. The risk was estimated to be low based on the Track 1 evaluation. The Track 1 risk assessment assumed an institutional control period for the future residential scenario.

NRF-61 is within the grid area of the annual routine sampling conducted in support of NRF's Environmental Monitoring Program. The highest level detected during this routine annual sampling was 1.5 pCi/g Cs-137 in 1997 and is in the same general area where the maximum level was detected in 1992.

The maximum sample results from the 1992 (1.6 pCi/g) and 1997 (1.5. pCi/g) sampling events are below the remediation goal established in the NRF Final ROD and below the revised EPA preliminary remediation goal of 6.15 pCi/g for the release of a site for unrestricted use (current residential scenario). In addition, these two values have decayed to present day values of 1.0 pCi/g and 1.1 pCi/g, respectively. These decay corrected values are essentially at background levels for the INL. Based on the above evaluation, it appears that institutional controls at NRF-61 are no longer required.

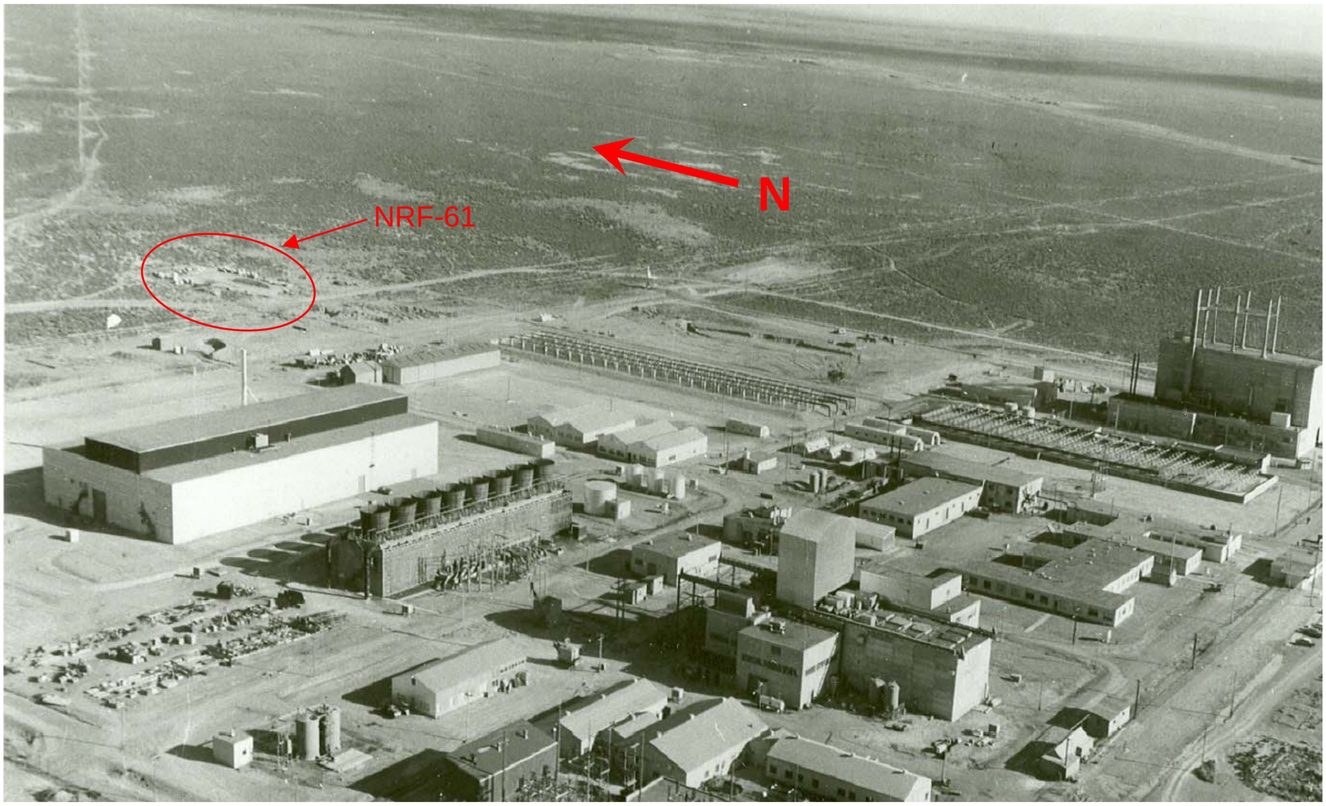

Figure A-2 NRF-61 in 1959.

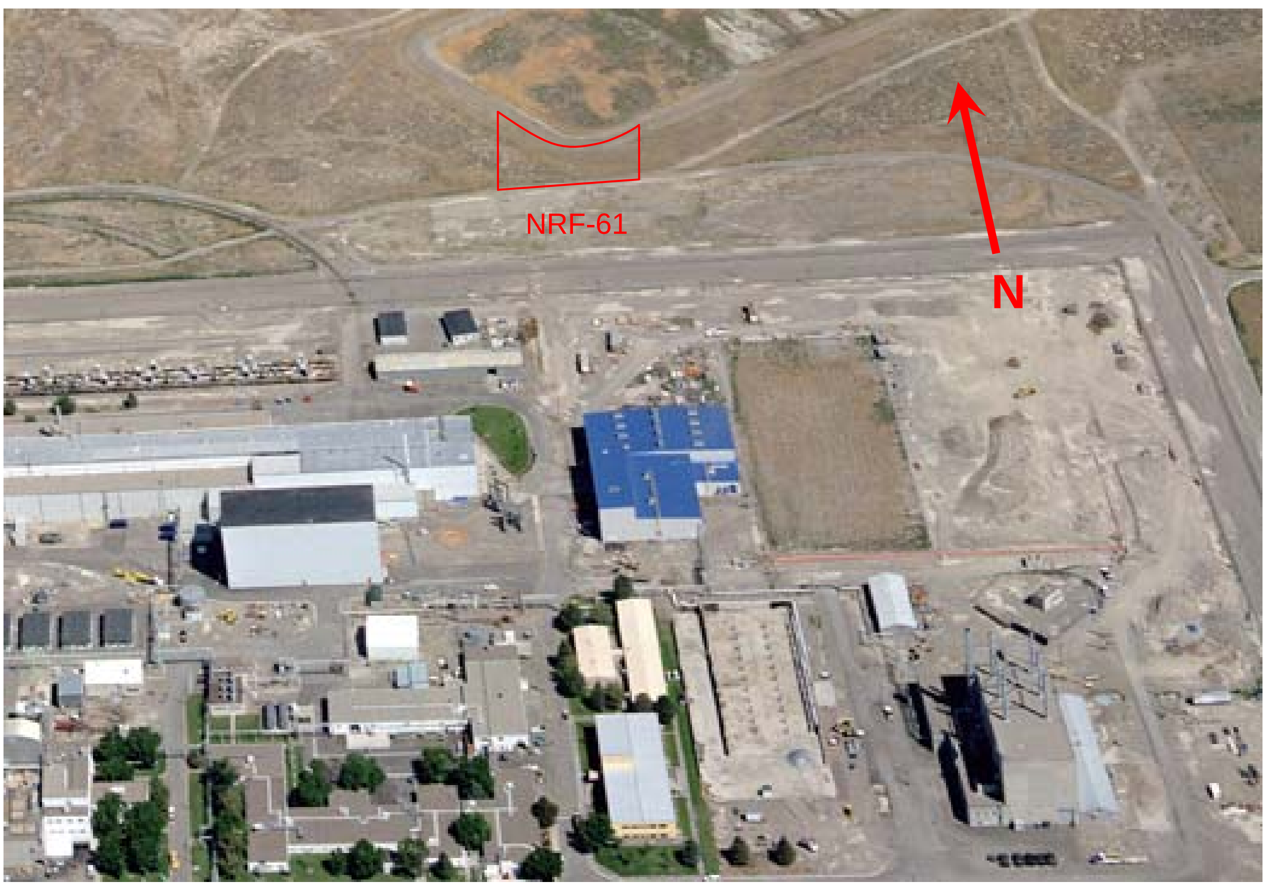

Figure A–3 NRF-61 under Present Conditions

NRF-81 (A1W Processing Building Area Soil)

