BGRR-055, FINAL
Volume 1 of 3

Brookhaven Graphite Research Reactor Decommissioning Project

FINAL

CHARACTERIZATION REPORT FOR THE 701 BELOW-GROUND STRUCTURES, 702 PILE, AND REMAINING SOILS

VOLUME 1

May 2003

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BROOKHAVEN SCIENCE ASSOCIATES
Under Contract No. DE-AC02-98CH01886 with the
UNITED STATES DEPARTMENT OF ENERGY

EXECUTIVE SUMMARY

Brookhaven National Laboratory (BNL) is a United States Department of Energy (DOE) facility that was placed on the New York State Department of Environmental Conservation (NYSDEC) Inactive Hazardous Waste Disposal Sites list in 1980. Subsequently, in 1989, the Laboratory was included on the U.S. Environmental Protection Agency (EPA) National Priorities List for cleanup. The Laboratory ranked high on the EPA rating system and was placed on this list because of the environmental effects of past practices, some of which could pose a threat to Long Island's sole-source aquifer in the vicinity of BNL. The cleanup of BNL is funded by the DOE and overseen by DOE, EPA, and NYSDEC.

The Brookhaven Graphite Research Reactor (BGRR) has been identified as Area of Concern 9 in the Interagency Agreement between the EPA Region II, the DOE, and NYSDEC. This is a Federal Facility Agreement under the *Comprehensive Environmental Response Compensation, and Liability Act* of 1980 (CERCLA) Section 120, Administrative Docket Number II-CERCLA-FFA-00201.

The structures, components and associated soils comprising the area of investigation are radiologically contaminated as a result of normal BGRR operation, water intrusion, and leaks throughout the history of the facility. A substantial characterization investigation, described in the *Sampling and Analysis Plan for the 701 Building, 701 Below-Ground Structures, 702 Pile, and Remaining Soils*, was performed to determine the nature and extent of radiological and non-radiological contamination. The findings for Subpart A of the Sampling and Analysis Plan, 701 Building, are detailed in *Characterization Report for Building 701 Above-Ground Surfaces, Systems, and Structures*. The findings from the other three subparts of the Sampling and Analysis Plan, "701 Below Ground Structures," "702 Pile," and "Remaining Soils," are documented in this report.

The data collected from the characterization surveys was evaluated to determine the locations and extent of contamination for the identified radionuclides of concern and hazardous materials of concern. These results will be evaluated in the *BGRR Risk Assessment* and *BGRR Feasibility Study* to decide if the Data Quality Objectives (DQOs) have been met and to determine if additional characterization information is necessary before the *BGRR Proposed Remedial Action Plan* and *BGRR Record of Decision* are prepared. The DQOs were established by analyzing the potential contamination pathways as outlined in the *United States Environmental Protection Agencies (EPA) Guidance for the Data Quality Objectives Process.*

The characterization approach used for the 701 below-ground structures, 702 pile, and remaining soils was to investigate both biased and unbiased locations. Biased locations were determined from the facility operating history, known leakage paths, and lessons learned from previous BGRR characterizations. Unbiased locations were chosen to confirm or disprove the existence of contamination in locations thought to be clean via historical and anecdotal

assumptions and to estimate the lateral extent, or bounds, of contamination that may have migrated from other sources. The unique design and construction of the BGRR provided significant challenges in accessing the soils beneath suspect locations. For those areas where the soils were inaccessible, adjacent soil samples were obtained and the results are reported along with an engineering judgment regarding the extent of contamination in the soil that was inaccessible.

Field activities commenced with the characterization of the remaining soils and biological shield in June 2002 and were completed with the collection of the final soil sample in November 2002. Some previous characterization activities related to the graphite pile were completed in August 2000 and those results are also included in this report. Highlights of the characterization findings for the three areas of investigation are summarized as follows:

701 Below-Ground Areas

1. The primary liner of the north below-ground duct leaked contaminated water into the secondary liner and surrounding soils. A debris sample was obtained from the annular space between the expansion joints of the north and south ducts and it is contaminated with cesium-137 (Cs-137) and strontium-90 (Sr-90). The concrete structure of the north duct is also contaminated with Cs-137 and Sr-90 and analyses of concrete samples indicate that the contamination is limited to the first few inches in depth. The south duct primary liner did not leak therefore the concrete structure and soils beneath are not contaminated.

2. There are several inches of debris at the base of the north duct air plenum containing significant quantities of plutonium-239/240, plutonium-238, uranium-233/234, uranium-235, Cs-137, Sr-90, and cobalt-60. Similar radionuclides, in smaller concentrations, were detected at the base of the south duct air plenum.

3. The soil in the pipe trench that traverses the north end of Building 701 has isolated contamination in two locations. The soil in the trench is contaminated with Cs-137 and Sr-90, and, to a lesser extent, transuranics, and analyses of the soil samples indicate that the contamination is limited to the first few feet in depth.

4. Low levels of contamination were detected in soil samples obtained from beneath and adjacent to the canal, canal deep pit, canal deep pit sump, and canal deep pit sump transfer line. Due to the facility construction that limits sampling in all desired locations, it is probable that higher levels of contamination are present.

5. Most of the drains in the BGRR, including the drains that terminate in dry wells, are contaminated with Cs-137, Sr-90, and, to a lesser extent, transuranics.

6. The 8 pCi/L limit for Sr-90 was slightly exceeded at one of the twenty-six sample locations.

702 Pile and Biological Shield

1. Visual inspection of the fuel channels revealed graphite deformity that occurred as a result of overheating during the failed-fuel events. Dose rates in the fuel channels are as high as 10 Roentgen per hour. Visualizations developed from the dose rate surveys indicate the highest dose is at the center and bottom of the pile. The high levels of dose at the bottom of the pile are from the activation of steel components and the debris that fell into the air gap during reactor refueling evolutions.

2. Graphite samples were analyzed detecting the full ranges of fission products and transuranics with carbon-14 and tritium the predominant radionuclides present.

3. Biological shield concrete, biological shield steel and miscellaneous pile steel components were sampled and indicate significant activation. The biological shield concrete activation is limited to the inner few inches.

Remaining Soils

1. All surface and deep soil samples obtained have concentrations of Cs-137 and Sr-90 below the previously established cleanup goals of 23 picoCuries per gram (pCi/g) and 15 pCi/g, respectively.

2. All of the groundwater samples taken have radionuclide concentrations below the applicable standards.

3. Hazardous constituent contamination was detected inside the Building 703 F waste collection cell but the soil samples obtained from beneath the concrete do not have elevated levels of hazardous or radiological contaminants. The F Waste transfer line successfully passed a vacuum test conducted to verify the piping integrity.

Volume 1 of this report presents the analysis of results and data summaries. Volumes 2 and 3 contain the Appendices that are comprised of the complete set of survey and analytical results.

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ACRONYMS AND ABBREVIATIONS

Am-241	americium-241
BGRR	Brookhaven Graphite Research Reactor
BNL	Brookhaven National Laboratory
C-14	carbon-14
CAS #	Chemical Abstract Services number
ccpm	corrected counts per minute
cfm	cubic feet per minute
cpm	counts per minute
CFR	Code of Federal Regulations
Co-60	cobalt-60
COPC	Contaminants of Potential Concern
CRDL	contractor required detection limit
CLP	Contract Laboratory ProgramCs-137 cesium-137
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ESH	Environmental Safety and Health
ESH&Q	Environmental Safety, Health, and Quality
Eu-152	europium-152
Eu-154	europium-154
FC	fuel channel
Fe-55	iron-55
FFC	failed fuel channel
GM	Geiger Mueller
HEPA	high-efficiency particulate air
ISO	International Organization for Standardization
ISOCS®	*In-Situ* Object Counting System®
MCL	Maximum Contaminant Level
MDA	minimum detectable activity
MDC	minimum detection concentration
MDL	method detection limit
mg/kg	milligram per kilogram
mR/hr	milliRoentgen per hour
mrem/yr	millirem per year
n/a	not applicable
NaI	Sodium Iodide
ND	not detectable
NFC	non-fuel channel
Ni-63	nickel-63
NL	no limit
NYSDEC	New York State Department of Environmental Conservation

NYSDOH	New York State Department of Health
OPM	Operations Procedure Manual
OU	operable unit
PCB	polychlorinated biphenyl
pCi/cc	picoCuries per cubic centimeter
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
Pu-238	plutonium-238
Pu-239/240	plutonium-239/240
Ra-223	radium-223
Ra-224	radium-224
Ra-226	radium-226
RESRAD	Computer code to calculate dose from residual radioactivity
R/hr	roentgens per hour
ROC	radionuclides of concern
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
Sr-90	strontium-90
TAGM	Technical and Administrative Guidance Memorandum (NYSDEC)
TCLP	Toxicity Characteristic Leaching Procedure
Tc-99	technetium-99
Th-228	thorium-228
Th-230	thorium-230
Th-232	thorium-232
U-232	uranium-232
U-234	uranium-234
U-235	uranium-235
U-238	uranium-238
VOCs	volatile organic compounds
yr	year(s)
Y-90	yttrium-90
µCi/ft	microCuries per foot
µg/l	micrograms per liter
µR/hr	microRoengten per hour

1. INTRODUCTION

1.1. Purpose

The purpose of this document is to provide information on the characterization of the Brookhaven Graphite Research Reactor (BGRR) 701 Below-Ground Structures, 702 Pile, and Remaining Soils to the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and other stakeholders. This characterization report also provides the information required to prepare the Comprehensive Risk Assessment and Feasibility Study. The primary goal of the characterization was to determine the nature and extent of radiological and non-radioactive contaminants in the 701 below-ground structures, pile, and remaining soils.

Specific objectives were established to meet these goals. They are summarized below:

- Characterize the soils and groundwater west of and below Building 701 to determine the nature and extent of contamination.
- Characterize the building drains to determine the nature and extent of contamination.
- Characterize the nature and extent of contamination in the inner below-ground duct concrete structure and carbon steel liner and assess the physical condition of the structural components.
- Characterize the pile and biological shield to determine the nature and extent of activation and contamination.
- Develop waste profiles for the systems and components within and below Building 701.

Field investigative activities to complete the *Sampling and Analysis Plan for the 701 Building, 701 Below-Ground Structures, 702 Pile, and Remaining Soils* (BNL 2002c) were conducted by the BGRR Decommissioning Project from June to November 2002. Samples of soil, groundwater, steel, concrete, aluminum, and debris were taken and the results of the field investigation are presented in this report. The results of the 701 Building Characterization is presented separately in report BGRR-054, *Characterization Report for Building 701 Above Ground Surfaces, Systems, and Structures* (BNL 2002b), which was written separately to document the past and present radiological and hazardous contaminants in the systems and working areas of the facility.

This report is structured similar to the Sampling and Analysis Plan (SAP) and provides a description of the facilities and structures, a summary of the characterization approach, and a detailed explanation of the characterization results for each SAP Subpart.

1.2. History and Description of the Brookhaven Graphite Research Reactor

The BGRR at Brookhaven National Laboratory (BNL) was the first reactor built for the sole purpose of providing neutrons for research. During its years of operation, it was one of the principal research reactors in the United States. Construction of the BGRR was completed in August 1950, and initial criticality of the reactor was achieved the same month. Annealing the graphite was completed September 28, 1969 and deactivation of the facility was initiated. In June 1972, defueling and shipment of the fuel to the DOE Savannah River Site was completed. The BGRR complex was described as being in a safe shutdown condition by the U.S. Atomic Energy Commission and became a Surplus Facility within the DOE complex. From 1977 until 1997, portions of the facility were used as the BNL Science Museum.

The BGRR was an air-cooled, graphite-moderated reactor. During reactor operations, filtered outside cooling air was drawn through the reactor pile, then through ductwork where it was cooled, filtered, and eventually exited through the 100-meter tall exhaust stack. The primary air-cooling system utilized cooling fans that were located in a building (704) separate from the reactor building (701). Exhaust ducting constructed of reinforced concrete runs in two separate ducts below the ground from the reactor exhaust plenums to the system filters and coolers. Downstream of the filters, ducting rises above the ground and combined into one large duct, which was located on, and was supported by, the Fan House (704). The individual cooling fans took suction through 48-inch diameter ducts that penetrated the building roof and connected at the duct bottom. There were approximately 225 feet of above-grade ducting that carried the cooling air to the stack. These ducts were removed as part of a previous BGRR remediation project. An aerial photograph of the BGRR site, with the above-ground ducts intact, is shown in Figure 1-1.

Figure 1-1. BGRR Site Looking North

1.3 Characterization Plan Summary

1.3.1 General Information

The characterization activities were subdivided into four major subparts with the following designations:

SAP Subpart	BGRR Facility Area
A	Building 701 - Above-Ground Surfaces, Systems, and Structures
B	Building 701 and 702 - Below-Ground Structures and Soils
C	702 - Reactor Pile
D	Remaining Soils Characterization

The following are brief summaries of the characterization activities for each facility subsection. The summary sections include a brief facility description, the characterization approach, and a sample summary.

The data collected from the characterization surveys was evaluated to determine the locations and extent of contamination for the identified radionuclides of concern (ROC) and hazardous materials of concern. These results will be evaluated in the BGRR Feasibility Study to decide if the Data Quality Objectives (DQO) have been met and to determine if additional characterization information is necessary before a remediation plan can be prepared. The DQOs were established by analyzing the potential contamination pathways as outlined in the EPA's *Guidance for the Data Quality Objectives Process* (EPA 2000).

1.4 Building 701 – Above-Ground Surfaces, Systems, and Structures [Subpart A]

1.4.1 Description

The radiological and hazardous data that was collected and analyzed during the 701 above-ground characterization included locations, distribution, makeup and levels of contamination on structural surfaces, equipment, and building systems. General area and equipment radiation dose rates were also obtained.

Subpart A's characterization approach, sample summary, and results are in the *Characterization Report for Building 701 Above Ground Surfaces, Systems, and Structures* (BNL 2002b).

1.5 Building 701 and 702 - Below-Ground Structures and Soils [Subpart B]

1.5.1 Description

The below-ground area of the BGRR has been defined as the components, structures, and soil that lie beneath the 110-foot elevation floor slab. The specific structures and components that were addressed included the following: the section between the deep pit and the canal joint, canal deep pit, canal deep pit sump including the suction line from the deep pit, inner below-ground duct, deep drain sump, intake air duct system, trenches located north of the pile, various drains, and random location points. In addition, three sampling locations east of column No. 7 were sampled and evaluated.

1.5.2 Characterization Approach

Characterization of the below-ground portion included assessment of sub-surface drain discharge points, deep structures and soil. Boreholes were drilled at selected biased and unbiased locations to collect concrete, soil, and groundwater samples. Deep boreholes were drilled using coring bits and macro-bore or limited-bore samplers to refusal or groundwater using the Geoprobe® sampling devices and Direct Push Technology (DPT).

1.5.3 Sample Summary

The samples prescribed to characterize the below-ground structures and soils of the 701 Building were grouped into the following survey units:

- Deep cores, 701 floors and pits
- Deep cores, east exterior
- Drains (intake system)
- Inner below-ground ducts
- Intake ducts
- Pit/sump interiors

1.6 Building 702 – Reactor Pile Characterization [Subpart C]

1.6.1 Description

The characterization of the pile and biological shield included surveys and samples of the following components: pneumatic transfer tubes, experimental and instrumentation ports, fuel channels, graphite moderator, graphite plugs, biological shield concrete, and the biological shield steel liner. Table 1-1 lists the pile sample summary.

Table 1-1. Pile Sample Summary

Face	Description	Number to be characterized	Total number available	% of total
South	Failed fuel channels	25	26	96
South	Fuel and non-fuel channels, symmetrical	51	1,342	4
North	Pneumatic transfer tubes	6	11	55
North	Irradiation port	1	1	100
East & West	Experimental ports	18	30	60
East & West	Instrumentation ports	2	8	25
Bottom of pile	Animal tunnel	1	1	100
Bottom of pile	Instrument tunnel	1	1	100
Graphite samples	Four types of graphite	9	-	N/A
Biological shield wall	Core bore	8	-	N/A
Steel inside biological shield	Drilling sample	8	-	N/A
Biological shield wall	Penetrations	83	1,398	6
Between biological shield wall and pile	Debris	As designated by Field Engineer	-	N/A
In pile area	Debris	As designated by Field Engineer	-	N/A
Southeast corner	Control rod	1	8	13
Southwest corner	Control rod	1	8	13

1.6.2 Characterization Approach

The characterization of the pile, biological shield, and associated equipment was primarily a radiological characterization. The facility operating procedures were written to prevent introduction of hazardous materials so that the internals of the pile did not become chemically contaminated. Additionally, the heat generated within the pile area during operations and subsequent continuous ventilation of the pile is expected to have removed any volatile and semi-volatile material. To verify these conclusions, samples of graphite and biological shield components were sent to an off-site laboratory for hazardous contaminant analysis.

1.7 Remaining Soils Characterization [Subpart D]

1.7.1 Description

The SAP addressed the data necessary to determine the extent and boundaries of contamination in the Remaining Soils west of Building 701. Characterization of the remaining soils included investigation of surface and deep soils to assess contamination in the horizontal and vertical directions.

Much of the soils within the footprint of the BGRR were included in the characterization of the pile fan sump, canal, and below-ground ducts projects. The soils that were included in this effort are those predominantly located to the west and southwest of Building 701.

