ICP/EXT-04-00702

Surface Geophysics and Downhole Geophysical Logging Results for the Radioactive Waste Management Complex, 2003-2004

Idaho Completion Project

Bechtel BWXT Idaho, LLC

March 2005

ICP/EXT-04-00702
Project No. 23957

Surface Geophysics and Downhole Geophysical Logging Results for the Radioactive Waste Management Complex, 2003-2004

Nick Josten

March 2005

GeoSense
Idaho Falls, Idaho 83415

Prepared under Subcontract No. 00022841
for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-99ID13727

ABSTRACT

Surface geophysics and downhole geophysical logging activities are performed as needed to support the Idaho Completion Project at the Idaho National Laboratory Radioactive Waste Management Complex. The logging efforts are performed to collect data directly from the waste zone for characterization purposes.

This report is a compilation of a large number of informal analyses of surface geophysics and downhole geophysical logging data collected between September 2003 and August 2004. Much of the material collected in this report has not been published in any form, though it has been used to support the ongoing environmental restoration decision-making process. The primary purpose of this report is to provide Subsurface Disposal Area surface geophysics and downhole geophysical logging information in a form that can be easily referenced.

CONTENTS

FIGURES

TABLES

ACRONYMS

bgs	below ground surface
FY	fiscal year
INL	Idaho National Laboratory
NA	not applicable
ND	not detected
NRF	Naval Reactors Facility
OU	operable unit
PLN	plan
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
TRU	transuranic
VOC	volatile organic compound
vol%	volume percent
wt%	weight percent

Surface Geophysics and Downhole Geophysical Logging Results for the Radioactive Waste Management Complex, 2003-2004

1. INTRODUCTION

Surface geophysics and Type A downhole geophysical logging activities have been performed at the Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA) as needed in support of the Idaho Completion Project at the Idaho National Laboratory (INL). The logging efforts are performed to collect data directly from the waste zone for characterization purposes.

An initial Type A probing effort was performed from 1999–2001, during which 139 Type A probes were installed in Pits 4, 5, 6, 9, and 10. Probing equipment and methods are described in *OU 7-10 Initial Probing Campaign Downhole Logging Results* (Josten and Okeson 2000) and *Type A Nuclear Logging Data Acquisition and Processing for Operable Units 7- 13/14 and 7-10* (INL 2002). Interpretation, results, and discussion may be found in various reports. General results for the entire probing effort are documented in the *Compilation of Analytical Notes and Data Analyses for the Integrated Probing Project 1999–2002* (Josten 2002). Pit 9 probing results are recorded in *OU 7-10 Stage I Subsurface Exploration and Treatability Studies Report (Draft) - Initial Probing Campaign - December 1999–June 2000* (Okeson et al. 2000). *Evaluation of OU 7-10 Stage I Soil Moisture Readings* (Beitel et al. 2000) contains a detailed discussion of soil-moisture logging tool performance and results at Pit 9. *Estimating the Mass of Pu-239 Waste Near P9-20 Probe Hole for the OU 7-10 Glovebox Excavator Method Project* (Jewell et. al. 2002) describes efforts to perform quantitative calculations of Pu-239 mass at Pit 9. *Estimating Carbon Tetrachloride and Total Volatile Organic Compound Mass Remaining in Subsurface Disposal Area Pits* (Sondrup et al. 2004) describes efforts to perform quantitative calculations of volatile organic compound (VOC) mass based on nuclear logging measurements.

1.1 Purpose and Scope

This report is a compilation of a large number of informal analyses of surface geophysics and downhole geophysical logging efforts performed between September 2003 and August 2004. For the purposes of this report, this testing period is referred to as Fiscal Year (FY) 2004. Much of the material collected in this report has not been published in any form, though it has been used to support the ongoing environmental restoration decision-making process. The primary purpose of this report is to provide the surface geophysics and downhole geophysical logging information in a form that can be easily referenced.

It should be noted that some of the analysis results contained in this report represent interim compilations and conclusions.

1.2 Description of Logging Area

The INL is a U.S. Department of Energy facility located 52 km (32 mi) west of Idaho Falls, Idaho that occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Idaho Snake River Plain. The RWMC is located in the southwestern portion of the INL as shown in Figure 1-1. The SDA is a 39-ha (97-acre) portion of the RWMC. Low-level, transuranic (TRU), mixed, and other radioactive waste was buried in shallow pits and trenches in the SDA (see Figure 1-2) from 1952 until 1970, when burial of the TRU portion of the waste ceased. Since 1985, only low-level waste has been buried at the SDA. Contaminants of concern detected in the unsaturated zone beneath the SDA include nitrates, carbon tetrachloride, C-14, Tc-99, and uranium isotopes (Holdren et al. 2002).