NRF-81, which is the A1W processing building area, is located west of the A1W prototype plant. The area contains several tanks and associated piping systems that were used to process radioactive effluent from the prototype plant. Several historical inadvertent releases have occurred in the area from past operations. Of these releases, two are known to have occurred in 1980 and 1982. The soil would have been cleaned up to the standards established at the time of the release. Soil samples were collected from the area after the releases were cleaned up. In 1994, underground radioactive piping was removed from the processing building area during Decontamination and Dispositioning work at NRF. Soil samples were collected frequently during the excavation work and analyzed for radioactivity. No elevated radioactivity levels were found associated with these samples. Sampling was not performed during the NRF Comprehensive RI/FS in this area because evidence suggests that past spills in the area were cleaned up and the area was very similar to other areas where surface spills occurred. A conservative assumption was made during the RI/FS that the maximum concentrations of other radionuclides not sampled for at NRF-81 but detected at similar sites were present at this site. Cs-137 and uranium-235 (U-235) were retained as contaminants of concern for the risk assessment for the residential scenario and Co-60 was retained for the occupational scenario; however, the risk assessment concluded that Cs-137 was the primary risk driver. The maximum extent of contamination at NRF-81 would be the upper three feet of soil and an area approximately 100 feet by 130 feet. The area represents a fenced in location around the processing building and the estimated size is considered conservative (see Figure A-4).

In 1982, ten surface soil samples were collected west of the A1W processing building and 14 surface soil samples were collected north of the building. The samples were analyzed for Cs-137 and Co-60. The samples were taken to verify that an inadvertent release in the area was cleaned up to NRF standards at the time. The ten samples collected west of the A1W processing building were all less than 1 pCi/g for both Cs-137 and Co-60. Cs-137 was detected at a maximum of 2.9 pCi/g and Co-60 was detected at a maximum of 8.8 pCi/g north of the building.

The maximum sample result from the 1982 sampling event (2.9 pCi/g Cs-137) is below the remediation goal established in the NRF Final ROD and below the revised EPA preliminary remediation goal of 6.15 pCi/g for the release of a site for unrestricted use (current residential scenario). In addition, the maximum result has decayed to a present day value of 1.49 pCi/g. The Co-60 would have decayed to an activity level of 0.19 pCi/g, which is below the EPA preliminary remediation goal of 3.9 pCi/g. U-235 was not detected during past sampling at NRF-81, but the maximum sample result (0.18 pCi/g) from samples collected from similar areas was used during the RI/FS risk assessment. This value (0.18 pCi/g U-235) is well below the EPA preliminary remediation goal of 19.5 pCi/g. Based on the above evaluation, it appears that institutional controls at NRF-81 are no longer needed.

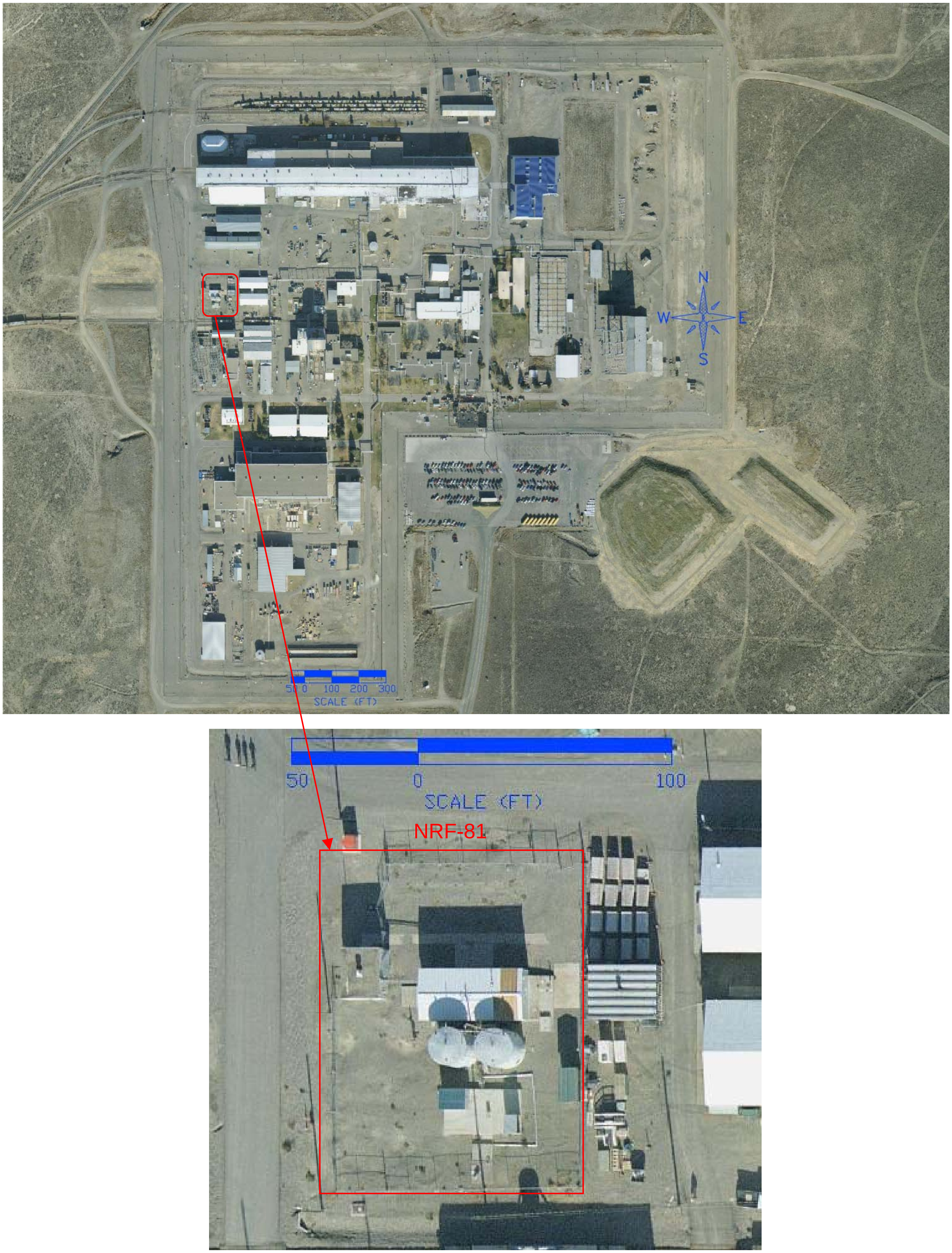

Figure A–4 NRF-81 Location

NRF-66 (Hot Storage Pit)