The purpose of characterizing the surface soils is to determine the amount of contamination in the soils resulting from BGRR stack emissions. The *Radiological Emissions and Environmental Monitoring Report for Brookhaven National Laboratory 1947-1961* (BNL 2001a) documents the stack emissions from the BGRR and other facilities at BNL. The soil at BNL that does not lie within the BGRR footprint is sampled and analyzed as part of the site-wide soil and vegetation sampling plan and the results are detailed in the *Brookhaven National Laboratory Site Environmental Report* (BNL 2001b).

1.7.2 Characterization Approach

The SAP specified both biased and systematic (unbiased) approaches for determining where samples were taken. The biased locations allow for the study of potentially contaminated areas or leakage paths. The unbiased locations were useful to confirm or deny the existence of contamination in locations thought to be clean via historical and anecdotal assumptions.

1.7.3 Sample Summary

The samples prescribed to characterize the 701 Remaining Soils Area were grouped into the following survey units:

- Surface soil study
- Deep cores
- 701A pad
- Chemo-Nuclear Loop off-gas pit
- Drain lines and 703 west wing F waste collection cell

1.8 Data Quality Objectives

1.8.1 State the Problem

- The location, identity, and concentration of radiological and hazardous contaminants must be determined to allow planning of future decommissioning and waste disposal efforts.

1.8.2 Identify the Decision

- Determine if existing data, process knowledge, and newly performed measurements can adequately specify the locations, type, and extent of contamination for decommissioning planning and waste characterization.

1.8.3 Identify Inputs to the Decision

- Existing characterization data obtained during prior BGRR activities
- Facility and process knowledge germane to the construction, operation, and history of the BGRR including lessons learned from previous BGRR decommissioning investigations
- New sample analysis information collected in selected areas to determine the presence or indicate the absence of radiological and hazardous contaminants.
- NYSDEC Technical Action Guidance Memoranda (TAGM).
- 40 Code of Federal Regulations (CFR) 261, EPA Regulations, Hazardous Waste

1.8.4 Define Boundaries of the Study

- The 701 below-ground survey boundaries follow:
  - Upper: the 110-foot elevation floor slab
  - Lower: the ground water level or drilling refusal, whichever is higher in elevation
  - Sides: the four walls of Building 701 plus three additional boreholes in the eastern yard near the canal in order to resolve questions regarding the extent of contamination from the canal and east intake plenum floor drains
- The pile and biological shield include the following:
  - Graphite moderator with fuel channels, instrumentation ports, and experimentation ports
  - Biological shield consisting of high-density reinforced concrete and steel plates on east, west, north, south, top and bottom of the graphite

- The remaining soils include the following:

  - Much of the soil associated with the BGRR was included in the characterization of the pile fan sump, canal, and below-ground ducts projects. The soils that are included in this SAP are those predominantly located to the west and southwest of Building 701.

1.8.5 State the Decision Rules

- The effectiveness of the characterization survey in localizing and quantifying contamination depends on two general considerations:

  - the quantity and placement of sampling/measurement locations must be sufficient to spatially characterize the area
  - the quantity and types of measurements and analyses performed must be sufficient to radiologically and chemically characterize the area

1.8.6 Limits on Decision Errors

- Constraints on decision errors are not applicable to this survey because subjective, rather than statistical techniques were used.

1.8.7 Optimization of the Survey Design for Collecting Data

- There are a few alternatives for determining contaminant concentrations deep within the ground. The options are summarized as follows:

  - **Accessing the test area:** Drilling with a small rig (i.e., Geoprobe®) is generally more mobile, less damaging, and more cost effective than larger rigs and excavators.
  - **Obtaining contaminant data within the borehole:** Core sampling and *in-situ* measurement (i.e., gamma logging) have complementary functions. Sampling provides a very quantitative assessment of contaminate concentration and is the only method available to assess non-gamma-emitting contaminates. However, sampling is susceptible to core compression, core drop out, and depth registration problems. *In-situ* measurement via in-hole gamma logging provides good depth registration, reasonable concentration estimation, and is relatively inexpensive. However, it is only useful for measurement of cesium-137 (Cs-137) and Cobalt-60 (Co-60).
  - **Analysis of core samples:** Options include a wide range of radiological and chemical analysis techniques with a wide range of associated costs. In some cases, radionuclide ratio relationships can be used to estimate upper limits of some contaminates based on the concentration of others.

- The various analytical and measurement techniques available are listed below:

    - *In-situ* Object Counting System (ISOCS®), a HPGe-based spectrometer, to perform on-site laboratory gamma spectroscopy of samples
    - BetaScint™ counter to perform on-site laboratory analysis for strontium-90 (Sr-90) in samples.
    - Off-site certified laboratories for sample analyses for verification of on-site analysis and screening results.
    - Sodium iodide (NaI) gamma spectroscopic detectors for gamma-logging of boreholes or embedded piping.
    - Small Geiger Mueller (GM) detectors may be used for gross gamma logging of embedded pipes where elbows prevent use of NaI detectors.

1.9 Sampling and Analysis Plan

1.9.1 Sampling and Analysis Protocols

This section specifies both biased and systematic (unbiased) approaches for determining where samples were taken. The biased locations allow for the study of suspected contaminated areas or leakage paths. The unbiased locations were required to confirm or deny the existence of contamination in locations thought to be clean via historical and anecdotal assumptions.

Approved BNL procedures were used for sampling, analysis, and sample validation. A complete list of referenced BNL procedures is provided.

1.9.2 General Sampling Criteria and Information

<u>Borehole Installation</u>

Deep boreholes were accessed using coring bits and macro-bore samplers to refusal or groundwater using a Geoprobe®. Soil and concrete core samples were collected and composited from each six-inch interval for concrete and soil less than eighteen inches deep. Four-foot lifts were utilized for deeper cores. The four-foot lifts were split into two-foot samples with ISOCS® counts performed on alternating two-foot sections. All samples have been archived for subsequent analysis to vertically bound detected contamination. The concrete samples were field screened with the Ludlum LU-177 frisker and either the Eberline RO-20 or Bicron microrem meter. If the concrete samples indicated activity above background, ISOCS® analysis was performed.

Various control techniques, such as decontaminating, applying a fixative, or installing sleeving, were used to minimize the potential for cross contamination of samples especially when drilling through highly contaminated surfaces such as the ducts and pit/canal floor.

If gamma logging was required after sampling, steps were taken to prevent hole collapse due to the loose, sandy soil typical to the area. The Dual Tube-21 System, a steel sleeve over the macro-bore, was utilized to prevent hole collapse when the macro-bore was withdrawn.

Gamma Logging

Gamma logging was specified in certain boreholes per the SAP. Gamma logging was performed using a NaI-based detection system. Gross count rates were logged at twelve-inch depth intervals.

Additional Sampling

If concrete, soil, or structural samples were contaminated at levels above fifty percent of the investigation level for either Cs-137 (greater than 11 picoCuries per gram [pCi/g]) or Sr-90 (greater than 7.5 pCi/g), then further sampling was performed, if technically feasible, to bound the contamination.

Sample Analyses

Each of the alternating two-foot deep core sections, all of the shallow cores (less than 24 inches), and all scraping samples were analyzed via ISOCS®.

Gamma Spec QC: A minimum of five percent of ISOCS® samples were sent to independent laboratory for QA confirmation purposes.

BetaScint™: One sample from each borehole was composited from two four-foot lifts for Sr-90 analysis via BetaScint™. This was accomplished by combining two twenty-four inch samples from each of the four-foot lifts.

Confirmatory Analyses

A minimum of five percent of the ISOCS® analyzed samples were sent to an independent laboratory for isotopic alpha, beta, and gamma analyses. Additional samples (not to exceed ten percent of the total) were sent if they were found to contain greater than fifty percent of the investigation level for either Cs-137 (greater than 11 pCi/g) or Sr-90 (greater than 7.5 pCi/g).

1.10 Training and Quality Assurance

The Characterization Project Manager, Field Engineer, and Facility Support Representative supervised the performance of the radiological survey work.

Technicians performing radiological surveys and collecting samples were trained in accordance with approved procedures and are qualified to execute characterization survey and sampling activities. Radiological Control Technicians supporting this characterization effort meet the training and qualification requirements established by the BNL Radiological Control Division.

The training associated with this characterization task is documented as required by the BNL Quality Assurance Program. All data generated in support of this activity was documented and controlled using BNL procedures for sample collection, handling, and analysis.

1.10.1 Analytical Quality Assurance

Brookhaven National Laboratory is registered to and complies with International Organization for Standardization (ISO) 14001. Activities associated with the characterization are in accordance with the applicable ISO 14001 criteria for operational controls, monitoring/measurements, and corrective action.

Selected samples were analyzed on site using the ISOCS® gamma spectrometer and the BetaScint™ Sr-90 beta spectrometer. Other *in-situ* and direct measurements were also performed. The specific quality assurance requirements that were followed for these tasks are listed in the applicable BNL procedures for those systems. The results of all sample analyses were applied to the cleanup goals for the ROCs as well organic and inorganic Contaminants of Potential Concern (COPC) presented in Tables 1-2 to 1-5. These preliminary cleanup goals are being used as screening values only. Final cleanup goals for the BGRR will be determined once a decommissioning alternative has been chosen and risk assessment performed.

Activities associated with the characterization were performed in accordance with the BNL Environmental Restoration Division *Quality Assurance Implementation Guidelines* (BNL 2001d). These guidelines address the following:

- Personnel training and qualification
- Quality improvement
- Documents and records
- Work processes
- Design
- Procurement
- Inspection and acceptance testing
- Management and independent assessment

Table 1-2. Surface Soil Cleanup Goals for Radionuclides of Concern

Radionuclide	Preliminary Cleanup Goals (pCi/g)	Reference	Target Goal[1] (pCi/g)
Americium-241	39 (OU I/VI)	CDM (1996), Table 6.2-10	39
Americium-241	40 (OU II/VII), 39 (OU IV)	CDM (1999), Table 1-3	
Carbon-14	NL		31 [2]
Cesium-137	23 (OU I/VI)	CDM (1996), Table 6.2-10	23
Cesium-137	23 (OU II/VII, IV)	CDM (1999), Table 1-3	
Cobalt-60	1100 (OU I/VI)	CDM (1996), Table 6.2-10	1100
Cobalt-60	NL	CDM (1997), page D-6	
Cobalt-60	1300 (OU II/VII), 1160 (OU IV)	CDM (1999), Table 1-3	
Europium-152	49 (OU IV)	CDM (1999), Table 1-8	49
Europium-154	170 (OU IV)	CDM (1999), Table 1-8	170
Europium-155	150,000 (OU IV)	CDM (1999), Table 1-8	1.50 E+05
Iodine-129	NL		2.4 [2]
Nickel-63	NL		2.9 E+05 [2]
Plutonium-238	65 (OU I/VI)	CDM (1996), Table 6.2-10	65
Plutonium-238	66 (OU II/VII, IV)	CDM (1999), Table 1-3	
Plutonium-239	40 (OU I/VI)	CDM (1996), Table 6.2-10	40
Plutonium-239	40 (OU II/VII, IV)	CDM (1999), Table 1-3	
Plutonium-240	40 (OU I/VI)	CDM (1996), Table 6.2-10	40
Plutonium-240	40 (OU II/VII, IV)	CDM (1999), Table 1-3	
Radium-226	5 (OU II/VII, IV)	CDM (1999), page ES-5 and Table 1-3, per DOE Order 5400.5	5
Samarium-151	NL		4.0 E+06 [2]
Strontium-90	15 (OU I)	CDM (1997), page D-7 groundwater protection	15
Strontium-90	33 (OU I/VI)	CDM (1996), Table 6.2-10	
Strontium-90	15 (OU II/VII, IV)	CDM (1999), Table 1-3	
Technetium-99	NL		44 [2]
Thorium-232	5 (OU II/VII, IV)	CDM (1999), Appendix B page B-2, per DOE Order 5400.5	5
Tritium	9.6 E+15 (OU I/VI)	CDM (1996), Table 6.2-10	1010 [2]
Tritium	NA	CDM (1999), Table 1-3	
Uranium-234	13	CDM (1999), Table 1-8	9 [3]
Uranium-235	11 (OU I/VI)	CDM (1996)	9
Uranium-235	9 (OU II/VII), 10 (OU IV)	CDM (1999), Table 1-3	
Uranium-238	11	CDM (1997), page D-7 groundwater protection	9
Uranium-238	14 (OU I/VI)	CDM (1996)	
Uranium-238	9 (OU II/VII), 11 (OU IV)	CDM (1999), Table 1-3	

[1] The numbers in this column are generally chosen as the lowest that have been used in the other referenced Operable Units (OUs). For radionuclides that have not been considered in the other OUs, see footnote 2.

[2] The goals for radionuclides that were not previously estimated for a residential scenario were estimated as the soil concentration, which could cause a hypothetical onsite resident to receive no more than 15 mrem/yr using the regulator-specified scenario.

[3] This goal was chosen to be consistent with the other uranium isotopes. The dose to source ratio (mrem/yr per pCi/g) for uranium-234 will be essentially identical to uranium-238 under the scenarios used in previous OUs.

Table 1-3. Alpha Isotope Surface Soil Cleanup Goals

Radionuclide	Preliminary Cleanup Goal	Reference	Target Goal[1] (pCi/g)
Americium-241	39 (OU I/VI)	CDM (1996), Table 6.2-10	39
Americium-241	40 (OU II/VII), 39 (OU IV)	CDM (1999), Table 1-3	
Plutonium-238	65 (OU I/VI)	CDM (1996), Table 6.2-10	65
Plutonium-238	66 (OU II/VII, IV)	CDM (1999), Table 1-3	
Plutonium-239	40 (OU I/VI)	CDM (1996), Table 6.2-10	40
Plutonium-239	40 (OU II/VII, IV)	CDM (1999), Table 1-3	
Plutonium-240	40 (OU I/VI)	CDM (1996), Table 6.2-10	40
Plutonium-240	40 (OU II/VII, IV)	CDM (1999), Table 1-3	
Radium-226	5 (OU II/VII, IV)	CDM (1999), page ES-5 and Table 1-3, per DOE Order 5400.5	5
Thorium-232	5 (OU II/VII, IV)	CDM (1999), Appendix B page B-2, per DOE Order 5400.5	5
Uranium-234	13	CDM (1999), Table 1-8	9[3]
Uranium-235	11 (OU I/VI)	CDM (1996)	9
Uranium-235	9 (OU II/VII), 10 (OU IV)	CDM (1999), Table 1-3	
Uranium-238	11	CDM (1997), page D-7 groundwater protection	9
Uranium-238	14 (OU I/VI)	CDM (1996)	
Uranium-238	9 (OU II/VII), 11 (OU IV)	CDM (1999), Table 1-3	

[1] The numbers in this column are generally chosen as the lowest that have been used in the other referenced Operable Units (OUs). For radionuclides that have not been considered in the other OUs, see footnote 2.
[2] The goals for radionuclides that were not previously estimated for a residential scenario were estimated as the soil concentration that could cause a hypothetical onsite resident to receive no more than 15 mrem/yr using the specified scenario.
[3] This goal was chosen to be consistent with the other uranium isotopes. The dose to source ratio (mrem/yr per pCi/g) for uranium-234 will be essentially identical to uranium-238 under the scenarios used in previous OUs.