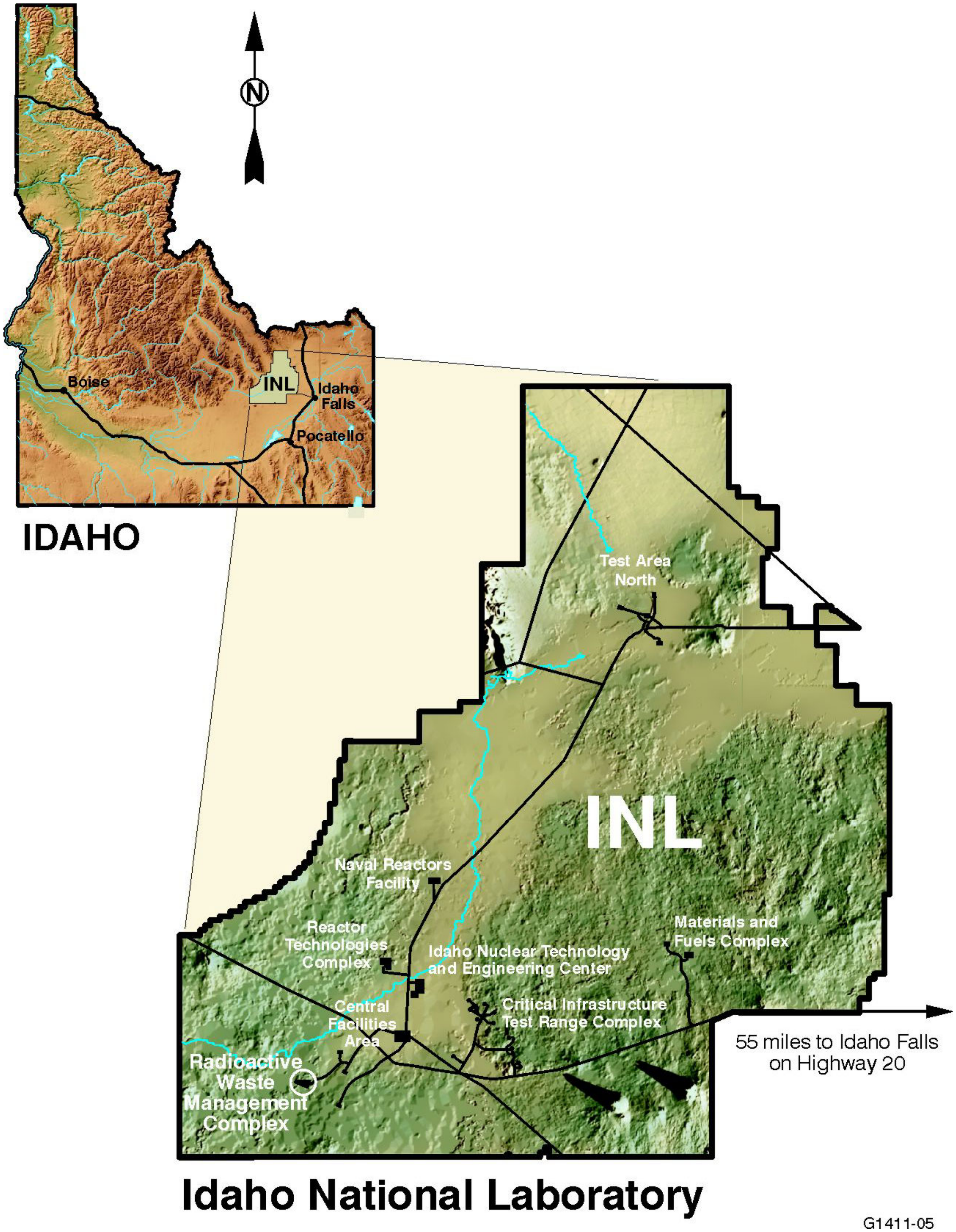

Figure 1-1. Map of the Idaho National Laboratory showing the location of the Radioactive Waste Management Complex and other major Site facilities.