NRF-66, previously misnamed the hot storage pit, is an area where a waste tanker was located north of the S1W prototype plant in the early 1960s. The tanker was used to collect radioactive liquid waste that could not be diluted to meet release criteria to on-site discharge facilities. The tanker waste was sent to other INL facilities for processing and/or disposal. Various inadvertent releases may have occurred in the tanker loading area. The releases would have been cleaned up to established standards at the time of the release. In 1980, work documents were issued to remove soil just north of the S1W prototype plant at NRF-66 (see Figure A-5 for the location of NRF-66). The documents required the removal of soil in one-inch layers to a depth of 6 inches. Samples were collected at various intervals during soil removal. The removed soil was disposed as solid radioactive waste to another facility at the INL. After the soil was removed, yellow plastic sheeting was placed in the excavated area, and clean soil was placed on the sheeting to fill in the excavated area. The areal extent of the excavation is unknown. In 1993, several pipes that ran underground from the radiography building area (NRF-16) to the north side of S1W, where NRF-66 is located, were removed during Decontamination and Dispositioning activities. Prior to and during removal of the pipes, samples were collected along the length of pipe including in the vicinity of NRF-66.

The only known samples collected in NRF-66 were in 1980 and 1993. The sample results for 1980 could not be located, although reportedly activity levels up to 245 pCi/gm of total gamma activity were detected in 1980 before the soil was removed. Samples were collected in 1993 prior to, and during, piping excavation. These samples were collected to a five foot depth. The highest activity found along the pipe was 13.5 pCi/g of total gamma activity. Several samples had detectable Cs-137, while only a few had detectable amounts of Co-60. During piping removal, samples were collected for every cubic yard of soil excavated. Two samples were found greater than or equal to 30 pCi/g of total activity (30 pCi/g and 32 pCi/g) just below the surface adjacent to the north side of S1W in the area of NRF-66. These samples were within ten feet of the north wall of S1W. No additional soil samples above 30 pCi/g were found during excavation work.

Samples were collected in January 1996 during the NRF Comprehensive RI/FS. Samples were collected in 14 locations north of S1W at the waste tanker loading area, NRF-66. The samples covered a 10 foot by 45 foot area. Samples were collected from the 1 and 2 foot depths. The sample depths were chosen based on past information that at least the upper 6 inches of soil were removed in 1980 to remove surface contaminated soil.

A total of 28 samples were analyzed by NRF Chemistry for the gamma emitting radionuclides Cs-137 and Co-60. Samples were also sent to an off-site laboratory for radionuclide analysis. After receiving the results from NRF Chemistry, the data were reviewed and only two samples showed activity greater than 1 pCi/g of Cs-137 (no cobalt-60 was detected) with a maximum detected amount of 1.6 pCi/g. Since only a very small amount of radioactivity was found in any of the samples, a composite sample for off-site analysis of radionuclides was made of three samples from the locations that showed the highest NRF Chemistry results. The composite sample would represent over ten percent of the samples collected for NRF Chemistry analysis. The composite sample result revealed activity of 1.88 pCi/g Cs-137. From the risk assessment screening process, the primary contaminant of concern for NRF-66 was Cs-137.

The maximum sample result from the 1996 (1.88 pCi/g Cs-137) sampling event is below the remediation goal established in the NRF Final ROD and below the revised EPA preliminary remediation goal of 6.15 pCi/g for the release of a site for unrestricted use (current residential scenario). In addition, the maximum result has decayed to the present day value of 1.33 pCi/g. This decay corrected value is essentially at the background level for the INL. Based on the above evaluation, it appears that institutional controls at NRF-66 are no longer required.

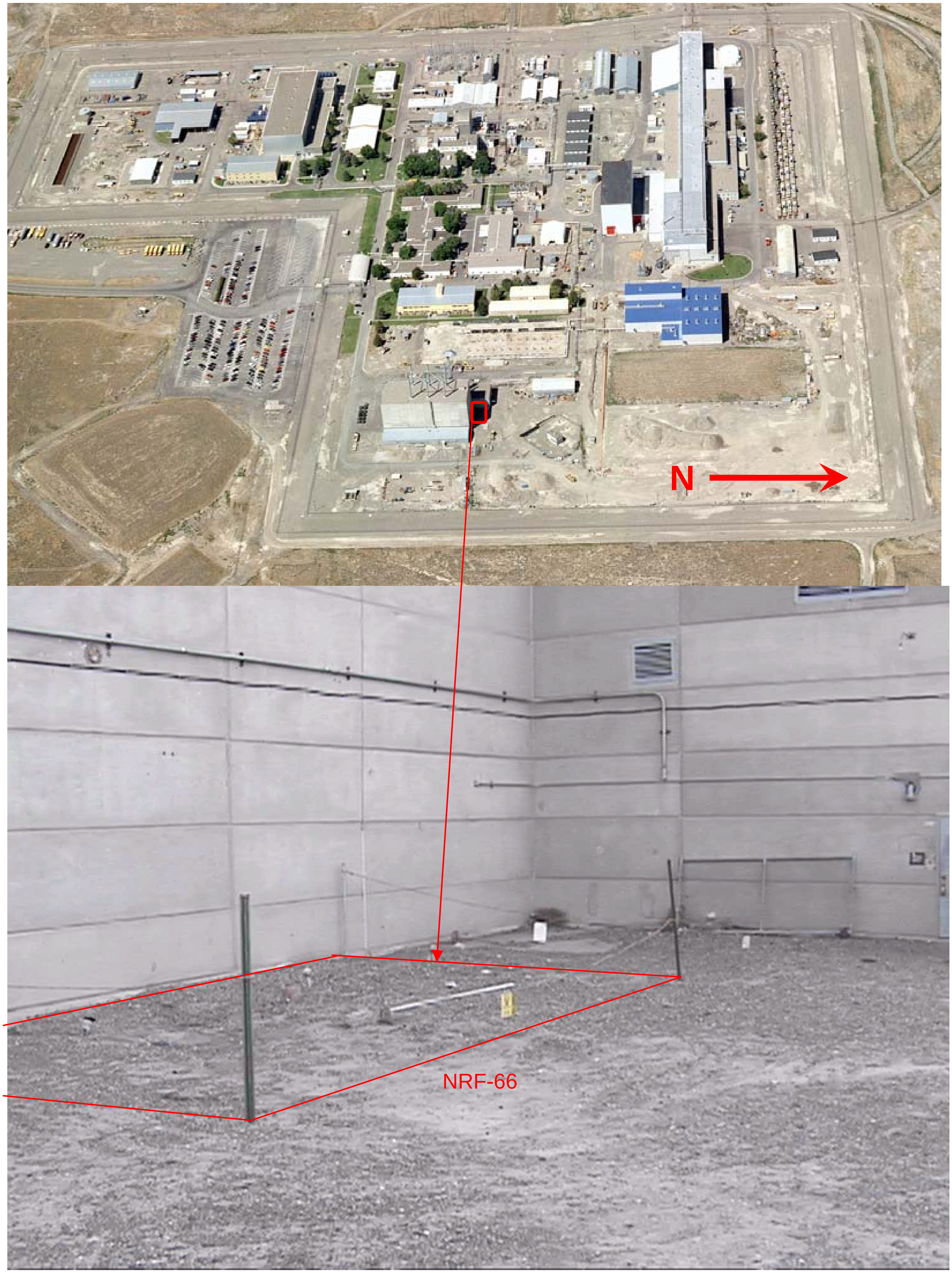

Figure A–5 NRF-66 Location behind the S1W Prototype Building

Summary

In summary, the four sites that are recommended for the removal of institutional controls are NRF-2 (Old Ditch Surge Pond), NRF-61 (Old Radioactive Materials Storage and Laydown Area), NRF-66 (Hot Storage Pit), and NRF-81 (A1W Processing Building Area Soil) based on the re-evaluation of existing data as presented in the previous sections.