Table 1-4. Screening Levels and Detection Limits for Inorganic COPCs

Analyte	Clean-up Action Limit TAGM milligrams per kilogram (mg/kg)	CRDL Low Soil Contract Laboratory Program (CLP)[a] (mg/kg)
Aluminum	16,491 [b]	2.0
Antimony	13.1 [b]	0.6
Arsenic	7.5	0.1
Barium	300	2.0
Beryllium	0.43 [b]	0.05
Cadmium	1.5 [b]	0.05
Calcium	434 [b]	50
Chromium	14.2 [b]	0.1
Cobalt	30 [b]	0.5
Copper	25 [b]	0.025
Chromium VI	14.2 [b]	NA
Cyanide	ND	0.1
Iron	14,429 [b]	1.0
Lead	400 [c]	0.03
Magnesium	2122 [b]	50
Manganese	148 [b]	0.15
Mercury	1.84 [c]	0.002
Nickel	13	0.4
Potassium	628 [b]	50
Selenium	2	0.05
Silver	2 [b]	0.1
Sodium	196 [b]	50
Thallium	0.35 [b]	0.1
Vanadium	150	0.5
Zinc	22.4 [b]	0.2

[a] CRDL is contract required detection limit, the soil CRDL is approximately 10 times the CRDL for water.
[b] Site background: 97.72 percentile of available results for background soil samples. Operable Unit 1 ROD (BNL 1999a)
[c] Operable Unit I ROD
ND = not determined
NA = not available

Table 1-5. Screening Levels and Detection Limits for Organic COPCs (4 sheets)

Analyte	Chemical abstract services number (CAS #)	Cleanup Goal TAGM (mg/kg)	Quantitation Limit Low Soil CLP (mg/kg)
Volatiles			
Chloromethane	74-87-3	NL	0.01
Bromomethane	74-83-9	NL	0.01
1-Chloroethene	75-01-4	0.2	0.01
Chloroethane	75-00-3	1.9	0.01
Dichloromethane (Methylene Chloride)	75-09-2	0.1	0.01
2-Propanone (Acetone)	67-64-1	0.2	0.01
Carbon disulfide	75-15-0	2.7	0.01
1,1-Dichloroethene	75-35-4	0.4	0.01
1,1-Dichloroethane	75-34-3	0.2	0.01
1,2-Dichloroethylene	540-59-0	NL	0.01
Chloroform	67-66-3	0.3	0.01
1,2-Dichloroethane	107-06-2	0.1	0.01
2-Butanone (Methyl ethyl ketone)	78-93-3	0.3	0.01
1,1,1-Trichloroethane	71-55-6	0.8	0.01
Carbon tetrachloride	56-23-5	0.6	0.01
Bromodichloromethane	75-27-4	NL	0.01
1,2-Dichloropropane	78-87-5	NL	0.01
cis-1,3-Dichloropropene	10061-01-5	0.3	0.01
1,1,2-Trichloroethylene	79-01-6	0.7	0.01
Dibromochloromethane	124-48-1	NL	0.01
1,1,2-Trichloroethane	79-00-5	NL	0.01
Benzene	71-43-2	0.06	0.01
trans-1,3-Dichloropropene	10061-02-6	NL	0.01
Tribromomethane	75-25-2	NL	0.01
4-Methyl-2-pentanone (MIBK)	108-10-1	1	0.01
2-Hexanone	591-78-6	NL	0.01
1,1,2,2-Tetrachloroethene	127-18-4	1.4	0.01
1,1,2,2-Tetrachloroethane	79-34-5	0.6	0.01
Toluene	108-88-3	1.5	0.01
Chlorobenzene	108-90-7	1.7	0.01
Ethyl benzene	100-41-4	5.5	0.01

Analyte	Chemical abstract services number (CAS #)	Cleanup Goal TAGM (mg/kg)	Quantitation Limit Low Soil CLP (mg/kg)
Styrene	100-42-5	NL	0.01
Xylene	1330-20-7	1.2	0.01
Semivolatiles			
Phenol	108-95-2	0.03 or method detection limit (MDL)	0.33
Bis(2-chloroethyl) ether	111-44-4	NL	0.33
2-Chlorophenol	95-57-8	0.8	0.33
1,3-Dichlorobenzene	541-73-1	1.6	0.33
1,4-Dichlorobenzene	106-46-7	8.5	0.33
1,2-Dichlorobenzene	95-50-1	7.9	0.33
o-Cresol	95-48-7	0.1 or MDL	0.33
Bis(2-Chloroisopropyl) ether	108-60-1	NL	0.33
4-Methylphenol	106-44-5	0.9	0.33
N-Nitroso-di-n-propylamine	621-64-7	NL	0.33
Hexachloroethane	67-72-1	NL	0.33
Nitrobenzene	98-95-3	0.2 or MDL	0.06
Isophorone	78-59-1	4.4	0.33
2-Nitrophenol	88-75-5	0.33 or MDL	0.05
2,4-Dimethylphenol	105-67-9	NL	0.33
Bis(2-Chloroethoxy)methane	111-91-1	NL	0.33
2,4-Dichlorophenol	120-83-2	0.4	0.33
1,2,4-Trichlorobenzene	120-82-1	3.4	0.33
Naphthalene	91-20-3	13	0.33
4-Chloroaniline	106-47-8	0.220 or MDL	0.07
Hexachlorobutadiene	87-68-3	NL	0.33
4-Chloro-3-methylphenol	59-50-7	0.240 or MDL	0.07
2-Methylnaphthalene	91-57-6	36.4	0.33
Hexachlorocyclopentadiene	77-47-4	NL	0.33
2,4,6-Trichlorophenol	88-06-2	NL	0.33
2,4,5-Trichlorophenol	95-95-4	0.1	0.83
2-Chloronaphthalene	91-58-7	NL	0.33
2-Nitroaniline	88-74-4	0.43 or MDL	0.09
Dimethyl phthalate	131-11-3	2	0.33
Acenaphthylene	208-96-8	41	0.33

Analyte	Chemical abstract services number (CAS #)	Cleanup Goal TAGM (mg/kg)	Quantitation Limit Low Soil CLP (mg/kg)
2,6-Dinitrotoluene	606-20-2	1	0.33
m-Nitroaniline	99-09-2	0.5 or MDL	0.09
Acenaphthene	83-32-9	50	0.33
2,4-Dinitrophenol	51-28-5	0.200 or MDL	0.06
4-Nitrophenol	100-02-7	0.1 or MDL	0.07
Dibenzofuran	132-64-9	6.2	0.33
2,4-Dinitrotoluene	121-14-2	NL	0.33
Diethyl phthalate	84-66-2	7.1	0.33
4-Chlorophenylphenyl ether	7005-72-3	NL	0.33
Fluorene	86-73-7	50	0.33
4-Nitroaniline	100-01-6	NL	0.83
4,6-Dinitro-o-cresol	534-52-1	NL	0.83
N-Nitrosodiphenylamine	86-30-6	NL	0.33
4-Bromophenylphenyl ether	101-55-3	NL	0.33
Hexachlorobenzene	118-74-1	0.41	0.33
Pentachlorophenol	87-86-5	1.0 or MDL	0.83
Phenanthrene	85-01-8	50	0.33
Anthracene	120-12-7	50	0.33
Carbazole	86-74-8	NL	0.33
Di-n-butylphthalate	84-74-2	8.1	0.33
Fluoranthene	206-44-0	50	0.33
Pyrene	129-00-0	50	0.33
Butylbenzylphthalate	85-68-7	50	0.33
3,3 –Dichlorobenzidine	91-94-1	NL	0.33
Benzo(a)anthracene	56-55-3	0.224 or MDL	0.09
Chrysene	218-01-9	0.4	0.33
Bis(2-ethylhexyl) phthalate	117-81-7	50	0.33
Di-n-octylphthalate	117-84-0	50	0.33
Benzo(b)fluoranthene	205-99-2	1.1	0.33
Benzo(k)fluoranthene	207-08-9	1.1	0.33
Benzo(a)pyrene	50-32-8	0.061 or MDL	0.33
Indeno(1,2,3-cd)pyrene	193-39-5	3.2	0.33
Dibenz[a,h]anthracene	53-70-3	0.014 or MDL	0.33
Benzo(ghi)perylene	191-24-2	50	0.33

Analyte	Chemical abstract services number (CAS #)	Cleanup Goal TAGM (mg/kg)	Quantitation Limit Low Soil CLP (mg/kg)
PCBs			
Total PCBs	1336-36-3	1.0 (surface) 10 (subsurface)	NL
PCB-1016	12674-11-2	NL	0.033
PCB-1221	11104-28-2	NL	0.067
PCB-1232	11141-16-5	NL	0.033
PCB-1242	53469-21-9	NL	0.033
PCB-1248	12672-29-6	NL	0.033
PCB-1254	11097-69-1	NL	0.033
PCB-1260	11096-82-5	NL	0.033

CAS # = chemical abstract services number
MDL = method detection limit
CLP = Contract Laboratory Program

2.0 BUILDING 701 AND 702 BELOW-GROUND STRUCTURES AND SOIL

2.1 General Area Description

The below-ground area of the BGRR has been defined as the components, structures, and soil that lie beneath the floor slab at the 110-foot elevation. Descriptions of the specific structures and components are provided in the following sections. Figure 2-1 shows the two-by-two-meter grid map that was used to identify the exact location of the sample points. Figure 2-2 also shows specified sample locations with respect to the below-ground structures overlaid on a drawing of the 110-foot floor plan. Figure 2-2 is frequently referenced throughout this section.

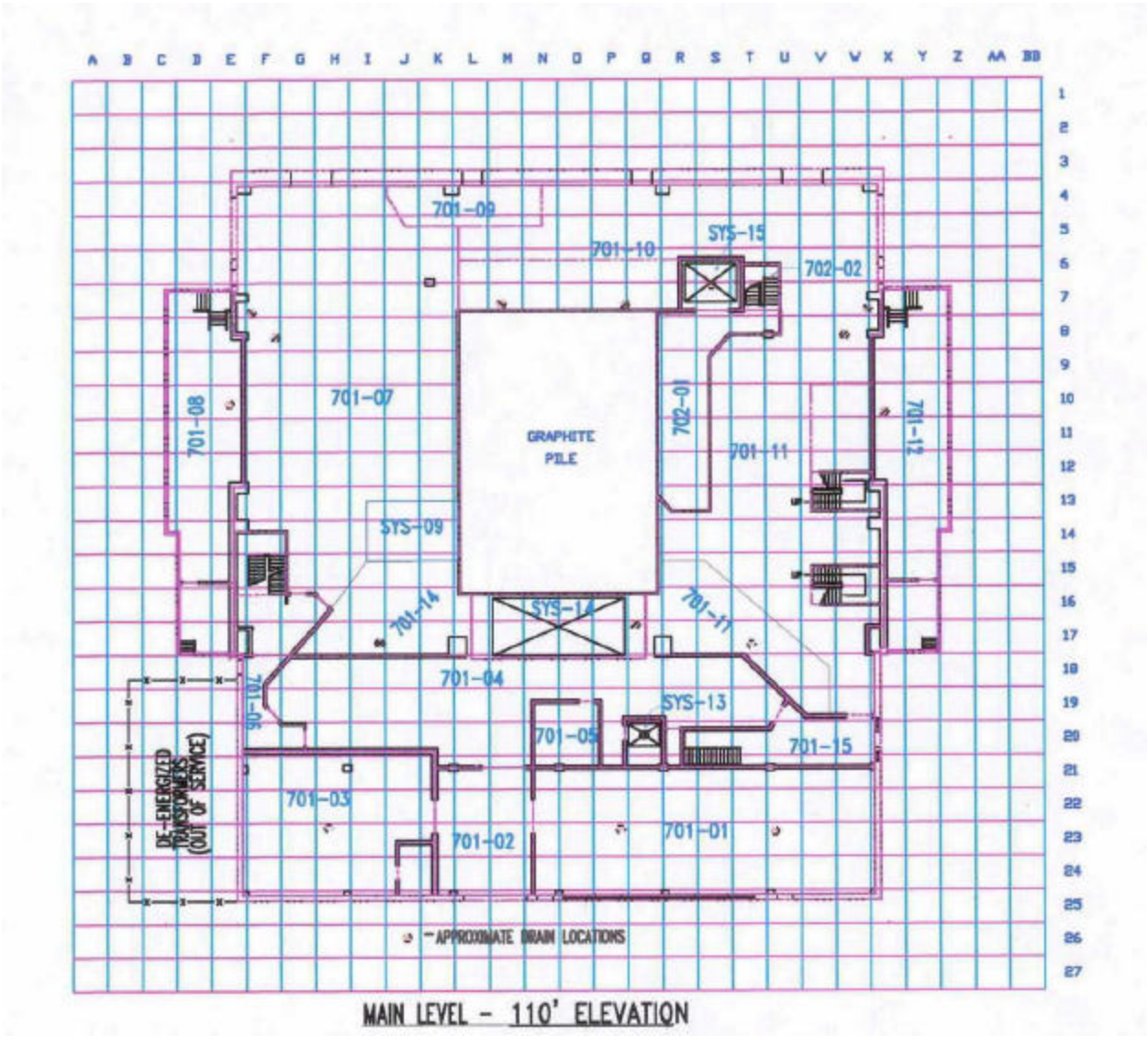


Figure 2-1. 701 Grid Map

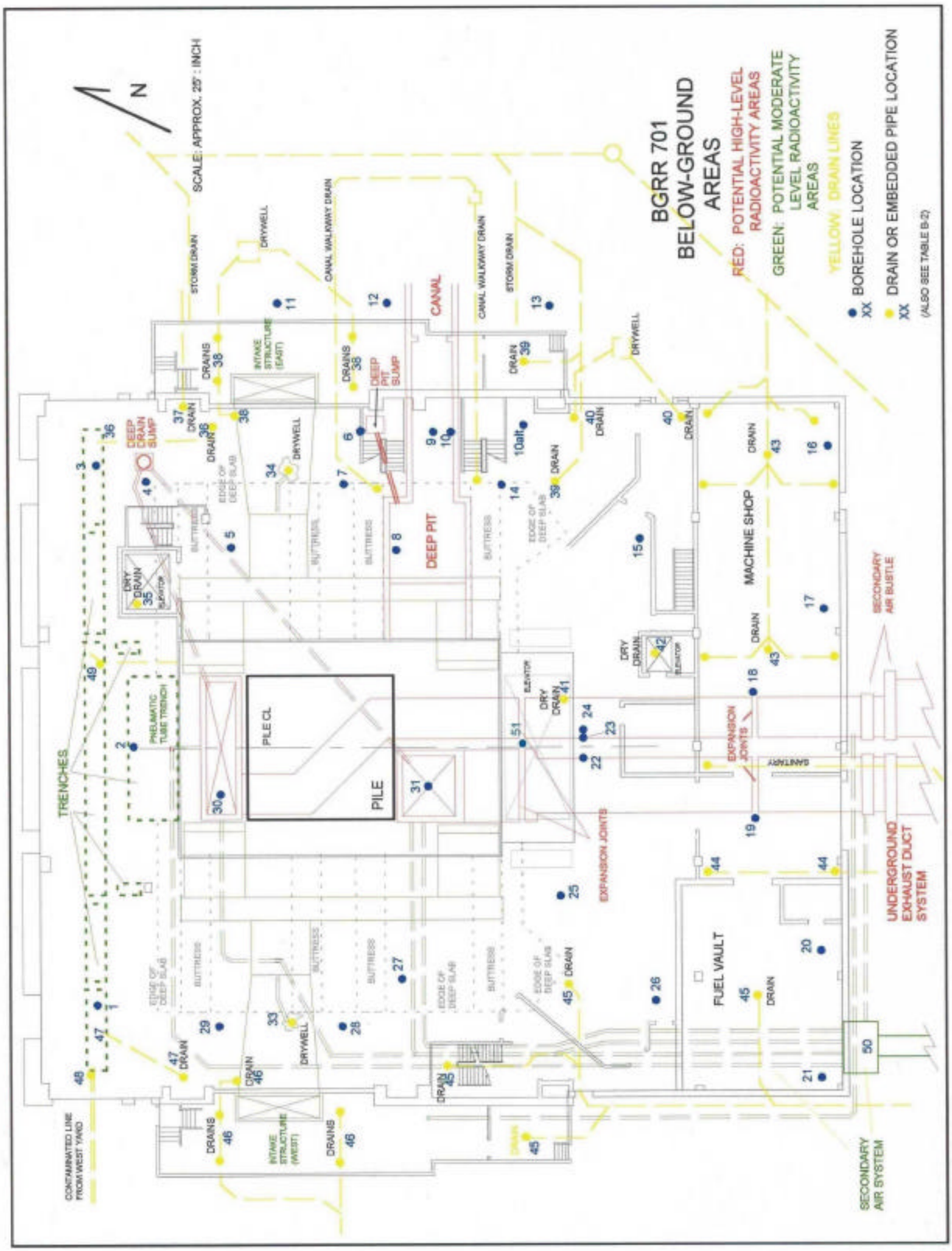


Figure 2-2. 701 Below-Ground SAP Survey and Sampling Locations

2.1.1 Survey Areas

2.1.1.1 Deep Pit, Canal, and Deep Pit Sump

The deep pit and canal are shown in red in Figure 2-2. The deep pit was used to store spent fuel rods and other in-core components. The canal was used to transfer fuel rods out of Building 701 in preparation for shipment off-site. The rods were also cut up while underwater in the canal, thus being a major source of contamination.

The deep pit sump is connected to the deep pit via an eight-inch line. The sump was taken out of service and filled with concrete in 1961 due to contamination and system leakage problems (BNL 1961).

Previous measurements of the canal east of Column #7 of Building 701 showed high levels of contamination (more than 200,000 pCi/g of Cs-137) saturating the entire concrete base of the canal shallow sumps and the lower walls of the canal (BNL 2001c). This situation was also expected in the portion of the canal located within the footprint of Building 701, the deep pit, and the deep pit sump.

The deep pit is sandwiched between two of the pile support buttresses with an additional one-foot thick layer of concrete making up the deep pit north and south walls. It was assumed that these walls and the adjacent buttresses were contaminated. Cores of the canal and pit floors were collected and provide an indication of the contamination present in the walls and adjacent buttresses. The extent of soil contamination on either side of the buttresses, along the canal, and beneath the deep pit and canal was not known and thus was one of the subjects of the characterization effort. Biased locations for boreholes were specified in the deep pit, in the canal, along side of the buttresses, near the sump, and in the area near the canal (Locations 6 through 14). Location 15 is approximately thirty-feet south of the deep pit and the samples collected were not expected to contain contamination. The purpose of this location was to bound any contamination detected in Locations 9, 10, and 14.