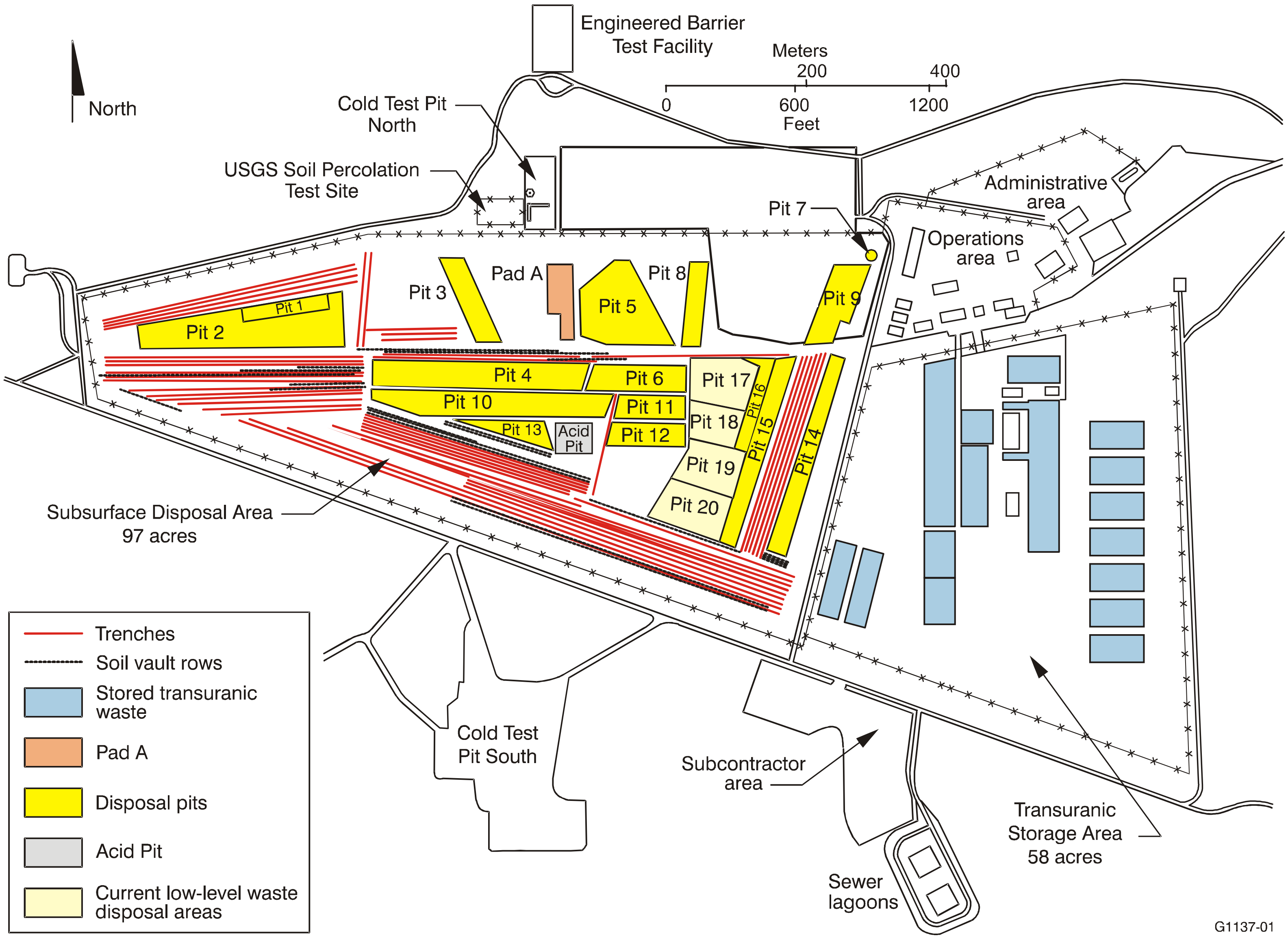

Figure 1-2. Map of the Radioactive Waste Management Complex showing the pits and trenches at the Subsurface Disposal Area.

2. BACKGROUND

2.1 Description of Geophysical Investigations

Two types of geophysical data were used for the analyses presented in this report. The first was surface geophysics data, collected over many years of SDA operations including several new surveys collected in FY 2003 and 2004. Surface geophysics data were used mainly to delineate waste versus nonwaste areas, a basic segregation that supports many of the analyses presented in this report. The second was downhole geophysical logging data, which provide information on in situ conditions within the waste zone, overburden, and underburden.