The NRF OU 8-08 Final ROD did not establish a time frame for when these sites could be released from institutional controls. However, the ROD stated that "the "No Further Action" decision means that the site will be included in a CERCLA review performed at least every five years to ensure that site conditions used to evaluate the site have not changed and to verify the effectiveness of the No Further Action decision. If site conditions change, including present institutional controls, additional sampling, monitoring, or action will be considered. Site conditions would include the natural decay of radionuclides associated with a site and the term "action" could include the removal of institutional controls based on decay of radionuclides to levels allowing unrestricted use of a site

In 1998, the NRF OU 8-08 Final ROD developed preliminary remediation goals from risk-based concentrations that represented a concentration that would decay to a level that would allow unrestricted use of an area in 100 years (future residential scenario). Cs-137 was determined to be the primary risk driver. Since that time, EPA has provided updated slope factors and preliminary remediation goals for radionuclides presented on the EPA website (http://epa-prgs.ornl.gov/radionuclides/). This was discussed above in the Introduction; however, the new values have not been incorporated into any previous recent site-specific evaluation until now. To determine if these four sites could be released from institutional controls, the concentrations found at these sites during past sampling were decay corrected to today's value and compared to the newer EPA preliminary remediation goal values in Table A-1. The information in Table A-1 indicates that the current institutional controls at these four sites can be terminated. A minor change to the ROD (via a memorandum of non-significant change to the ROD) can accomplish this, since removal of institutional controls is consistent with the ROD as noted above.

Table A-1 Comparison of Decay Corrected Values to 1998 and EPA PRGs for Residential Soil

Site	Contaminant of Concern(1)	Maximum Detected Activity (pCi/g)	Date Detected	Decay Corrected Value (pCi/g)	1998 PRGs based on Risk-Based Concentrations		EPA PRG (pCi/g)4 at 1E-04 for Residential Soil (Unrestricted Release)
					Residential Soil Cleanup Level for 1998	Residential Soil Cleanup Level in 100 years (Unrestricted Release)	
NRF-2	Cs-137	4.7	1992	3.0	16.7	1.7	6.15
	Co-60	11.28	1991	0.81	(3)	(3)	3.9
NRF-61	Cs-137	1.6	1992	1.0	16.7	1.7	6.15
NRF-66	Cs-137	1.88	1996	1.33	16.7	1.7	6.15
NRF-81	Cs-137	2.89	1982	1.49	16.7	1.7	6.15
	Co-60	8.82	1982	0.19	(3)	(3)	3.9
	U-235	0.18(2)	1996	0.18	13.2	13.2	19.5

(1) Contaminant of Concern for either residential or occupational scenario
(2) The value used for U-235 was the maximum activity found during remedial investigation sampling performed at similar release sites at NRF. This was considered a very conservative assumption.
(3) Cobalt-60 was one of the primary contaminants of potential concern for the occupational scenarios. However, with a half-life of near five years, the cobalt-60 will have decayed to insignificant amounts within 100 years which would be the earliest a residence at NRF could be expected.
(4) Values obtained from EPA website (http://epa-prgs.ornl.gov/radionuclides/; last visited on September, 2011)

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Appendix B

Responses to EPA and IDEQ Comments on the Draft Five-Year Review of CERCLA Response Actions at NRF

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Preface

The following text provides the Naval Reactors Facility's (NRF's) responses to comments on the Draft Five-Year Review of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Response Actions at NRF received from the U.S. Environmental Protection Agency (EPA) and the Idaho Department of Environmental Quality (IDEQ) on December 13 and December 15, 2011, respectively.

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NRF Responses to EPA Comments on the Draft Five-Year Review of CERCLA Response Actions at NRF

General Comments

EPA Cover Letter – The report does not carefully follow the EPA Five Year Review Guidance in some areas, particularly the documentation of the response to the three main Technical Assessment questions. The Technical Assessment discussion lacked some details called for in the Guidance, such as providing a clear summary of the issues identified which could affect protectiveness and the assessment of the performance of the Institutional Control component of the remedy to a degree similar to other remedy components.

Response

The title of Section 7.2.2.7 “Assessment Summary” was changed to “Technical Assessment” to better follow the EPA Guidance manual. Table 7-5 was similarly renamed and Section 7.2.2.7 was enhanced to provide a Technical Assessment Summary that clearly identifies the one issue (siltation in groundwater monitoring well NRF-6) resulting from the technical assessment. In addition, the answers to the Technical Assessment questions were modified to provide an assessment of the performance of the Institutional Controls implemented as a component of each remedy.

EPA Cover Letter – In addition to lacking a Technical Assessment Summary, the draft lacks a table summarizing all issues identified in this review (only one is listed on the Summary Form, but table 9-1 seems to suggest there are three) with an explanation that none of the issues affect protectiveness. The list of issues on the table and the form should match, and the recommendations section of the form should be edited to start with a declaration that the issues which follow warrant follow-up, but do not affect current or future protectiveness.

Response

The Five-Year Review identified only one issue that was a potential deficiency and may warrant follow-up action (siltation in groundwater monitoring well NRF-6). The other items shown on Table 9-1 were not considered deficiencies or issues, but were rather recommendations based on the accumulation of data and information from the past five-years to reduce sample frequency and administrative controls. Table 9-1 was modified to clarify this difference. The last two columns of Table 9-1 indicate protectiveness status of the items. The Summary Form was modified to indicate that the one potential deficiency does not affect protectiveness. A declaration was added at the beginning of the section on the Summary Form that states: “The following issue may warrant follow-up actions, but does not affect current or future protectiveness”.

In addition to the changes noted above in Table 9-1, the targeted dates for recommendations related to administrative controls were changed to better reflect the timeline for submittal and concurrence on the related documents.

EPA Cover Letter – OSWER Directive 9355.7-18, entitled "Recommended Evaluation of Institutional Controls: Supplement to the '5-Year Review Guidance: IC Supplemental" (9/11) should be reviewed and information updated as appropriate. This would ensure adequate documentation of the performance of ICs to date, any problems encountered, whether the objectives remain adequate and appropriate, and any changes that are needed.

Response

OSWER Directive 9355.7-18 was reviewed and the Five-Year Review revised where appropriate. For example, the Technical Assessment (Section 7.2.2.7) was revised to specifically address Institutional Controls and to note the adequacy of long-term protectiveness provided by the Institutional Controls.

EPA Cover Letter – In addition to the differences from the Guidance in the TA section, there are other areas of the document lacking information and could be improved, including:

• The draft documents the RAOs for the remedies selected, but lacked sufficient details of the selected remedies to support a clear understanding of the remedies selected and the technical assessment of them. While those details are in the ROD(s), they really should be presented in the Five Year Review document. For example, section 3.6.4 documents groundwater contamination, and Section 4 suggests there is a selected remedy for groundwater and it appears to be limited to monitoring.