2.1.1.2 Exhaust Duct System and Associated Sump

During reactor operation, two exhaust ducts carried contaminated air from the pile, under the building in a southerly direction, and eventually to the exhaust filter bank, Fan House, and out the 100-meter stack. These large ducts (nominally 10’6” x 14’6” in cross section) passed 30 feet under the pile within the concrete foundation (see Figures 2-3 and 2-4). During reactor operations, water from the exit air cooler system leaked into and accumulated in the below-ground ducts. Rainwater leaked into and accumulated in the below-ground ducts after the facility ceased operation in 1969. Approximately 57,500 gallons of contaminated water was pumped from the below-ground ducts in 1998. Characterization of the below-ground ducts and associated soils located outside the footprint of Building 701 confirmed that water had leaked from the ducts into the surrounding soils (BNL 2002c). Characterization of the ducts below Building 701 also included the collection of soil samples from suspect locations. The most obvious points of potential leakage from the system are the duct expansion joints south of the pile (See Figure 2-2).

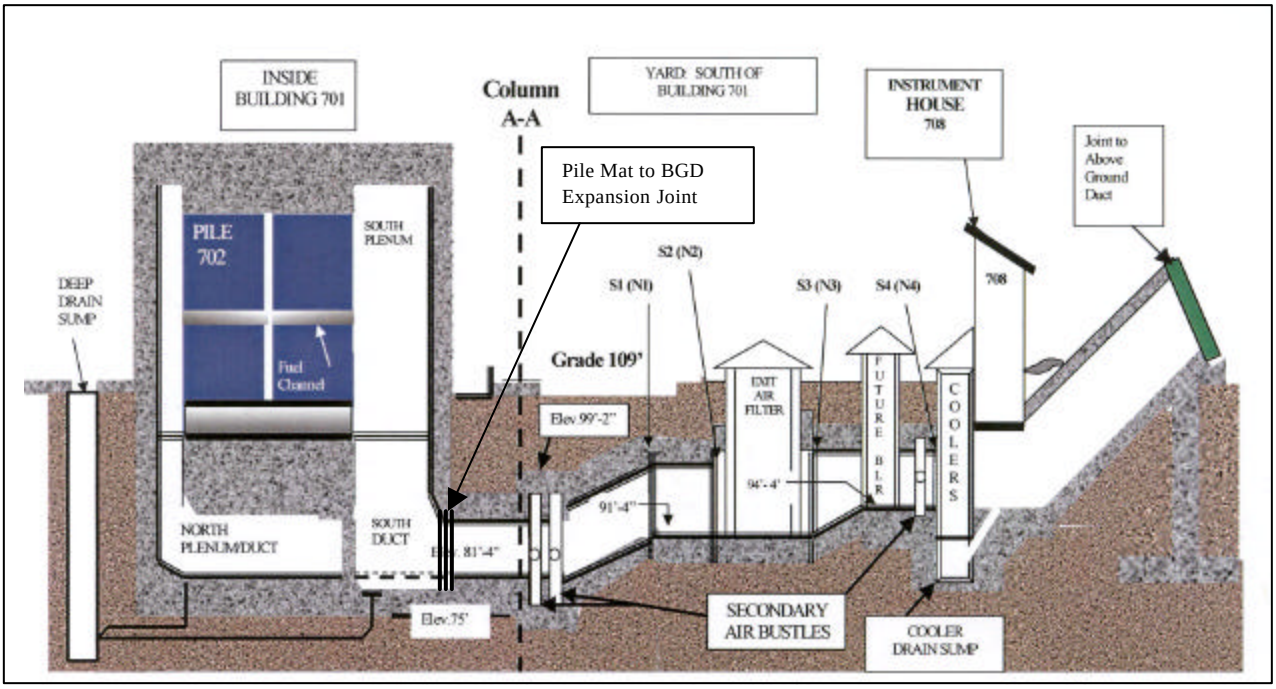


Figure 2-3. Below-Ground Ducts Elevation Layout

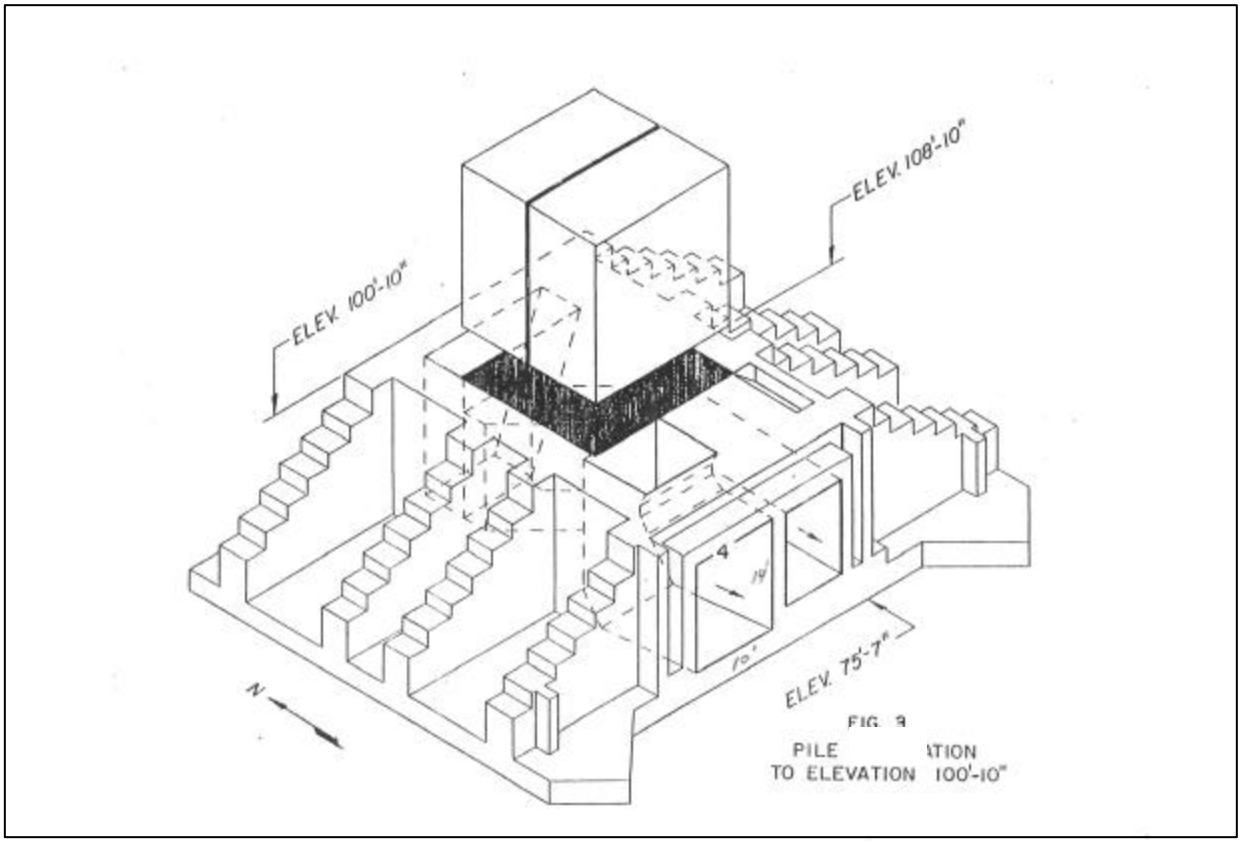


Figure 2-4. Isometric View of Pile Foundation

Preliminary observations of the inner duct secondary air system indicated that water did not leak from the primary liner into the secondary annular space. The characterization plan was written to provide for both a visual inspection and soil sampling at biased locations to verify that assumption. The plan also provided for additional sampling if it was determined that water did leak from the primary liner into the secondary air system. Thus, assessment of nearby or underlying soil was specified in the plan at biased measurement locations near potential leakage points (Locations 18, 19, 22, 23, 24, and 30) and at various random locations around the system.

2.1.1.3 Trench and Unbiased Locations

As discussed in previous sections, biased sampling was performed to determine if individual components had leaked contamination and if so, the type and concentrations of contaminants present and the vertical extent of contamination near its source. Unbiased sampling was also needed to confirm or deny the existence of contamination in locations thought to be clean via historical and anecdotal assumptions and to estimate the lateral extent, or bounds, of contamination that may have migrated from other sources.

Some of the specified locations had a dual purpose. For example, the three trench locations (1 to 3) served as biased locations for study of contamination from pipe leakage and for unbiased detection of potential migration of contamination from Building 701 deep structures.

The remaining unbiased locations (5, 15, 16, and 25 to 29) were located in areas where contamination was not expected. They were necessary to prove or disprove the existence of contamination from potentially unknown drain line discharges or migration from the deep sources.

2.1.1.4 Drains, Associated Lines, and Discharge Points

Many floor drains exist on the 110-foot elevation level. They were studied via direct beta-gamma readings and debris scraping taken from system low points. For sampling purposes, some drains were grouped together based on the piping systems to which they are connected. A scraping was collected from each drain of a group, and the scrapings combined into one sample for analysis.

The storm drains had been previously analyzed and contain no significant radioactivity; therefore they were not resampled.

2.1.1.5 Secondary Air System

The secondary air system consisted of six airflow circuits used to ventilate the annular space of the main exhaust ducts. One of these pipes, external to the south side of the building, was surveyed and partially removed as clean debris during the below-ground duct characterization project. Video inspection and some radiation survey of the eight pipes under the west side 110-foot elevation floor were also conducted. Data from this inspection were reviewed and is included in this report.

2.1.1.6 Intake Duct System

The cooling air intake system is comprised of two duct sub-systems, running underground from the east and west sides of the building inward to the pile. The intake duct system is depicted in green in Figure 2-2. While only fresh air passed through the system, previous radiological surveys had shown low to moderate contamination levels in the system.

Two drain systems exist in each side of the system: one in the floor of the intake structure and one at the low point of the underground portion of the ducts. Plant drawings and visual confirmation show that the low-point duct drain empties into a drywell at the foot of nearby buttresses (see Figure 2-5). To assess these drains and drywells, scrapings of the drains and soil samples from the drywells were collected and analyzed.

Characterization of the intake system included:

- Review and use of the radiological surveys of the intake plenum and filter supports performed as part of the 701 above-ground duct SAP
- Radiological surveys of the duct interiors up to the vertical tee where the duct branches into two paths that supply the north and south sections of the pile
- Drain scrapings of the embedded pipes
- Nearby random boreholes

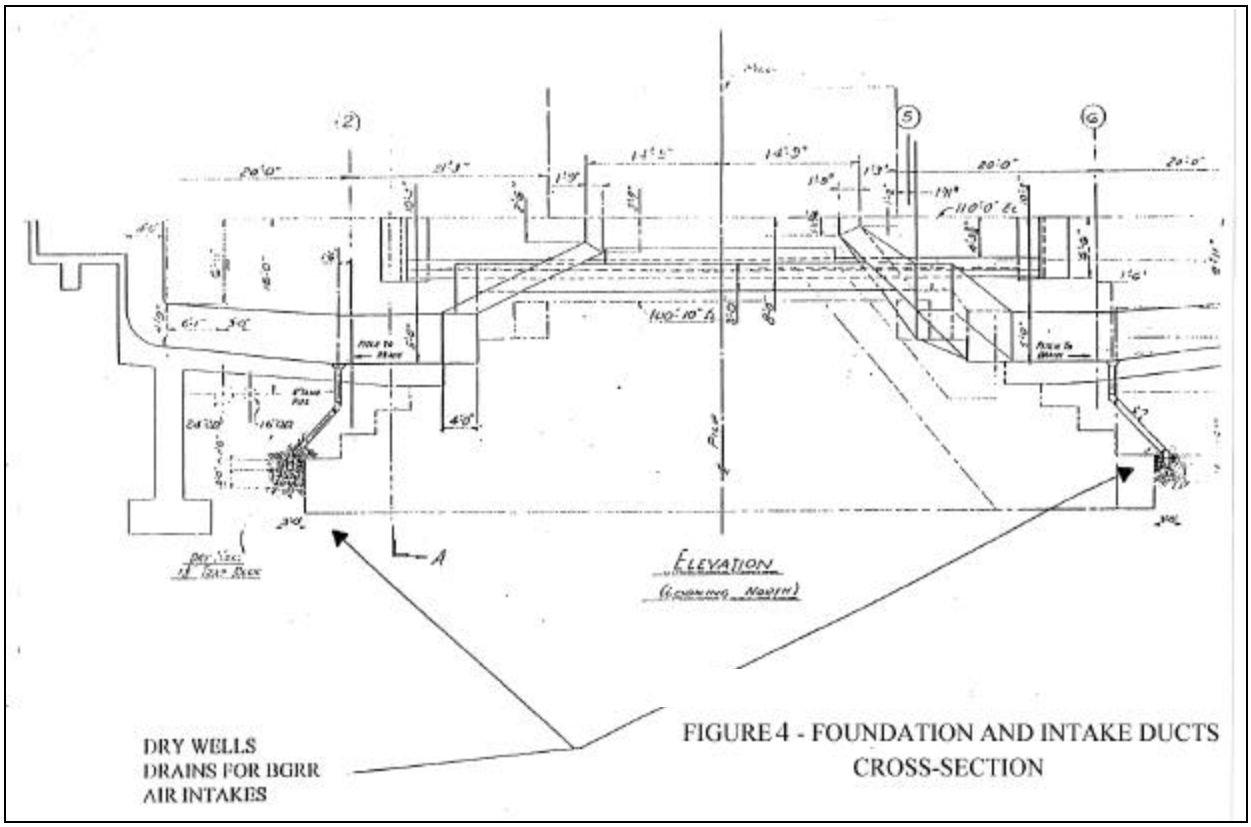


Figure 2-5. Pile Foundation and Intake Ducts Cross-Section View

2.2 Characterization Results

The radiological characterization results are addressed per survey area and separate sections address the groundwater and hazardous analysis. The soil and concrete samples are discussed for each location and summary data tables for the concrete are included in the following sections. Complete analytical results are included in Appendix A, "ISOCS® and BetaScint™ Results," Appendix B, "Off-site Radiological Sample Results," and Appendix C, "Off-site Hazardous Sample Results".

2.2.1 Deep Pit, Canal, and Deep Pit Sump

Sample Locations 6 to 14 will be discussed in this section, refer to Figure 2-6.

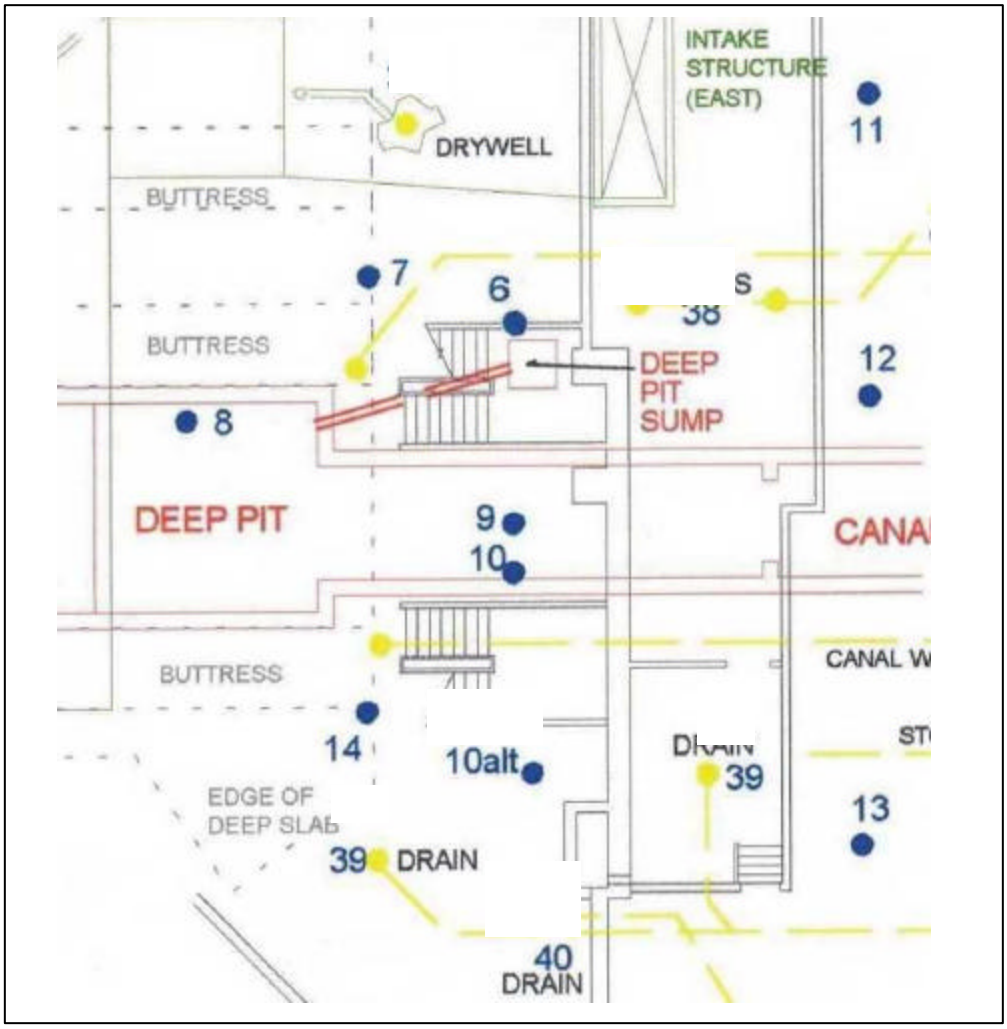


Figure 2-6. Canal Area Sample Locations

Location 6 (Grid W12) - This location is adjacent to the canal deep pit sump and was anticipated to be a key sample point when the characterization plan was developed. During the early years of facility operation, the staff determined that the deep pit sump leaked. Attempts were made to stop the leak, including the installation of a liner, but the sump continued to leak. Eventually the sump was abandoned and filled with concrete in 1961. The bottom of the sump foundation is at the same elevation as the pile and deep pit foundation, thirty-five feet below the main floor of 701. The concrete main floor and canal walkway were cored through to obtain soil samples as close to the sump as possible. The canal walkway concrete ISOCS® results are presented in Table 2-1. Small amounts of Cs-137 and Sr-90, 66 pCi/g and 22.3 pCi/g respectively, were detected five feet below and approximately twelve inches west of the sump.