2.1.1 Surface Geophysics

Table 2-1 lists two surface geophysical studies performed by Sage Earth Science at the SDA from FY 2003 through 2004. These studies were conducted to support analysis of remedial alternatives and future environmental restoration needs for the SDA, with the exception of Pit 9 and the low-level waste pit. The FY 2004 survey produced comprehensive, high-resolution geophysical data for most of the SDA. The subcontractor report for this survey is included as Appendix A. All SDA surface geophysical data, including the surveys listed in Table 2-1, have been archived in Plan (PLN) -1709, "Software Documentation for the Nuclear Logging and Surface Geophysics Database."

Table 2-1. Summary of Subsurface Disposal Area surface geophysical surveys conducted in 2003–2004.

Performer	Year	Methods	Survey Area
Sage Earth Science	2003	Magnetics, electromagnetic induction	Pad A, SDA east, SDA southwest, Trench 3, Trench 47, Trench 57
Sage Earth Science	2004	Magnetics, electromagnetic induction	Entire SDA except Pit 9 and low-level waste pit

SDA = Subsurface Disposal Area

2.1.2 Downhole Geophysical Logging

From August 2003 through January 2004, 48 Type A steel probes were installed at various locations in the SDA. Probe locations were selected based on combined analysis of surface geophysical data and waste inventory records. A suite of geophysical logging tools was deployed in these probes to investigate subsurface characteristics of buried waste. Table 2-2 lists the geophysical tools used and gives a brief summary of the scope of the FY 2004 logging program. All SDA geophysical logging data, including the surveys listed in Table 2-2, have been archived in the Nuclear Logging and Surface Geophysics Database, housed in the Environmental Data Warehouse.

Table 2-2. Summary of Subsurface Disposal Area FY 2004 geophysical logging program.

Tool	Primary Application	Number of Probes Logged	Linear Feet Logged
Passive spectral gamma ray	Detect gamma-emitting radionuclides	48	527.90
Passive neutron	Detect neutrons associated with TRU radionuclides	48	477.55
Neutron-activated spectral gamma ray	Detect chlorine	48	477.80

Table 2-2. (continued).

Tool	Primary Application	Number of Probes Logged	Linear Feet Logged
Neutron-neutron moisture	Measure moisture content	48	649.73
Azimuthal spectral gamma ray	Delineate compact versus distributed radioactive sources	13	57[a]

a. Azimuthal surveys conducted at 57 depths.

TRU = transuranic

Geophysical logging was performed in accordance with specifications defined in the "Statement of Work for Nuclear Geophysical Logging" (SOW-561). These data have yielded qualitative and semiquantitative information about the distribution and environment of radionuclides and chlorinated solvents in the subsurface. Table 2-3 gives a summary of contaminant detections for the FY 2004 logging program.

Table 2-3. Overall summary of downhole logging results for the FY 2004 logging program.

Parameter	Pu-239 375 keV	Am-241[a] 662 keV	Np-237 312 keV	U-235 186 keV	U-238 1,001 keV	Cs-137[a] 662 keV	Co-60 1,333 keV	Chlorine 1,165 keV
Total measurements	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,039
Number of detects	199	229	116	69	172	177	85	486
Number of nondetects	946	916	1,029	1,076	973	968	1,060	553
Detect percent	17.4	20.0	10.1	6.0	15.0	15.5	7.4	46.8
Nondetect percent	82.6	80.0	89.9	94.0	85.0	84.5	92.6	53.2

a. After subcontractor correction for interference between Cs-137 and Am-241 662-keV gamma rays.

The subcontractor chart summary for all logging data acquired under this program is reproduced in Appendix B.

2.1.3 Notes on Quantitative Use of Type A Geophysical Logging Data

Responses of the Type A nuclear logging tools (and in particular the passive gamma-ray logging tool) are known to depend on many factors, but the three most important are (1) the amount of radionuclide source present, (2) geometry of the radionuclide source distribution (i.e., anywhere between a compact point source and a homogenous distribution), and (3) density of the waste and soil matrix surrounding the source. Modeling exercises show that these three factors have roughly equal influence on the logging-tool response. As a consequence, the logging data cannot provide an unequivocal estimate for one factor unless the other factors are known. The existing calibration method handles this problem by making simplifying assumptions for the source geometry and soil-matrix density such that the third factor, the amount of radionuclide, can be estimated directly.

Radionuclide estimates produced by the existing calibration methodology have very limited utility because the underlying uniformity assumptions are indefensible. Inventory records, waste drum scan records, and logging data all indicate highly heterogeneous conditions within SDA waste. Furthermore, no known methods will independently measure the waste and soil matrix density.