Response

Section 4.1 was revised to provide specific details of each selected remedy and how those remedies meet the RAOs. Regarding the groundwater, previous CERCLA investigations of residual groundwater contamination concluded that the risks were acceptable and remedial actions were not required. Groundwater monitoring was a component of the selected remedies to ensure the effectiveness of the selected remedy (in limiting contaminant migration to the aquifer). The revision to Section 4.1 clarifies this position.

EPA Cover Letter – • Sections 1 and 4 of the text mention changes made to the selected remedies, such as changing sites from No Further Action with ICs to No Action without ICs, but do not clarify whether all such changes have been made and documented in accordance with CERCLA, the NCP and EPA Guidance (e.g. Section 4.2.7.1, 4.2.7.2). Any time the selected remedy is modified or proposed for modification, the change needs to be made in accord with CERCLA, the NCP and EPA Guidance. The Recommendations section appropriately includes recommendations to modify the selected remedy where changes appear to be warranted, but it appears these are additional changes needed.

Response

Sections 4.2.7.1 and 4.2.7.2 were revised to more clearly show that the actions taken at both NRF-18A (S1W Spray Pond #1) and NRF-80 (A1W/S1W Radioactive Lines) were consistent with the Final ROD for Operable Unit 8-08 as noted in the EPA letter “Re: Recommended Course of Action for the Disposition of S1W Spray Pond #1 at the Naval Reactors Facility (NRF)” dated November 8, 2008. As noted in the comment, the new recommendations proposed in Section 9.0 will require modification to the selected remedy where appropriate.

EPA Response to Recommendation (in IBO Cover Letter) Recommendation # 1-Groundwater Monitoring Network. "Reduce sample collection frequency ... in USGS-97, -98 and -99" to every other year. However, Section 3.2.2.6 (p.16) specifically identified USGS-98 as a well that is likely to be impacted by falling water levels and cautions that "water levels can drop rapidly; therefore, NRF must continually track water level changes to ensure ample time is available to deepen the wells if needed". Furthermore, Table 3-2 indicates that as of May 2011, USGS-97 showed only 7.71' of water above the pump intake, and USGS-99 showed only 15.02' of water above the pump intake.

EPA recommends that IF sample collection frequency is reduced, the current schedule for measuring DTW (depth to water) is retained.

Response

NRF agrees with the comment and clarifying text was included in Section 9.3 and on Table 9-1 that water level measurements will continue to be collected on a biannual basis as currently performed.

Specific Comments

1) **p.14, Section 3.2.2.5;** When NRF-16 was constructed to replace NRF-13, NRF-7 and USGS-12 as the regional upgradient well, were NRF -13, NRF -7 and USGS-12 properly and completely abandoned? Please describe.

Response

Wells NRF-13, NRF-7, and USGS-12 were not abandoned and will continue to be used to collect observational data when needed (i.e., water level measurements). The following new text was inserted into the second to last paragraph of Section 3.2.2.5: “Both NRF-7 and USGS 12 continue to be used as monitoring wells for other purposes. NRF-13 continues to be used to collect water table elevation information.”

2) **p.16, Section 3.2.2.7;** Second paragraph states that the validity of the recurrence interval of flooding from the Big Lost River depends on the diversion dam located to the SW of NRF, and that it would shrink considerably without the diversion. Please state briefly who maintains the diversion dam and its present integrity.

Response

The following sentence was added to Section 3.2.2.7 to identify who maintains the diversion dam and its present integrity: “The diversion dam is under the cognizant of DOE Idaho Operations Office of Environment and Sustainability and is maintained by the Central Facilities Area Operation/Maintenance group. Its present operational integrity is considered good”.

3) **p.28, Section 3.5.2.4;** This paragraph indicates elevated concentrations of radionuclides and metals have been found in the sediment of the sewage lagoon (with a clay liner constructed in 1960). Which wells monitor the perched water quality beneath the Sewage Lagoon (and IWD) and where are these data available? Is there any expectation that the volume of effluent discharged to either the Sewage Lagoon or the IWD will increase significantly in the future?

Response

Section 3.2.2.3 contains a brief discussion about the perched water located beneath the northeast sewage lagoon. This section states that evidence for a perched water zone is provided by two shallow wells located near the lagoons. These wells are situated as follows: one well is located along the southeast side of each cell of the sewage lagoons. These wells are between 20 and 30 feet deep and monitor water that is perched on top of a clay deposit prevalent beneath NRF. Water samples are infrequently collected from these wells. Although not part of any associated CERCLA response actions, extensive sampling of these wells occurred in the early 1990s. Data from multiple samples were included as part of the Remedial Investigation/Feasibility Study performed at the NRF IWD and issued in 1994.

New lagoons were constructed in 2011 to replace the aging existing lagoons and are expected to become operative in early 2012 and thus, eliminate the discharge of sewage effluent to the existing lagoons. The perched water zone below the existing lagoon is expected to shrink in size over time.

The amount of water discharged to the IWD is expected to rise modestly from approximately 10 million gallons per year now to between 12 and 20 million gallons per year over the next 10 years. Increases in the future are due primarily to increased run-off due to the addition of new buildings at NRF.

Section 3.2.2.3 was modified to provide more details about these perched water wells. Section 3.5.2.4 was modified to include a reference to Section 3.2.2.3.

4) **p.30, Section 3.5.3.1;** Lists Remedial Actions sites but does not include NRF-12B. However, this site is listed individually in Table 3-5 (p.33). Please include a description of NRF-12B in Section 3.5.3.1.

Response

Site NRF-12B (S1W Leaching Pit) was not a "remediated radiological site" as the other sites were in this section. NRF-12B was entirely covered by an engineered cover and was therefore included in Section 3.5.3.2. The original asphalt cover that was removed from NRF-12B was part of the remedy for the cover construction to prepare the area for the engineered cover. Table 3-5 includes both the remediated radiological sites and the sites covered by an engineered cover.

5) **p.33, Table 3-5 NRF-14;** Why is Aroclor-1242 listed as a COC remaining after remedial action if it was not a COC before the remedial action? Similarly, for NRF-21A, Sr-90 is listed as a COC remaining after remediation (not before). For NRF-80, Co-60 is listed as a COC remaining after remediation (not before). Please explain.

Response

Aroclor-1242 was not originally identified as a COC for the NRF-14 site. Even though it was not a COC, the remedial actions for this site included confirmatory sampling for Aroclor-1242 (and other polychlorinated biphenyls (PCBs)) since there was potential to find PCBs during the excavation. As noted in the footnote in Table 3-5, Aroclor-1242 was detected below the 10 foot depth at concentrations above residential unrestricted release values, but below industrial use values. This is described in more detail in the "Operable Unit 8-08 Remedial Action Report for Naval Reactors Facility". Footnote (4) on Table 3-5 was modified as follows to clarify this issue: "*Even though Aroclor-1242 was not originally a COC, the confirmatory sampling for the remedial actions at this site included Aroclor-1242 (as well as other PCBs) since there was a potential to find PCBs during the excavation of contaminated soil.* Aroclor-1242 was detected (below the 10 foot depth) a concentrations above residential unrestricted release values, but below industrial use values."