These results indicate that the sample point probably missed the precise location of the sump leak. Past characterization activities have found that contamination associated with a water leak spreads vertically downward with a very limited horizontal profile. Detecting these small profiles via vertical sampling is extremely difficult and the construction of the building prevents us from obtaining samples on a horizontal plane. Several directional soil samples were taken at thirty-six feet down and trace amounts of Cs-137 and Sr-90 were detected.

Table 2-1. Location 6 Concrete Cores

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)								
		Sample			Co-60		Cs-137		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC
W12CC-01	IG02068	1,814	Concrete	12.5-12.95	ND	1.1	205 ± 16.6	3.0	ND	8.0
W12CC-02	IG02069	3,487	Concrete	12.95-13.5	ND	1.1	ND	1.6	ND	4.9
W12CC-03	IG02070	3,912	Concrete	13.5-14.25	ND	4.7	ND	6.0	ND	22.4
W12CC-04	IG02072	3,204	Concrete	14.25-14.75	ND	1.4	ND	2.5	ND	9.1

The modeling assumption for these cores: The contamination was homogeneously distributed throughout the core.
MDA = Minimum detectable activity in pCi/g at the 95% condfidence level.
ND = not detected; result was less than the 95% critical level.
Uncertainty reported at the 95% confidence level and represents counting error and ISOCS-generated effieciency error.

Location 7 (Grid U13) - This location is adjacent to the north canal deep pit buttress and close to the pipe that enters the deep pit sump. This location was chosen for two reasons: deep pit wall and transfer pipe leakage would be detected here. The main floor (110-foot elevation) and canal walkway were cored through; concrete ISOCS® results are in Table 2-2. Contamination was detected in the soil from 35 to 44' with peak concentrations of Cs-137 and Sr-90 at 108 pCi/g and 30.9 pCi/g respectively. These elevations correspond to just beneath the foundation for the deep pit. Also, a small piece of wood was obtained at thirty-five feet, probably remaining from the concrete forms used during construction, and it is saturated with Cs-137 at 791 pCi/g indicating that it was exposed to water leakage. It is not possible to determine if the contamination was from the deep pit, deep pit sump transfer pipe, or the canal north wall.

Table 2-2. Location 7 Concrete Cores

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)								
		Sample			Co-60		Cs-137		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDA	Result	MDA	Result	MDA
U13CC-04	IG02092	1,374	Concrete	12.5-12.75	ND	2.0	5,225 ± 391	11.0	ND	28.7
U13CC-05	IG02093	3,232		12.75-13.5	ND	0.8	1,535 ± 115	5.3	ND	12.4
U13CC-06	IG02095	4,139		13.5-14.25	ND	0.8	4.7 ± 1.0	1.1	ND	3.3
U13CC-07	IG02096	3,416		14.25-14.9	ND	0.9	0.8 ± 0.7	1.1	ND	4.2
U13CC-08	IG02097	600		14.9-15.0	ND	2.6	3.7 ± 2.0	3.0	ND	7.9

Each concrete core was intially screened using a Ludlum, Model 3 Survey Meter to locate contamination hot spots prior to ISOCS counting. This procedure determines the sample counting orientation, which optimizes the modeling efficienices and improves the accuracy of calculated radionulcide concentrations .

All concrete cores were modeled assuming a homogeneous contamination distribution throughout the entire sample.

MDA = Minimum detectable activity in pCi/g at the 95% condfidence level.

ND = not detected; result was less than the 95% critical level.

Uncertainty reported at the 95% confidence level and represents counting error and ISOCS-generated effieciency error.

Location 8 (Grid T14) - This location is through the canal deep pit foundation, approximately eighteen inches from the north wall. The concrete is saturated with Cs-137 contamination to a depth of two feet (concrete ISOCS® results in Table 2-3). The bottom section of concrete, 3'9" down, also has slight Cs-137 contamination. The soil beneath the foundation is contaminated from 35 to 41' with peak concentrations of Cs-137 and Sr-90 at 405 pCi/g and 103 pCi/g respectively. The combination of slight soil and concrete contamination indicates that there was probably leakage from the deep pit and it slightly pooled underneath the foundation.

Table 2-3. Location 8 Concrete Cores

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)								
		Sample			Co-60		Cs-137		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC
T14CC-04[1]	IG02036	254	Concrete Fines	31.0-31.25	0.4 ± 0.1	0.2	2,200 ± 165	2.5	ND	2.3
T14CC-04	IG02037	602	Concrete		ND	5.7	1,410 ± 127	11.4	ND	24.1
T14CC-05	IG02003	433		31.25-31.65	ND	5.4	4.2 ± 2.9	4.4	ND	18.6
T14CC-06	IG02004	508		31.65-32.0	ND	4.7	ND	6.9	ND	18.8
T14CC-07	IG02005	593		32.0-32.4	ND	3.5	57.3 ± 8.1	5.2	ND	17.0
T14CC-08	IG02006	584		32.4-32.75	ND	4.4	340 ± 33.1	6.5	ND	19.5
T14CC-09	IG02007	399		32.75-33.0	ND	5.7	4.9 ± 2.8	3.9	ND	24.9
T14CC-10	IG02018	1,344		33.0-33.6	ND	4.1	ND	6.1	ND	15.6
T14CC-11	IG02008	292		33.6-33.75	ND	8.5	ND	11.3	ND	29.8
T14CC-12	IG02017	1,225		33.75-34.5	ND	5.4	ND	5.8	ND	16.7
T14CC-13	IG02009	648		34.5-34.75	ND	3.4	2.8 ± 2.1	3.1	ND	15.1

All concrete cores were modeled assuming a homogeneous activity distribution throughout the entire sample.

[1] Poly bottle T14CC-04 contained both concrete coring fines (spoils) and the concrete core. For modeling purposes it was necessary to separate the two fractions and recount for result accuracy.

Location 9 (Grid W14) - This location is inside the canal, west of Column 7. A core was made through the floor trough that feeds sump S1. The soil beneath this location does not have contamination. Concrete results are presented in Table 2-4.

Location 10 (Grid W15) - This location is inside the canal, west of Column 7. A 45-degree core was made through the floor and south wall construction joint (see Photograph 2-1). Characterization of the outer canal, east of Column 7, showed that there was leakage through the floor/wall construction joint in several locations. The soil through this location does not have contamination. ISOCS® concrete analyses are presented in Table 2-4.

Photograph 2-1. Coring activities through the floor and wall seam at Location 10

Table 2-4. Locations 9 and 10 Concrete Cores

Sample ID	Spectrum File Name	Length of Concrete Core Modeled (cm)	Summary of Radionuclides of Concern (pCi/gram)								
			Sample			Co-60		Cs-137		Am-241	
			Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC
W14CC-01[1]	IG02040	7.5	4,990	Concrete	0.0-1.0	ND	8.9	4,715 ± 363	20.0	ND	56.8
		15.0				ND	7.2	4,035 ± 310	17.1	ND	57.2
W14CC-02[2]	IG02047	27.5	4,763	Concrete	1.0-2.0	ND	0.6	1.0 ± 0.6	0.9	ND	2.9
W14CC-2A[3]	IG02049	0.5	143	Paint	0.0-0.5	342 ± 53.8	67.9	37,300 ± 2,900	215	ND	211
W15CC-01[1]	IG02042	7.5	1,758	Concrete	0.0-1.0	ND	16.5	7,485 ± 567	46.8	ND	138
		15.0				ND	13.4	6,480 ± 505	40.5	ND	138
W15CC-02[2]	IG02044	6.0	1,758	Concrete	1.0-1.75	ND	1.4	3.2 ± 1.4	2.0	ND	3.3
W15CC-03[2]	IG02045	27.5	1,658	Concrete	1.75-2.65	ND	1.8	ND	2.1	ND	6.1

[1] Each concrete core was initially measured the length of the core for activity levels with a hand held Ludlum. It was determined that each ~30 cm core was contaminated/activated only half the length of the core with the highest activity reading at one end approximately 7.5 cm in length, which was modeled. A second ISOCS model using a 15 cm length of contamination/activation was also performed to include the majority of the activity measured with the Ludlum.

[2] All these concrete cores were modeled assuming a homogeneous activity distribution throughout the entire sample.

[3] A cylindrical layer of paint, ~0.5 cm thick was modeled assuming homogeneous activity distribution.

Locations 11, 12, and 13 (Grids Z10, Z11, and Z13) - These three locations are east of Building 701. They were selected to bound any contamination detected in the canal area. Trace amounts of Sr-90 were detected at location 12.

Location 14 (Grid U16) - This location was placed adjacent to the south canal deep pit buttress, similar to location 7's placement adjacent to the north canal deep pit buttress. This location was chosen because it was believed that if water had leaked through the canal wall, it would have pooled on the buttress ledge, contaminating the adjacent soil. No contamination was detected at this location.

Supplemental Canal Characterization – Five additional soil samples were obtained from beneath the canal walkway sump. During the remediation of the canal, significant contamination was detected in the walkway sump and it was determined that the sump could have leaked into the soil. A core was made through the canal wall and Cs-137 (103 pCi/g), Pu-239/240 (29.6 pCi/g), and Sr-90 (186 pCi/g) were detected in the soil beneath the sump.

2.2.2 Exhaust Duct System and Associated Sump

Sample Locations 18, 19, 22, 23, 24, and 51 are discussed in this section, refer to Figure 2-7. Locations 4 and 30 are also related to the below-ground ducts and are included in this section, refer to Figure 2-2. Drain Locations 41 and 42 are discussed in section 2.3.4.

Location 18 (Grid P24) - This location is in the southwest corner of the machine shop and is adjacent to the north duct expansion joint. Slight contamination was detected from 32 to 36' at 45 pCi/g of Cs-137; this depth is associated with the bottom of the duct. Location 18a was added, approximately three-feet south of Location 18, to determine if the contamination is part of the large area detected during the below-ground duct characterization or is a new source. No contamination was detected at 18a indicating that the source of contamination is probably the inner duct expansion joint.

Location 19 (Grid L23) - This is similar to Location 18 and it is adjacent to the south duct expansion joint. No contamination was detected at this location.

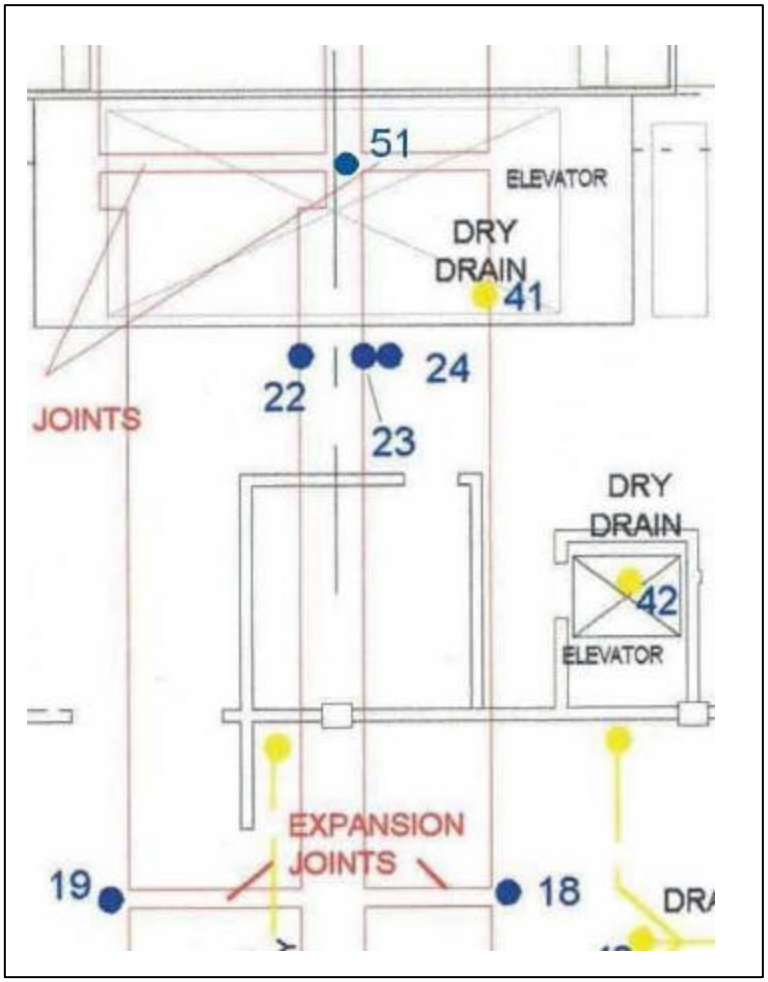


Figure 2-7. Below-Ground Duct Sample Locations

Locations 22, 23, and 24 (Grids N18 and O18) - These locations were selected to inspect the interior of the north duct, inspect the secondary air space of the north and south ducts, collect liner and debris samples, and to collect soil and groundwater samples from beneath (Figure 2-8). Location 24 was cored first to inspect the interior of the north duct and to take precise measurements to access the three-inch annular space in both ducts. The interior of the duct has several inches of contaminated debris and what remains of a solar neutrino experiment was found inside the north duct (Photograph 2-2). Water lines on the wall of the duct are clearly visible to a height of approximately four-feet. Liner, concrete, and thermal shield samples were also obtained and analyzed (See Tables 2-5 and 2-6 for ISOCS® results). High levels of contamination were detected on the bottom of the secondary liner and in the concrete indicating water had leaked through the primary liner.

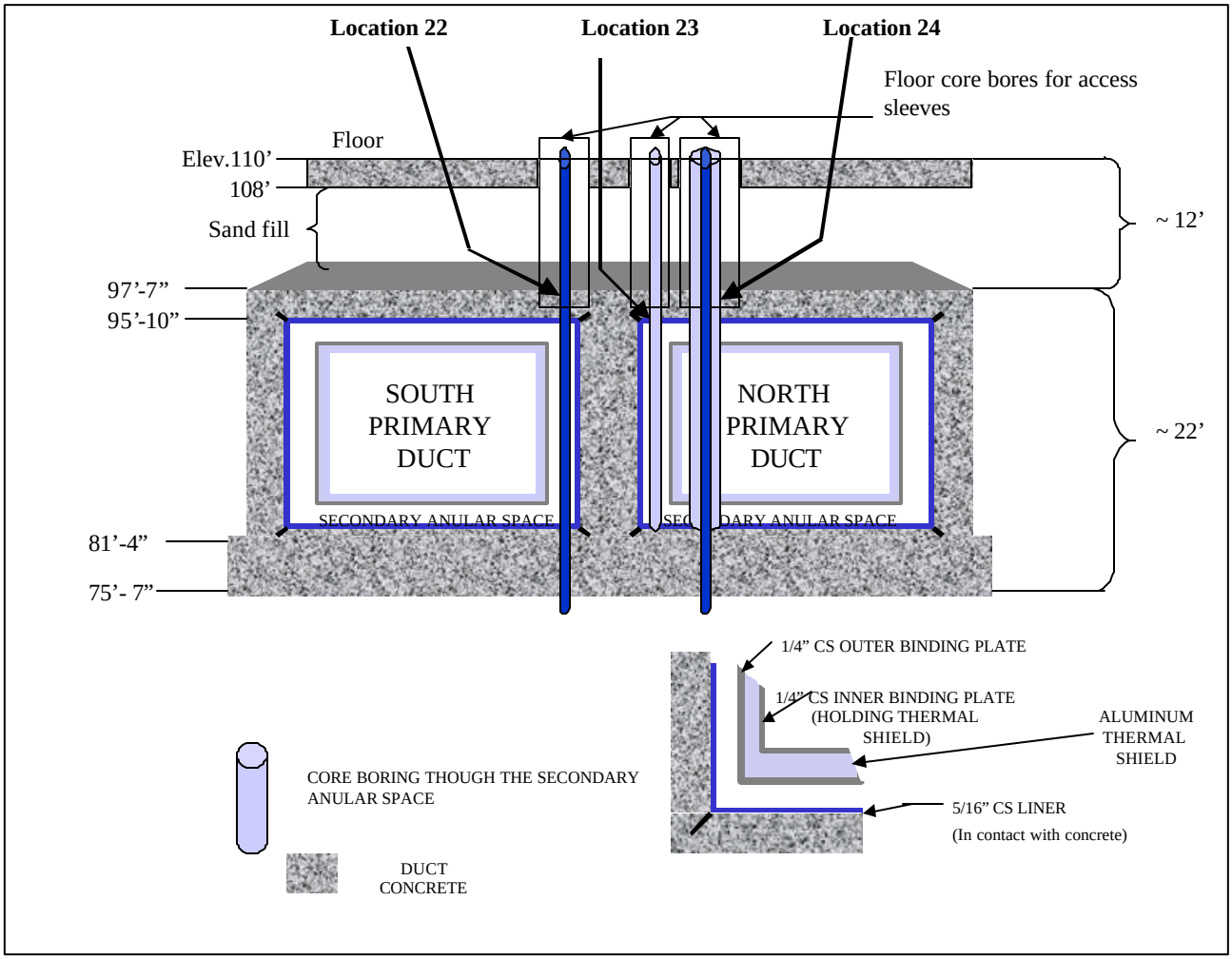


Figure 2-8. Sample Locations 22, 23, and 24

Photograph 2-2. Solar Neutrino Experiment and Duct Debris

Table 2-5. Location 24 Steel and Aluminum Samples

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	H-Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
18BST-04-T	IG02030	120	Steel	28.2-28.4	ND	29.0	21,125 ± 1,625	66.1	ND	79.2	ND	58.9
18BST-04-B	IG02029				ND	27.4	16,250 ± 1,250	63.1	ND	75.1	ND	50.2
018BAL-02-T[1]	IG02032	43.4	Aluminum	28.4-28.7	ND	15.7	64,885 ± 4,940	71.9	ND	54.1	ND	55.4
018BAL-02-B[1]	IG02024[2]	54.8			ND	13.1	54,960 ± 4,185	62.2	ND	37.5	ND	47.0
18BST-05A-T	IG02031	211	Steel	28.7-28.8	ND	25.5	2,700 ± 225	45.7	ND	36.2	ND	24.0
18BST-05A-B	IG02025				ND	24.0	3,850 ± 310	27.1	ND	38.2	ND	28.9
18BST-05B-T	IG02014	200	Shavings	28.8	ND	70.0	41,460 ± 3,195	151	ND	265	ND	248
18BST-05B-B	IG02028				ND	14.1	45,730 ± 3,485	70.8	ND	49.0	ND	111
18BST-06-T	IG02016	165	Steel	28.8-29.0	ND	275	26,625 ± 2,275	512	ND	1,020	ND	659
18BST-06-B	IG02026				ND	22.4	17,875 ± 1,375	54.8	ND	72.4	ND	54.4

T = Top surface of the sample

B = Bottom surface of the sample

Higher MDA's are associated with samples that were counted at increased detector/source distances (>40cm). This elevated MDA is associated with Canberra's software calculations, which occurs sometimes when samples are radiologically hot, remodeled, and/or the sample to detector measurement distance is increased.

All steel cores were modeled assuming a thin contamination layer on the the surface of the core to a depth of 0.05 cm. The aluminum disc samples and the metallic shavings/debris were modeled assuming the contamination was homogenously distributed throughout sample.

[1] There were six - 7 cm diameter discs removed from the aluminum thermal shield, which were stacked on top of each other for gamma counting purposes. These six stacked discs were modeled as one monolithic sample.

[2] The reason the mass is different for the two measurements is because 018BAL-02-B was measured in it's original container that included some shavings. 018BAL-02-B was removed from the original container and turned 180 degrees to measure the opposite surface, and placed into another container for counting purposes.

MDA = Minimum detectable activity in pCi/g at the 95% condfidence level.

ND = not detected; result was less than the 95% critical level.

Uncertainty reported at the 95% confidence level and represents counting error and ISOCS-generated effieciency error.

Table 2-6. Location 24 Concrete Cores

Sample ID	Spectrum File Name	COC Number	Summary of Radionuclides of Concern (pCi/gram)								
			Sample			Co-60		Cs-137		Am-241	
			Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC
O18BCC-12-T-0.1 cm[1]	IG02027	14519	676	Concrete	28.66-29.16	ND	6.3	4,675 ± 360	19.1	ND	12.7
O18BCC-12-T-2.5 cm[1]						ND	0.5	358 ± 27.6	1.5	ND	1.6
O18BCC-13	IG02065	14520	2,376	Concrete	29.16-30.5	ND	7.3	ND	8.7	ND	32.5
O18BCC-14	IG02061	14520	629	Concrete	30.5-30.85	ND	4.7	ND	5.6	ND	20
O18BCC-15	IG02066	14520	1,969	Concrete	30.85-32.1	ND	6.6	ND	10.7	ND	40.2
O18BCC-16	IG02067	14520	1,979	Concrete	32.1-33.35	ND	8.8	ND	12.0	ND	36.3
O18BCC-17	IG02062	14520	654	Concrete	33.35-33.7	ND	4.2	ND	6.2	ND	18.9
O18BCC-18	IG02063	14520	525	Concrete	33.7-34.0	ND	6.2	ND	6.3	ND	22.1

All concrete cores were modeled assuming a homogeneous activity distribution throughout the entire core. This was not the case with Sample I.D. O18BCC12 (see footnote 1 for explanation).

[1] Using a Ludlum Model 3 Survey meter it was determined that all of the radiological contamination was located at one end of the concrete core only and, therefore the entire core was not modeled. Instead, the same concrete core was modeled at two different core depths, 0.1 cm and 2.5 cm.

Higher MDA's are associated with samples that were counted at increased detector/source distances (>40cm). This elevated MDA is associated with Canberra's software calculations, which occurs sometimes when samples are radiologically hot, remodeled, and/or the sample to detector measurement distance is increased.

MDA = Minimum detectable activity in pCi/g at the 95% condfidence level.

ND = not detected; result was less than the 95% critical level.

Uncertainty reported at the 95% confidence level and represents counting error and ISOCS-generated effieciency error.

The core was made at Location 23 to inspect the north duct secondary annular space. The inspection revealed watermarks indicating that water had leaked from the primary liner into the secondary space. Also, a debris sample was obtained at the bottom of the secondary liner and off-site analysis indicated 16,800 pCi/g of Cs-137 and 4750 pCi/g of Sr-90. The location of the core was off by approximately one-inch preventing the core of the duct bottom to access the soils beneath. Soil samples were obtained at Location 24, approximately one-foot east, and they indicate no contamination. A directional soil sample was taken from beneath the duct at Location 24 towards Location 23 and no contamination was detected.

The secondary air space in the South duct was accessed at Location 22. The annular space was inspected and it was determined that water had not leaked into the annular space. A debris sample was obtained and it only had 2.1 pCi/g of Cs-137, confirming the visual inspection. The bottom of the duct was cored and a thirty-two foot guide tube inserted for sampling of the soil and groundwater beneath (Photograph 2-3). No contamination was detected at this location.

Since it was determined that water had leaked into the north duct secondary space, samples were obtained from Location 30, through the bottom of the north plenum, per the SAP. Also, since it was determined that water did not leak into the south duct secondary space, samples were not required to be obtained from Location 31, through the bottom of the south plenum.

Photograph 2-3. Thirty-two-foot Guide Tube Installation

Location 51 (Grid N17) - This location was added as a SAP modification after reviewing the findings at Locations 23 and 24. This location is between the north and south duct innermost expansion joints. The core accessed the area between the foundation mats for the pile and below-ground ducts and a visual inspection of the vertical space between the expansion joints for both ducts was performed. The bellows of the north duct is extremely degraded indicating water leaked from this expansion joint, onto the foundation, and eventually into the soil. A debris sample was obtained from the "clean" annular space between the expansion joints of the north and south ducts and indicated 2 milliRoentgen per hour (mR/hr). ISOCS® analysis of the sample indicated Cs-137 at 79,000 pCi/g. Off-site analysis indicated Cs-137 at 48,700 pCi/g and Sr-90 at 2200 pCi/g. The steel plates below the duct were cored and a nine-inch layer of grout was found beneath the plates. Samples from both the steel plates and grout were obtained and indicated some Cs-137 contamination. The plates span the entire width of the duct and finding the precise location where the contaminated water entered the soil would be impossible. The level of contamination and leakage path to the soil is similar to that found while characterizing the below-ground ducts during FY2001 therefore the volume of soil contamination should also be similar. The volume of contaminated soil found during that characterization effort was thirty-five cubic yards with peak concentrations of 89,000 pCi/g of Cs-137 and 11,200 pCi/g of Sr-90.

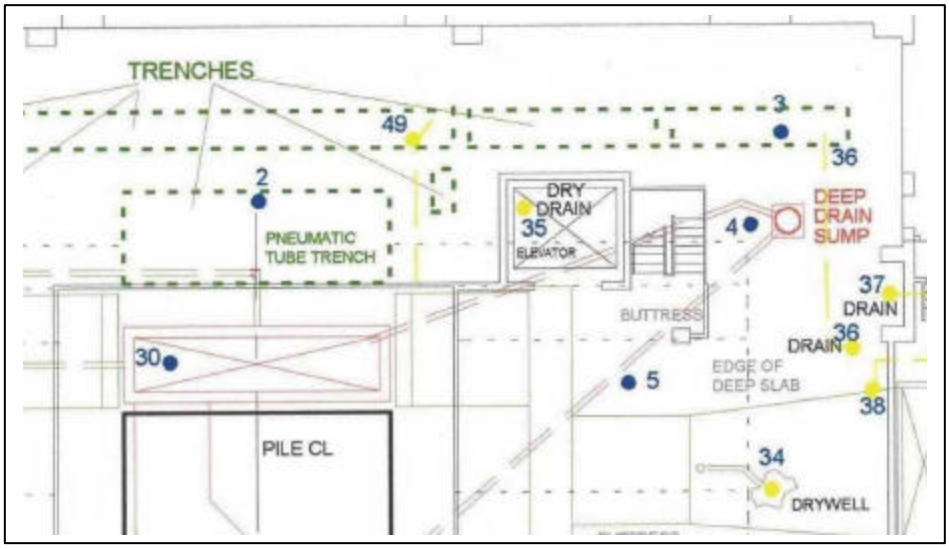


Figure 2-9. Locations 4 and 30

Location 4 (Grid U6) - This location was placed adjacent to the deep drain sump. The deep drain sump collects water that enters the north and south ducts through drainpipes that are located in the north and south exhaust air plenums. This location was chosen because water was found in the ducts and deep drain sump. No contamination was detected at this location.

Location 30 (Grid M8) - This location, through the bottom of the north plenum, was very difficult and required some innovative engineering to core through the plenum and sample the soils beneath. The location was selected to be adjacent to the drain line that goes from the north plenum into the deep drain sump. The placement of the core penetrated the concrete casing for the drain line, below the pile foundation. Some discoloration was evident in the concrete indicating a potential leak but the concrete was analyzed and it is not contaminated. The discoloration is probably from the original concrete pour around the drainpipe. The ISOCS® results of the analysis on the liner, thermal shield, concrete, and debris samples are in Table 2-7.

The debris sample that was taken from the floor of the plenum is highly contaminated. ISOCS® analysis of the debris sample indicates Cs-137 at 245,660 pCi/g, Co-60 at 9225 pCi/g, and americium-241 (Am-241) at 2380 pCi/g. This sample was sent to an off-site laboratory for full radiological analysis. The following are the radionuclides and concentrations detected in the sample: Cs-137 at 204,000 pCi/g, Co-60 at 7720 pCi/g, europium-152 (Eu-152) at 440 pCi/g, Eu-154 at 120 pCi/g, plutonium-238 (Pu-238) at 390 pCi/g, Pu-239/240 at 12,200 pCi/g, uranium-233/234 (U-233/234) at 169 pCi/g, U-238 at 160 pCi/g, radium-226 (Ra-226) at 10.1 pCi/g, Am-241 at 2720 pCi/g, and Sr-90 at 145,000 pCi/g. Previous samples taken from the north and south plenums in August of 2000 have similar results and they are in Appendix H, "Graphite and Biological Shield Components Off-Site Analyses". The debris at the bottom of the pile (see section 3.6.1) should have similar concentrations of radionuclides.

Table 2-7. Location 30 Concrete and Liner ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDA	Result	MDA	Result	MDA	Result	MDA
M8ST-01-T[1]	IG02098	169	Steel	28.00-28.03	2,950 ± 280	323	106,500 ± 8,275	735	ND	1,020	841 ± 528	826
M8ST-01-B[1]	SAM04882				2,300 ± 305	53.1	62,050 ± 5,070	771	ND	1,270	ND	927
M8AL-01	IG02113	47.6	Aluminum	28.03-28.36	ND	462	1,766,400 ± 134,525	2,380	ND	1,800	ND	2,890
M8ST-02-T[1]	IG02103	213	Steel	28.36-28.39	2,645 ± 260	286	621,500 ± 47,440	1,480	ND	1,050	ND	1,570
M8ST-02-B[1]	SAM04883				1,910 ± 315	312	726,150 ± 55,565	1,670	ND	1,570	ND	2,820
M8SC-01	IG02114	90.3	Debris	28.39	9,225 ± 465	269	245,660 ± 18,800	783	ND	943	2,380 ± 1,175	1,800
M8ST-03-T[1]	IG02104	223	Steel	28.39-28.42	3,430 ± 295	267	21,500 ± 1,820	470	ND	750	ND	503
M8ST-03-B[1]	SAM04884				87,910 ± 3,475	1,370	667,350 ± 51,110	2,530	ND	3,640	ND	2,740
M8SC-02	IG02112	81.8	Debris	28.42	791 ± 48.9	25.7	73,775 ± 5,630	134	ND	122	ND	213
M8CC-01	IG02099	456	Concrete	28.42-28.67	11.8 ± 3.3	3.2	810 ± 75.5	15.9	253 ± 17.7	14.5	ND	26.8
M8CC-02[2]	IG02100	1,708	Concrete	28.67-29.50	ND	3.1	ND	3.6	107 ± 6.4	1.0	ND	8.4
M8CC-02[3]					ND	28.4	ND	31.3	955 ± 59.0	9.3	ND	74.1
M8CC-03	IG02101	2,260	Concrete	29.50-30.75	ND	8.2	ND	10.7	ND	26.2	ND	28.3
M8CC-04	IG02105	1,860	Concrete	30.75-31.75	ND	2.8	ND	3.7	ND	9.7	ND	11.4
M8CC-05	IG02106	1,058	Concrete	31.75-32.40	ND	2.4	ND	3.4	ND	7.6	ND	8.6
M8CC-06	IG02107	3,073	Concrete	32.40-35.30	ND	5.7	ND	8.0	ND	18.1	ND	20.6
M8CC-07	IG02108	599	Concrete	35.30-37.75	ND	3.8	ND	5.5	ND	12.8	ND	15.3
M8CC-08	IG02109	302	Concrete	35.75-35.95	ND	7.8	ND	10.3	ND	22.3	ND	25.9
M8CC-09	IG02110	481	Concrete	35.95-36.25	ND	5.2	ND	6.3	ND	14.3	ND	17.4
M8CC-10	IG02111	856	Concrete	36.25-37.75	ND	3.2	ND	4.0	ND	9.3	ND	11.3

Each concrete core was intially screened using a Ludlum, Model 3 Survey Meter to locate contamination hot spots prior to ISOCS counting. This procedure determines the ISOCS sample counting orientation, which optimizes the modeling efficienices and improves the accuracy of calculated radionulcide concentrations.

Unless stated otherwise, the modeling assumption for all cores/materials was that the contamination was homogeneously distributed throughout the core.

[1] *Modeling assumption: The contamination was located on the two surface faces only (0.05 cm depth). The steel core surfaces were idenfified as either T=Top or B=Bottom.*

[2] *This core sample was modeled using two different assumptions: The first assumption was that the contamination was uniformly distributed throughout the core (see footnote 3)*

[3] *The second modeling assumption for sample M8CC-02 was that higher levels of contamination were located near one end surface (length modeled = 2.54 cm). A Ludlum, Model 3 Survery Meter revealed a slightly higher contamination level in this area compared to the remainder of the core.*

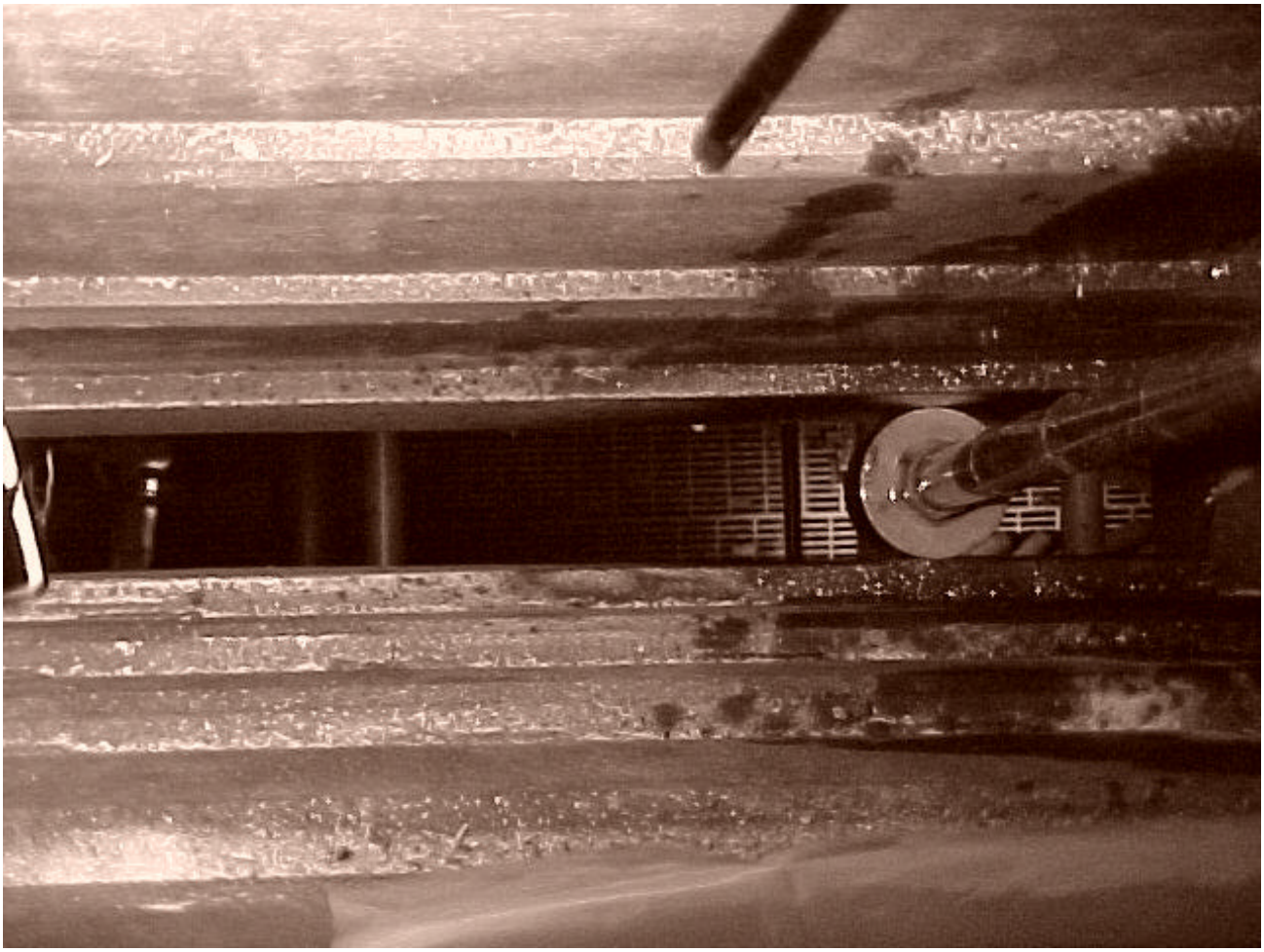
MDA = Minimum detectable activity in pCi/g at the 95% condfidence level.