Similarly Sr-90 was not originally considered a COC at NRF-21A (Old Sewage Basin). Samples collected during remedial action at NRF-21A showed Sr-90 was detected but not above the unrestricted release value, therefore, Sr-90 was removed from the table for NRF-21A (Old Sewage Basin).

Footnote (6) explains that Co-60 was not a COC requiring remedial action but was considered a COC for releasing the area for unrestricted residential use. The NRF OU8-08 Final ROD states that Co-60 is not a COC for the 100 year residential scenario but is a COC for the occupational scenario. Footnote (6) was revised for clarity as follows: "Cobalt-60 (Co-60) was not a COC *requiring remedial* *action* as determined in the ROD. However, this was based on the assumption of 100 years of controls and the resulting radioactive decay of Co-60. Co-60 *was* a COC when considering the potential for present-day unrestricted release of an area *."*

6) **p.44, Section 4.2.5.1.1** states that Sr-90 and Pb are not above cleanup levels at any of the excavation sites. Table 3-5 (p.33) lists Sr-90 and Pb as COCs remaining at the listed sites after the Remedial Action has been completed. Please confirm that Sr-90 and Pb remaining at the sites listed in Table 3-5 are not above MCLs.

Response

Neither Sr-90 nor Pb (or any COC listed on Table 3-5) has been detected in groundwater samples above MCLs. In addition, neither Sr-90 nor Pb was detected at the "remediated radiological sites" above remediation goals established in the ROD. However, both Sr-90 and Pb are present above remediation goals in the engineered cover locations.

7) **p.49, Section 4.2.6.2;** Third bullet states that a UXO survey will be conducted by the INL UXO expert team. Is this a single event or does it recur periodically (to address new items potentially revealed by the frost/heave cycle)?

Response

The UXO surveys include a 100% geophysical survey for potential subsurface UXO. All anomalies are investigated by the UXO survey team expert who clears the area from future UXO concerns. This process will be more clearly delineated in the DOE-ID Remedial Design/Remedial Action Work Plan for Operable Units 6-05 and 10-04, Phase IV and in the revision to the NRF Institutional Control Plan, which is planned for March 2012. Therefore, the third bulleted item was revised to provide more details of the process as follows: "Conducting a UXO survey by the INL UXO expert team *that will include a 100% visual and 100% geophysical survey (for any potential subsurface UXO). All anomalies are investigated by the UXO survey team expert who clears the area from future UXO concerns."*

8) **p.61, Section 6.2.1.4** describes the subsidence of the engineered cover at NRF-12B/14 and states that the entire cover has settled by approximately 1 inch. Has standing water been observed annually on the cover since 2006? What are the approximate dimensions of the area of standing water? (How deep is the subsidence area itself?)

Response

Standing water has not been observed on the cover since 2006 even after the occurrence of some major storms (one storm event in particular over about a three day period where approximately 1.5 inches of precipitation fell at NRF). The area of standing water in 2006 was estimated to be 30 ft^2. The depth of the subsidence area is 2 to 3 inches. This information was inserted in the second paragraph of Section 6.2.1.4 as follows: (1) the second sentence was revised to read, "This area was first noticed in the spring of 2006 where there was a small area of standing water *estimated to be 30* ft^2." (2) the third sentence was revised to read, "This area has been frequently inspected over the past several years *with no further observance of standing water even after the occurrence of some major storms (one storm event in particular where approximately 1.5 inches of precipitation fell over a three day period at NRF)*." (3) the last sentence was added to read, "The current depth of the subsidence area is 2 to 3 inches."

9) **p.80, Section 6.3.2.4** states that a residual perched water zone is releasing small quantities of water to the aquifer that may be accounting for the increased tritium concentrations at NRF-10 and -11. Is it possible that contributions from the perched water zone near the IWD are contributing the elevated chromium concentrations in NRF-6? If so, can the recharge to the perched water zone be minimized?

Response

It is possible that water in the perched water zone located beneath NRF-6 contains elevated levels of chromium (originating from the IWD sediments) and that this chromium is eventually detected in NRF-6. This perched water zone is not considered to be a major source for chromium. This was a conclusion of the IWD RI/FS performed in 1992. There does not appear to be a significant link between the amount of recharge to the IWD and chromium concentrations since water discharge volume to the IWD in 1991 was approximately 180 million gallons per year compared to approximately 10 million gallons per year now. Additionally, even though the amount of water discharged to the IWD has decreased over time, the chromium concentrations in NRF-6 have generally remained between 40 ppb and 50 ppb except when sedimentation issues in the well caused anomalous increases which were mitigated when the well was refurbished.

10) **P. 102, table 7-1, controls column, group 4**; Per current EPA guidance fences are not defined as institutional controls. Institutional controls are administrative in nature where fences are considered a physical control.

Response

The title of Table 7-1 has been changed to "Summary of *Land Use* Controls at NRF". This terminology, as noted in EPA OSWER Directive 9355.7-18, "Recommended Evaluation of Institutional Controls: Supplement to the '5-Year Review Guidance: IC Supplemental", is generally used by federal facilities to describe ICs and may include engineering components. The text in Section 7.2.1 was also modified to refer to Table 7-1 for Land Use Controls.

11) **p.108, Section 8.0;** This would be a good spot to mention the ponding/minor subsidence occurring @ NRF-12B/I4.

Response

The text was revised to include the ponding/minor subsidence as follows: (1) The first sentence was revised to read, "The only issues identified by the annual inspections included *a ponding/minor subsidence area observed at one of the engineered cover sites,* slight encroachment by weeds…". (2) New sentences were added prior to the last sentence that state: "With regard to the small area of subsidence where ponding of water was first observed in 2006, survey elevation data over several years shows that the rate of settling in the subsidence area appears to be about the same as the rest of the engineered cover. Based on survey data and visual observation, no repairs are necessary."

<u>Minor comments:</u>

1) **p.22, Section 3.3.5.2;** Is a figure/cross-section available that shows the undulating basalt surfaces beneath NRF and the direction of dip? If so, please include.

Response

Figure 2-8 of Appendix H of the NRF Comprehensive RI/FS shows a contour map of the area near NRF. Figure 2-10 of the same appendix also shows a cross-section beneath the IWD. A reference was included in Section 3.3.5.2 to these figures, i.e., WEC, 1997b, Appendix H, Figures 2-8 and 2-10.

2**) p. 40, Section 4.2.4 Second paragraph, Last sentence**; "selected for placement of an engineered ~~covert~~ cover."

Response

It was assumed that the comment refers to Section 4.2.5, and the comment was incorporated.

3) **p.49, Section 4.2.7.1 Last sentence;** "remain a NFA site until additional data ~~was~~ were available…"

Response

Comment incorporated.

4**) p.51, Figure 4-4;** Please add compass.

Response

Comment incorporated.

5) **p.54, Section 4.2.7.1 First paragraph;** " ... additional sampling in accordance with a sampling and analysis plan." Please provide the proper reference for this SAP.

Response

Details of this sampling are included in the Sample and Analysis Plan for the S1W Spray Pond #1 Soil Characterization. The sentence noted was changed to include reference to this document as "(BBI, 2007)", which was also added to the list of references.

6) **p.63, Figure 6-1;** Please include a reference line on the graph that shows the chromium MCL.