ND = not detected; result was less than the 95% critical level.

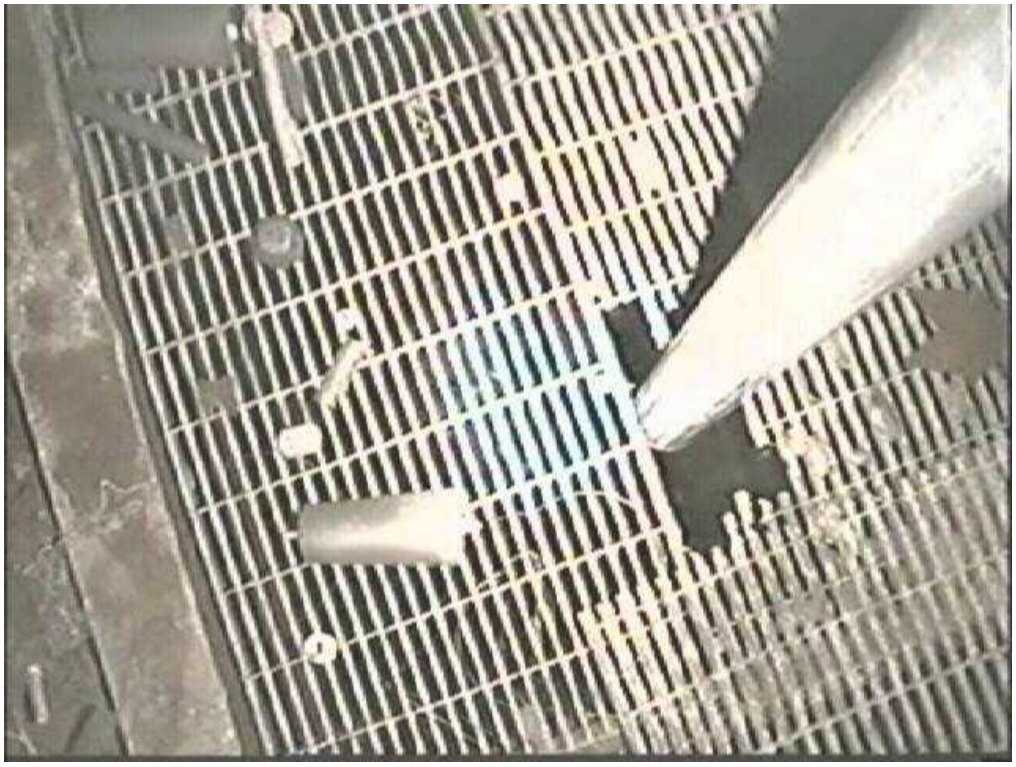
Uncertainty reported at the 95% confidence level and represents counting error and ISOCS-generated effieciency error.

Photograph 2-4 is a picture looking down through the removed scanner slot. The gap is only four-inch wide so special tools and techniques were used to core through the steel grating. Photograph 2-5 shows the hole that was cut through the grating and the sample guide tube that was inserted and fixed to the north duct liner. Also visible is some of the debris that is in the north plenum. Gamma spectrum analyses of some of the items retrieved from the plenum are in Appendix D, "ISOCS® Results for the Pile and Related Components". The predominant radionuclide present is Co-60 with 3,000,000 pCi/g detected on a stainless steel plug retainer spring.

Photograph 2-6 depicts the vacuum system that was used to retrieve the concrete core samples from sixty-feet below the top of the pile. Photograph 2-7 shows the Geoprobe® being lifted to the pile top in preparation for soil sampling. Soil samples were taken until the water table was reached at which time a groundwater sample was obtained.



Photograph 2-4. North Plenum Scanner Slot Opening



Photograph 2-5. North Plenum Steel Grating

Photograph 2-6. Sample Retrieval Process

Photograph 2-7. Geoprobe® Placement on Pile Top

2.2.3 Trench and Unbiased Locations

Sample Locations 1, 2, 3, 5, 15, 16, 20, 21, 25, 26, 27, 28, and 29 will be discussed in this section. Refer to Figure 2-2.

Locations 1, 2, and 3 (Grids H5, O5, and W5) - These three locations are in the pipe trench that runs the full length of the north end of Building 701. The pipe trench housed the pneumatic tubes used for experimental purposes, pile gutter drains, and the Building 703 "F" waste transfer line (Photograph 2-8). The trench is approximately four feet deep and the bottom is soil. The pipes have a tray system installed beneath them designed to collect any system leakage. A survey of the entire trench was performed and several spots of contamination were detected. The survey is in Appendix E, “Systems and Components Surveys”. In photograph 2-8, a water leakage line is visible on the right side of the picture and soil contamination was detected below the leakage path. Six additional sample locations, grids I5, K5, M5, Q5, S5, and U5, were added to bound the soil contamination. Summary ISOCS® and BetaScint™ results are provided in Table 2-8 and full radiological analyses are in Appendices A and B.

Photograph 2-8. North Pipe Trench

Table 2-8. Trench ISOCS® and BetaScint™ Results

Grid	ISOCS® (Cs-137 pCi/g)	BetaScint™
H5, 0"-6"	ND	0.15
I5, 0"-6"	ND	0.22
K5, 0"-6"	ND	0.24
M5, 0"-6"	686.0	147.25
M5, 6"-12"	324.0	147.25
M5, 12"-18"	38.7	8.42
M5, 18"-24"	18.1	8.42
M5, 24"-30"	6.1	2.21
M5, 30"-36"	3.0	2.21
O5, 0"-6"	ND	0.82
Q5, 0"-6"	17,726.0	446
Q5, 6"-12"	1307.0	446
Q5, 12"-18"	438.0	61.72
Q5, 18"-24"	3.7	61.72
S5, 0"-6"	ND	0.73
U5, 0"-6"	ND	0.35
W5, 0"-6"	ND	0.04

Location 5 (Grid T9) - This location is inside a storage space between buttresses 1 and 2, adjacent to the east biological shield wall. A 45-degree core was made in the corner to access the soils beneath the pile. Photograph 2-9 shows the Geoprobe® angled to collect soil samples from below the pile. No contamination was detected in either the concrete or soil.

Photograph 2-9. Location 5 Angled Sampling

Location 15 (Grid T9) - This location is in the southeast corner of Building 701, down gradient from the canal and deep pit. This location was chosen to potentially identify the deep pit as the source of the Sr-90 plume identified during the below-ground duct characterization. No contamination was detected at this location.

Location 16 (Grid V24) - This location is in the southeast corner of the machine shop and was selected for the same reasons as Location 15. During the below-ground duct characterization, a large area of soil contamination was detected south of Building 701 and this location provides additional bounding data. No contamination was detected at this location.

Locations 20 and 21 (Grids J23 and F22) - These two locations are inside the fuel vault. Historical information indicates that the fuel vault floor flooded several times thus providing the potential for contamination of the soil beneath the floor. Contamination was detected in the floor drain inside the vault but the soil samples obtained from beneath the floor did not contain any contamination.

Locations 25 and 26 (Grids J18 and G20) - These two locations are in the southwest corner of Building 701 and were chosen to potentially bound any contamination detected beneath the pile and below-ground ducts. Also, Location 25 is adjacent to the pile foundation and the project assumed if the south plenum had leaked water onto the foundation that it would seep into the adjacent soil. No contamination was detected at these locations.

Locations 27, 28, and 29 (Grids I14, G11, and F7) - These three locations are on the west side of Building 701. There are no systems that held large volumes of water in this area therefore these locations were predominantly looking for shallow contamination and to bound any contamination detected elsewhere in the facility. No contamination was detected at these locations.

Figures 2-10 and 2-11 are visual representations of the contamination associated with the structures below Building 701. Table 2-9 is the summary radiological data for the soil samples sent to an off-site laboratory for analysis. Complete off-site radiological laboratory results are in Appendix B.