Response

The scale of this figure was selected to best show the changes in chromium concentrations over time. Its scale is set to range from 15 ppb to 65 ppb. Expanding the scale to include the MCL of 100 ppb would interfere with the resolution of the figure. A footnote was added to the figure indicating the MCL for chromium is 100 ppb.

7) **p.66, Section 6.3.2.2 Last paragraph;** "The values in ~~Table 6-2~~ ... " "Table 6-3"?

Response

Table 6-2 and 6-3 were switched, and the text remained the same.

8) **p.75, Figure 6-3;** This graph would be clearer if the y-axis on the right hand side was properly labeled "Water Table Elevation" instead of listing both labels on the left hand side. Please add reference line for Chloride MCL.

Response

The axis on the right side of the graph was labeled “Elevation of Water Table in Feet.” The scale of the graph does not allow a reference line for the chloride Secondary MCL (250,000 ppb); therefore, a note was added to the upper left portion of the graph stating “Note: the Secondary MCL for Chloride is 250,000 ppb.”

9) **p.78, Section 6.3.2.4;** " ... and so too was the most easterly ~~extend~~ extent of the chromium plume"

Response

Comment incorporated.

10) **p.91, Figure 6-10, which is now Figure 6-12, Soil Moisture Curve for NRF-21A#1;** Key does not include red/maroon dashed line with triangles ['Optimum Moisture 80% Sat.'?]

Response

The figure was fixed to show the “Optimum Moisture 80% Sat”.

11) **p.112, Table 11-1 Protectiveness Statements;** "The data also ~~indicates~~ indicate ... "

Response

Comment incorporated.

DEQ Comments on Draft 5-Year Review of CERCLA Response Actions at the Naval Reactors Facility

<u>Specific Comments</u>

1) Section 3.2.2.2, page 12

Please clarify that the Industrial Waste Ditch is a former CERCLA site (previously investigated).

Response

The following paragraph was added to Section 3.2.2.2 to identify the Industrial Waste Ditch as a former CERCLA site: “The IWD was investigated through the Remedial Investigation/Feasibility Study process under CERCLA. The risks to human health and the environment associated with the IWD were determined to be low. The IWD was subsequently designated a “No Action” site in 1994.”

2) Figure 3-4, page 13

Please add the locations of the NRF production wells to this figure. Their locations may help explain the configuration of the 4464 ft. iso-contour line around NRF.

Response

The production well locations were not added to this figure because this map was created without elevation information from these wells. Future water table maps will use data from two drinking water wells and two production wells located within the NRF security fence.

3) Section 3.2.2.7, second paragraph, last sentence, page 16

The sentence states: "Without the diversion dam, the flood recurrence interval capable of inundating NRF shrinks to something considerably less." Please provide a more quantitative explanation of "considerably less."

Response

This statement was intended to be qualitative since the data required to predict detailed flooding recurrence intervals at NRF is limited. However, the text was changed to read “*A* diversion dam located approximately 8 miles southwest of NRF *diverts water into spreading areas southwest of Radioactive Waste Management Complex (RWMC) to help control flooding downstream. The probability that NRF could be flooded in the future would likely increase without this diversion dam*.”

4) Section 3.3.1, third paragraph, second to the last sentence, page 18

The text states: "Known eruption vents occur to the southwest of NRF, along what is referred to as the Arco volcanic rift zone, to the southeast along the axial volcanic zone, and to the north at Atomic Energy Commission Butte." A map or figure should be included (or reference provided) to identify areas such as the "Arco volcanic rift zone" and the "Atomic Energy Commission Butte" in order to locate these positions relative to the NRF.

Response

A new figure (Figure 3-9) that shows all of the key volcanic zones was added to the document in Section 3.3.1. The reference of the butte being located north of NRF was changed to southwest of NRF.

5) Section 3.5.2.2, last sentence; Section 3.5.2.4, last sentence; Section 3.5.2.6, third sentence, pages 27-28

These sections contain a statement that the risk assessment for the site was very conservative and a risk management decision was made that the actual risks are acceptable. Please explain if this decision was accepted by all the regulatory agencies and/or in which document it was noted.

Response

Similar statements, including risk management decision by the agencies, are documented in the NRF OU-8-08 Final ROD, therefore, a reference to this document "(WEC 1998)" was added where appropriate in each section.

6) Figure 4-4, page 51

Please add a north arrow and scale to this figure.

Response

Comment incorporated.

7) Figure 4-5, page 52

Please add a scale to this figure.

Response

Comment incorporated.

8) Section 4.2.7.1, second to the last paragraph of section, last sentence, page 54

Please include the disposal location for the waste (i.e. ICDF).

Response

The last sentence was modified to read "…including the disposal of the waste *to the ICDF*."

9) Figure 4-7, page 56

Please add a scale to this figure.

Response

Comment incorporated.

10) Section 5.0, page 57

Section 5.0 "Progress Since Last Review" of the document does not summarize all the remedial actions that have occurred since the previous 5-year report. For example, the document should reference the actions that took place at NRF18 A (S1W spray pond) and NRF-80.

Response

Section 5.0 followed the guidance provided in the EPA “Comprehensive Five-Year Review Guidance”, which states that this section should provide a summary of the recommendations and follow-up actions from the previous five-year review. The actions taken at NRF-18A and NRF-80 were not recommendations or follow-up actions related to the 2006 Five-Year Review. A summary of the actions taken at NRF-18A and NRF-80 was provided in Section 4.7 “Post ROD Response Actions”, which per the EPA guidance was to be included in Section 4.0 “Remedial Actions”.

11) Section 5.1.1, page 57

Based on EPA Five-year Review guidance (2001), this section is usually called the *"Protectiveness* Statement", not the Protective Statement, as stated.

Response

Comment incorporated.

12) Section 6.3.2.1, first full paragraph, fourth sentence, page 65

The basis for the reason why a low flow of 1-3 gallons per minute from NRF-7 will make samples collected from this well susceptible to "sediment cross-contamination" is not clear. Please explain.

Response

The third paragraph of Section 6.3.2.1 was modified to include the following new sentences: “During the sampling process, the water level in the well falls to near the intake depth. This in turn allows water to cascade down the well bore from the level of the regional aquifer to the level of the pump (approximately 20 feet). The cascading water creates turbulence which in turn loosens sediments lodged in fractures and pores in the aquifer material. Some of the dislodged fines potentially can be pulled into the pump along with the water being sampled. If the sediment is analyzed along with the water, anomalously high results can be generated”.

13) Section 6.3.2.1, first full paragraph, sixth sentence, page 65

Please add an explanation as to why NRF-7 is believed to contain " ...mostly 'old water'," and add a brief explanation of the meaning and the origin of "old water."

Response

NRF-7 is believed to be completed in a low permeability zone located north and east of NRF. Flow velocities in this zone are expected to be low compared to other portions of the Snake River Plain Aquifer near NRF; therefore, the turn-over rate of water in this zone is expected to be slower than the surrounding aquifer. The concentrations of key constituents in NRF-7 are very low compared to other NRF wells and upgradient (background) well locations. For example, the lifetime concentration averages for calcium at 26.2 mg/L, chloride at 5.1 mg/L, magnesium at 9.4 mg/L, nitrate at 0.51 mg/L, sodium at 8.9 mg/L, sulfate at 14.4 mg/L, and tritium at 1.7 pCi/L are the lowest respective concentrations compared to all other NRF groundwater monitoring results (including upgrading well results). These concentrations indicate little or no anthropomorphic influences, e.g., pre-bomb testing. Although the exact age of the water is not known, it is estimated to be greater than 50 years and may be much older. The third paragraph of Section 6.3.2.1 was modified as follows: "….Finally, NRF-7 is believed *by NRF and USGS scientists* to contain mostly "old water", *because it* is nearly unaffected by *anthropomorphic* influences (e.g., tritium produced by past above ground nuclear testing at the Nevada Test Site and other world sites) *unlike other nearby wells, including upgradient wells, which are affected by anthropomorphic influences*. *The concentrations of key ionic constituents (e.g., calcium, chloride, sodium, nitrates, etc.) are anomalously low compared to corresponding concentrations from other area wells. Although the exact age of the water is not known, it is believed to be greater than 50 years old and may be much older*".

14) Section 6.3.2.1, first full paragraph, last sentence, page 65

The last sentence of this paragraph; "Data collected from NRF-16 will be referenced and discussed as appropriate," should be further explained as it is not clear where the information will be referenced, or discussed.

Response

The sentence was left over from a previous revision of the draft document and has been deleted.

15) Section 6.3.2.4, fourth complete paragraph on page 76

This discussion would be much better served if a large-scale map of only the specific wells referenced, coupled with the groundwater flow lines and respective well concentration data, accompanied this discussion. In addition, based on the discussion in this paragraph, it appears what is being described in the last sentence is a *west-southwesterly* flow direction, not "east-southeasterly."

Response

Two new figures (Figures 6-6 and 6-7) showing flow lines and concentrations for 2002 and 2010 were added to this section of the document. As suggested, the last sentence of the referenced paragraph was modified to read: "This hypothetical chromium plume appears to be located just southwest of NRF-10 at the present time indicating a flow path that is currently passing beneath NRF in *a west-southwesterly* direction." Another reference to Figure 6-7 was inserted at the end of the paragraph as follows: "(again, refer to Figure 6-7).

16) Section 6.3.2.4, first paragraph, page 77

The second sentence states that "Comparisons of water table flow maps and constituent concentration maps with the graph depicted in Figure 6-6 indicate ..." Please provide a reference for these maps.

Response

The maps referenced in this section are working maps and therefore, since they are not published, reference to these maps has been removed from the text. The sentence was changed by deleting "Comparisons of water table flow maps and constituent concentrations maps with the graph depicted in Figure 6-6…" and replacing it with "…*Groundwater data*…".

17) Section 6.3.2.4, third paragraph on page 78

Please provide a reference for the third sentence (" ...graphs of ionic salts data for the same wells"). It is not apparent what figures are being referred to.

Response

Because the information associated with the referenced ionic salt is not essential to this discussion, the referenced sentenced was deleted from the paragraph.

18) Section 6.3.2.4, fourth paragraph on page 78

Please delete this paragraph that speculates about the effects of dispersion on down gradient contaminant concentrations. There may be more likely mechanisms that can affect the down gradient concentrations than dispersion. The effects of dispersion on contaminant plumes at the INL have largely been estimated as a fitting factor to get mathematical models to replicate contaminant plumes. Defensible data do not exist to quantify dispersivity which is a three-dimensional property in this environment.

Response

Comment incorporated.

19) Appendix A, Figure A-1, page 5

Please add a north arrow to the main figure and a scale to the main figure and the inset.

Response

Comment incorporated.

20) Appendix A, Figure A-2, page 7

Please add a directional arrow to this figure so the reader knows the direction of the line of site in this photograph.

Response

Comment incorporated.

21) Appendix A, Figure A-3, page 8

Please add a directional arrow to this figure so the reader knows the direction of the line of site in this photograph.

Response

Comment incorporated. Since the photograph in Figure A-5 is similar to Figure A-3 (but oriented 90 degrees), a directional arrow was also added to Figure A-5.

22) Appendix A, Figure A-4, page 10

Please add a north arrow and a scale to the main figure and the inset.

Response

Comment incorporated.

<u>Editorial Comments</u>

23) Section 3.5.2.8, first sentence, page 28

Please correct the typographical error by removing "the" from the sentence.

Response

Comment incorporated.

24) Section 3.5.3.1.3, last sentence, page 30

The sentence refers to "effluence" but it appears the correct term should be: effluent.

Response

Comment incorporated.

25) Table 3-5, footnote (5), page 33

The phrase "are not longer present" should be: are no longer present.

Response

Comment incorporated.

26) Section 4.2, first paragraph, last sentence, page 36

Please correct the typographical error. Actions completed at NRF-18A, NRF-43, and NRF-80 are discussed in Section 4.2.7 (not 4.2.6).

Response

Comment incorporated.

27) Section 6.2.1.5.3, fourth sentence, page 61

The phrase "in good conditions" should be: in good condition.

Response

Comment incorporated.

28) Section 6.3.2.2, third paragraph on page, tenth sentence and last paragraph, first sentence, page 66

Table 6-3 should be referenced instead of Table 6-2.

Response

Tables 6-2 and 6-3 were switched and the text remained the same.

29) Section 6.3.2.4, first paragraph, fourth sentence, page 68

Table 6-2 should be referenced instead of Table 6-3.

Response

It was assumed that the comment referred to Section 6.3.2.3. Table 6-2 and 6-3 were switched and the text remained the same.

30) Section 6.3.2.4, third complete paragraph on page 76

Please add *that* after the section in parentheses, i.e., "…below federal MCls) that is moving ..."

Response

Comment incorporated.

31) Section 6.3.2.4, fourth complete paragraph, fifth sentence, page 76

Line 7 refers to "Aquifer pumps tests" but should state Aquifer pump tests.

Response

Comment incorporated.

32) Section 6.3.2.4, second paragraph, second sentence, page 77

There appears to be a typographical error or word missing in the sentence: " ...can be at a higher angle (cross-ways to) reducing it exposure cross-section or parallel with (more southerly)." The "it" may need to be revised to *"it's."*

Response

To clarify this part of the paragraph, the following changes were made.

"The differences in the chromium concentration in NRF-6 and the Local Downgradient wells is explained in part by dispersion mechanisms and in part by the fact that *the aquifer* flow direction beneath the IWD, *which is a* source for the chromium *in the aquifer*, can *change over time. When the aquifer flow direction is more perpendicular with respect to the IWD, a greater portion of the aquifer is* expose*d to the contaminants originating in the IWD resulting in lower concentration of chromium in* *the aquifer. When the aquifer flow direction is* more parallel with *respect to the IWD* (more southerly*), a smaller portion of the aquifer is exposed to the contaminants and aquifer chromium concentrations are higher"*.

33) Section 6.3.2.4, first full paragraph, second sentence, page 78

The fourth line states "was the easterly most extend of the chromium plume" but "extend" should be extent.

Response

Comment incorporated.

34) Section 7.2.2.2.1, second full paragraph on page 98

The third line should use affected instead of "effected" in this context. The fourth line states "a phased approached was chosen" which should read: a phased approach was chosen.

Response

Comment incorporated.

35) Section 7.2.2.6.1, seventh sentence, page 105

The ninth line states "groundwater monitor portion" could be worded groundwater monitoring portion for readability.

Response

Comment incorporated.