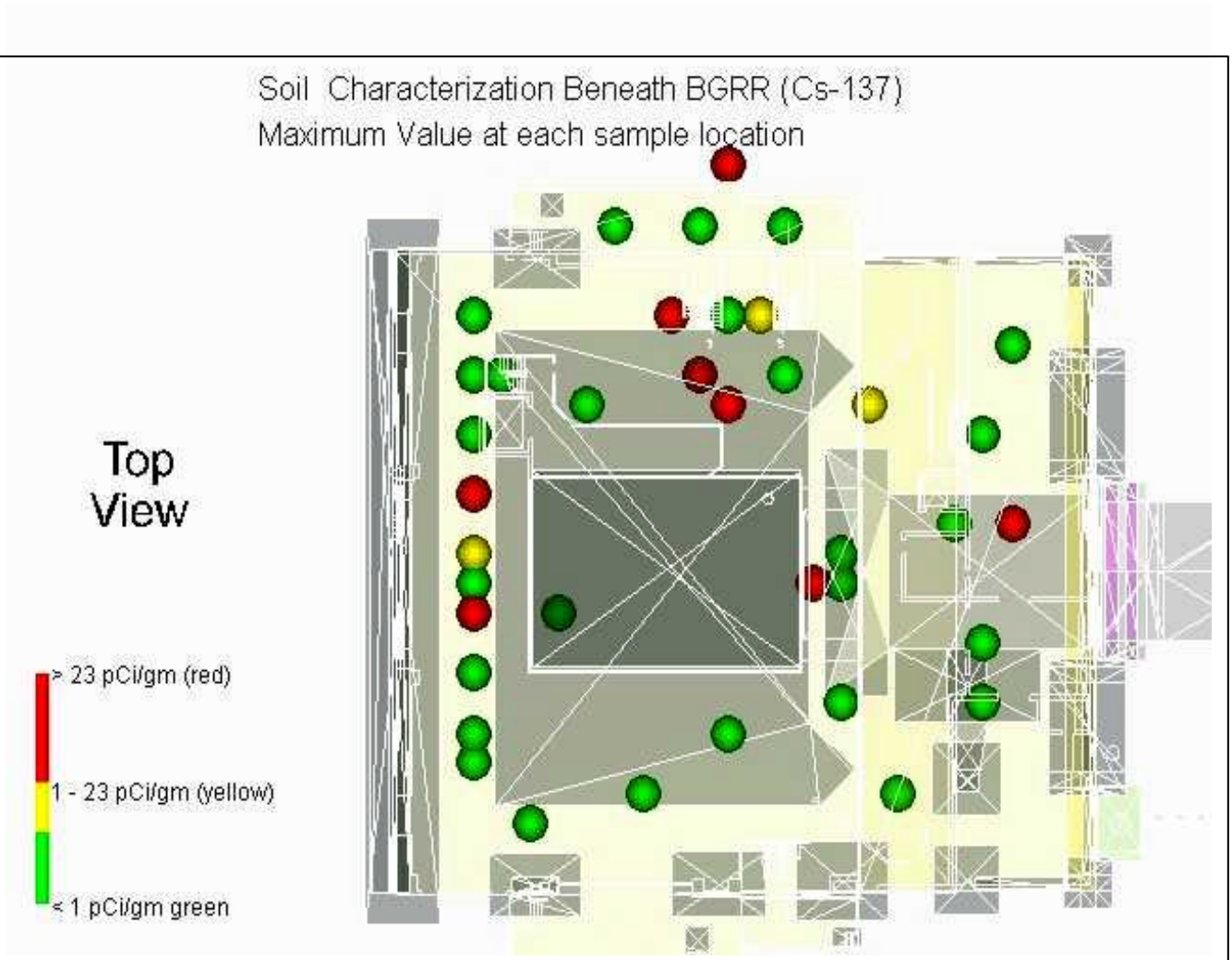


Figure 2-10. Cs-137 Contamination Below Building 701

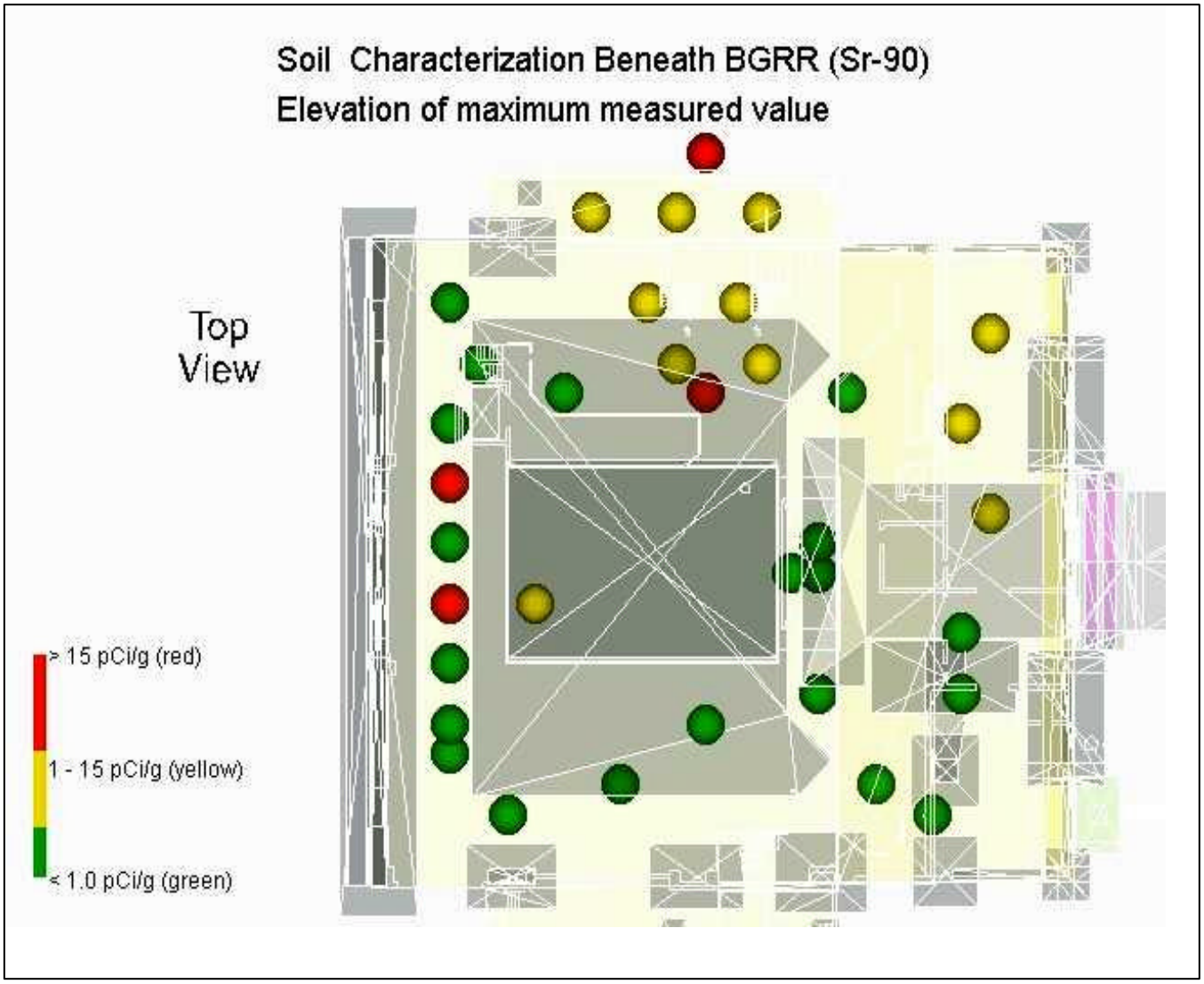


Figure 2-11. Sr-90 Contamination Below Building 701

Table 2-9. Summary Radiological Data for Soils Below 701/702

	Cs-137 (ISOCS ®) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Notes
U13DS -05 (35'-40')	92.2	108.0	ND	0.17	ND	0.20	0.011	0.065	0.27	0.65	0.97	0.26	0.16	0.14	
U13DS -06 (40'-44')	29.5	31.2	0.02	0.114	ND	0.071	0.011	0.093	0.44	43.5	30.9	0.01	ND	ND	
U13DS -07 (44'-48')	ND	0.252	0.001	0.121	0.008	0.06	0.005	ND	0.26	2.21	1.42	ND	0.06	0.045	
T14DS -01 (35'-39')	321	405.0	0.125	0.29	0.013	0.16	0.013	ND	0.37	47.2	103	ND	ND	0.04	
T14DS -02 (37'-39')	ND	0.77	0.011	0.171	0.006	0.22	ND	0.016	0.34	0.68	0.89	0.02	0.07	0.043	
T14DS -03 (39'-41')	ND	14.6	0.015	0.19	0.014	0.15	ND	0.008	0.45	9.2	6.4	0.02	ND	ND	
W12DS -12 (38'-40')	ND	ND	ND	0.095	ND	0.095	0.024	0.012	0.26	1.38	0.86	0.03	0.10	0.011	
W12DS -13/14 (40'-44')	ND	66.0	ND	0.038	ND	0.16	0.033	ND	0.21	40.7	22.3	ND	ND	0.09	
W12DS -15 (44'-46')	ND	ND	0.014	0.15	ND	0.18	0.02	ND	0.26	22.1	14.1	ND	ND	ND	
W14DS -01 (21'-22')	0.1	0.221	ND	0.115	0.064	0.17	0.024	ND	0.40	3.38	0.37	0.17	0.08	0.071	
W14DS -02 (22'-23')	ND	0.212	ND	0.25	ND	0.13	ND	0.004	0.30	0.93	0.29	0.08	ND	ND	
W14DS -03 (23'-24')	ND	0.065	ND	0.20	0.012	0.25	ND	ND	0.40	0.60	0.72	0.04	ND	0.104	
W15DS -01 (21'-22')	0.3	0.335	0.0004	0.22	0.003	0.20	ND	ND	0.64	1.43	0.21	ND	0.17	ND	Th-232 0.316 pCi/g
W15DS -02 (22'-23')	1.6	1.74	0.02	0.18	0.009	0.23	ND	0.052	0.27	1.75	0.61	ND	0.08	0.014	
W15DS -03 (23'-24')	.04	.31	ND	0.095	ND	0.112	0.009	ND	0.28	1.82	0.45	0.27	ND	0.003	

Table 2-9. Summary Radiological Data for Soils Below 701/702 (Cont.)

	Cs-137 (ISOCS) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Notes
O5DS-01/02 (4'-8')	14.6	16.3	0.003	0.65	0.07	0.50	0.026	0.02	0.83	5.20	3.97	ND	0.17	0.16	Th-232 0.89 pCi/g
Q5DS-01 (4'-4.5')	17,726	10,800.0	1.88	0.37	0.055	0.54	0.005	6.10	1.87	892.0	1020.0	1.3	2.4	ND	
Q5DS-02 (4.5'-5.0)	1307	820.0	0.136	0.39	0.015	0.22	0.005	0.51	0.58	241.0	208.0	0.29	0.21	0.37	
Q5DS-03 (5'-5.5')	438	235.0	0.056	0.44	ND	0.29	0.056	0.134	0.69	93.0	98.0	ND	ND	ND	
M5DS-01 (4'-4.5')	686	716.0	0.061	0.29	0.003	0.25	ND	0.134	0.55	182.0	131.0	ND	ND	ND	
M5DS-02 (4.5'-5')	324	374.0	ND	0.26	0.04	0.22	0.032	0.073	0.70	110.0	115.0	ND	ND	ND	
M5DS-03 (5'-5.5')	38.7	87.0	0.035	0.19	ND	0.089	0.003	0.028	0.39	34.5	22.5	ND	0.02	0.08	
M5DS-04 (5.5'-6')	18.1	13.0	ND	0.24	0.044	0.24	0.024	0.012	0.35	5.95	4.7	ND	0.03	ND	
N17DS-01 (34.75'-35.5')	53.9	64.4	0.009	0.14	ND	0.12	ND	0.24	0.27		60.0	0.31	0.37	ND	
N17DS-01A (36'-38')	3.6	2.9	ND	0.3	0.19	0.45	ND	.07	0.38		46.1	0.24	ND	0.04	
N17DS-02 (38'-40')	ND	0.072	0.024	0.30	ND	0.14	ND	ND	0.37		1.57	ND	0.12	ND	
N17DS-03 (40'-42')	0.2	ND	ND	0.29	0.016	0.21	0.035	1.22	0.38		ND	ND	0.02	0.032	
N17DS-04 (42'-44')	0.1	ND	0.007	0.16	0.009	0.15	ND	0.19	0.18		0.04	0.14	0.21	0.006	
T19DS-16 (30'-32')	ND	ND	0.19	0.18	ND	0.092	ND	ND	0.14	0.32	0.17	ND	ND	0.048	
T19DS-18 (34'-36')	ND	ND	0.01	0.149	0.006	0.108	0.022	0.011	0.08	0.59	ND	0.23	ND	0.002	
T19DS-20 (38'-40')	0.1	ND	ND	0.35	0.043	0.33	0.016	ND	0.20	0.28	0.11	0.35	ND	0.142	
T19DS-22 (42'-44')	ND	0.004	ND	0.123	ND	0.21	ND	ND	0.17	0.14	ND	ND	ND	0.007	

Table 2-9. Summary Radiological Data for Soils Below 701/702 (Cont.)

	Cs-137 (ISOCS) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Notes
N18DS -01 (36'-38')	ND	0.007	0.028	0.23	0.025	0.083	0.06	0.011	0.16	0.37	0.10	0.004	ND	0.044	
N18DS -02 (38'-40')	ND	ND	ND	0.045	ND	0.18	ND	0.008	0.08	0.19	ND	ND	0.20	ND	
N18DS -03/04 (40'-44')	ND	0.016	ND	0.19	ND	0.17	ND	ND	0.08	0.19	0.04	ND	0.14	0.073	
N18DS -05/06 (44'-48')	ND	0.015	ND	0.24	ND	0.17	ND	ND	0.19	0.31	ND	ND	0.27	0.05	
N18DS -07 (48'-50')	ND	ND	ND	0.087	0.024	0.18	ND	ND	0.13	0.39	0.21	ND	ND	ND	
N18DS -08 950'-52')	ND	0.018	0.02	0.079	ND	0.138	ND	ND	0.08	0.26	0.14	ND	ND	0.007	
O18BDS-01/02 (36'-40')	ND	ND	ND	0.19	0.058	0.16	0.07	0.02	0.14	ND	3.5	0.12	ND	0.065	
O18BDS-01A (34.5')	1.4	5.72	0.01	0.43	ND	0.26	ND	0.66	0.39		0.60	ND	0.47	0.083	
U16DS -01 (36'-38')	ND	0.96	0.015	0.26	0.014	0.27	0.010	0.123	0.37	1.61	1.22	0.24	ND	0.0002	
O18BDS-01B (34.5')	1.3	0.59	0.003	0.141	ND	0.27	0.022	ND	0.34		0.23	ND	ND	0.047	
P24ADS-05/06 (24'28')	ND	0.022	ND	0.19	ND	0.22	0.002	0.005	0.22	0.33	0.28	ND	ND	0.035	
P24ADS-07/08 (28'-32')	ND	ND	ND	0.21	ND	0.25	0.013	ND	0.18	1.98	0.14	0.16	ND	0.055	
P24ADS-10 (34'-36')	ND	0.015	0.017	0.105	ND	0.09	ND	0.019	0.16	0.06	0.31	0.24	ND	0.047	
P24BDS -03/04 (28'-32')	ND	0.034	0.06	0.36	0.037	0.25	0.004	0.008	0.42		0.09	ND	ND	0.03	
P24BDS -05 (32'-34')	ND	0.01	ND	0.32	0.048	0.27	0.66	0.009	0.29		0.001	ND	ND	0.069	
P24BDS -06 (34'-36')	0.1	ND	ND	0.21	0.017	0.21	0.046	0.019	0.67		3.9	0.23	ND	0.1	

Table 2-9. Summary Radiological Data for Soils Below 701/702 (Cont.)

	Cs-137 (ISOCS) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Notes
M8DS -02 (29'-31')	ND	ND	ND	0.07	ND	0.16	0.018	0.005	0.20	0.50	ND	0.36	0.17	ND	
M8DS -03 (31'-33')	ND	ND	0.09	0.11	ND	0.13	0.047	1.24	0.22	0.46	0.06	0.29	0.13	ND	
M8DS -04 (33'-35')	ND	0.091	ND	0.08	0.021	0.21	ND	0.005	0.26	0.39	ND	0.33	0.01	0.074	
M8DS -08 (41'-43')	ND	0.19	0.91	0.14	0.024	0.21	ND	0.03	0.14	0.46	0.48	0.16	0.13	ND	
M8DS -09/10 (43'-47')	0.3	0.37	0.029	0.31	ND	0.22	0.038	0.065	0.006	0.48	0.30	0.15	0.18	0.038	
BB14DS-01 (3'-4')	19.3	16.4	0.005	0.16	0.0	0.146	0.01	5.0	0.12	-	24.9	0.004	ND	ND	
BB14DS-02 (4'-5')	21.8	19.4	0.009	0.14	0.052	0.14	0.08	5.2	0.31	-	23.8	ND	0.04	0.09	
BB14DS-03 (5'-6')	4.0	3.21	ND	0.092	0.023	0.091	ND	0.90	0.27	-	4.9	0.20	ND	ND	
BB14DS-04 (6'-7")	121	103.0	ND	0.44	0.015	0.43	0.21	29.6	0.22	-	186	ND	ND	ND	
BB14DS-05 (7'-8')	28.2	23.0	ND	0.24	ND	0.27	0.10	9.7	0.27	-	148	ND	ND	ND	

2.3.3 Drains, Associated Lines and Discharge Points

The following sections describe the activities completed to characterize the building drains. A summary table of radiological results is at the end of this section. Full analytical results are in Appendices A, B, and C. Refer to Figure 2-2 for drain locations. Survey and smear results are in Appendix E

Locations 33 and 34, East and West Intake Plenum Floor Drains - The inlet filters were removed and the access to the intake plenums sealed during previous stabilization activities. For the characterization of the plenums and drains, the steel covers were removed and a radiological survey was performed. Initial surveys of the plenum indicated the presence of loose contamination therefore the plenum was vacuumed prior to sampling the drains. Twenty smears were obtained from each plenum and they indicated beta radioactivity above MDA, but below Radiological Surface Contamination Criteria as established in BNL FS-SOP-1001, Contamination Survey Techniques. No smears indicated alpha activity above MDA and general area dose rates ranged from five microRoengten per hour (µR/hr) to 200 µR/hr. The area beyond the drains was not entered because of the potential for significant loose contamination and higher dose rates from the pile.

The plenums are in excellent physical condition and there is no evidence of any water intrusion. Photograph 2-10 shows the plenum drain at the bottom of the slope and photograph 2-11 shows the area downstream of the drains where the plenum splits into two smaller ducts that supply air to the north and south halves of the pile. Both drains were remotely inspected via video camera and the dry wells were located approximately eight feet below the plenum floor. Water was found in both drains. This was not expected due to the plenums being sealed and no evidence of leakage detected. The conceptual model developed to explain the presence of water in the plenum dry well has several components. First, while coring through the main floor of Building 701 it was observed that the soil settled several inches beneath the concrete. Secondly, it is believed that water gets beneath the building by traveling along the underground components like the below-ground ducts and intake plenums. Lastly, the *Decommissioning Engineering Studies for the Brookhaven Graphite Research Reactor, Brookhaven National Laboratory Structural Stability Study* (B&R 2002) states that the soil beneath the concrete foundation has undergone densification. The result of these conditions is that a pathway exists for water to get into the soil beneath the building and most likely accumulate in areas of less compaction. Off-site laboratory analysis detected 458 pCi/g of Cs-137, 5.17 pCi/g of Co-60, and 1570 pCi/g of Sr-90 in the west plenum drain. The analysis of the east plenum drain sample detected 442 pCi/g of Cs-137, 2.4 pCi/g of Co-60, and 1890 pCi/g of Sr-90. After surveying and sampling was completed, the plenum cover plates were reinstalled and sealed.

Photograph 2-10. Intake Air Plenum Floor Drain

Photograph 2-11. Intake Air Plenum

Location 35, Freight Elevator - The drain was dry and free of excessive corrosion and/or debris thus a grab sample was not obtained. A GM beta/gamma probe attached to an ESP-2 was lowered into the drain and no indication above background was observed. Two smears were obtained and both indicate less than MDA for both alpha and beta activity. The drain was visually inspected with a remote camera to locate the drain end point. The end of the drain was found approximately eight feet below the 110-foot elevation and the soil was dry and compacted thus preventing the collection of a soil sample.

Location 36, Northeast Emergency Shower Drain - The drain was covered with a steel plate that was removed for survey and sampling. Fifteen smears were taken on the cover plate and within the drain line. The smear results indicated less than MDA for both alpha and beta activity. ISOCS® analysis of sediment present in the drain line indicated Cs-137 at 955 pCi/g. Off-site analysis detected U-233/234 at 30.9 pCi/g and a summary of the radiological data is presented in Table 2-10. This drain line previously exited Building 701 and terminates in the Building 801 F Tank Room. The piping section outside of Building 701 was removed and capped during the canal project and is no longer in service.

Location 37, Northeast Sink Drain - The drain line was capped above floor level. The cap was removed and there was insufficient sediment to collect a sample. A GM beta/gamma probe attached to an ESP-2 was lowered approximately 10 inches into the drain and no indication above background was observed. Two smears were obtained within the line and both indicated less than MDA for alpha and beta activity. Facility design drawings indicate that the outlet piping for this line was capped during construction and the drain was never placed into service.

Location 38, East Intake Filter House Floor Drains - Residue samples were obtained from the floor drains within the east intake structure and consolidated. ISOCS® analysis indicated Cs-137 at 81.5 pCi/g. Off-site analysis detected Sr-90 at 56 pCi/g and a summary of the radiological data is presented in Table 2-10. A GM pancake probe attached to a Ludlum Model 3 was lowered approximately 10 inches into each of the four drains within the intake structure. The two floor drains on the north end indicated between 400 and 1000 counts per minute (cpm) above background. The two drains on the south end indicated 100 cpm above background. A GM beta/gamma probe attached to an ESP-2 was lowered into the drain located within the reactor building (110-foot elevation) to a level of approximately 18 inches and no indication above background was observed.

Location 39, East Control Rod Drive Mechanism Floor Drain - A small amount of residue was collected from the drain under the east control rod drive mechanism and ISCOS® analysis indicated Cs-137 at 28.2 pCi/g. A GM pancake probe attached to a Ludlum Model 3 was lowered into the drain to a level of approximately eight inches and no indication above background was observed. Although Cs-137 was identified within the drain line residue, the two smears that were obtained within the drain line indicated less than MDA for both alpha and beta activity.

Location 40, Upper Elevations Equipment Drains - The two drains were inspected and there was insufficient sediment to collect for analysis. A GM beta/gamma probe attached to an ESP-2 was lowered into each drain to a level of approximately 18 inches and no indication above background was observed. One smear was obtained within each drain line and both indicated less than MDA for both alpha and beta activity.

Location 41, Charging Elevator Drain - Particle contamination was located in the elevator pit near the floor drain opening. Adequate corrosion/residue was available for a sample and ISOCS® results indicated Cs-137 at 78.8 pCi/gm. Off-site analysis detected 136 pCi/g of Sr-90. A GM pancake probe attached to a Ludlum Model 3 was lowered into the drain to a level of approximately six inches. Although particle contamination existed on the surfaces surrounding the drain opening, no indication above background was observed as the probe was lowered into the drain line. Two smears were obtained within the drain pipe and an additional two smears were obtained on the surface immediately adjacent to the drain. Three of the four smears indicated beta radioactivity above MDA but below 10 CFR 835, Appendix D, Surface Contamination Values. No smears indicated alpha activity above MDA.

Location 42, Passenger Elevator Drain - A debris sample was obtained and ISOCS® results indicated Cs-137 at 35.9 pCi/g. A GM beta/gamma probe attached to an ESP-2 was lowered into the drain approximately 12 inches and no indication above background was observed. Two smears were obtained within the drain line and both indicated less than MDA for alpha and beta activity.

Location 43, Machine Shop Floor Drains - There were eight floor/equipment drains identified within the machine shop. Four of the eight were accessible and a composite debris sample was obtained. ISOCS® results indicated Cs-137 at 8.7 pCi/gm. A GM beta/gamma probe attached to an ESP-2 was lowered into each of the four drain lines approximately 8 inches. There was no indication above background within any of the four drain locations. Twelve smears were obtained within the drain lines and all indicated less than MDA for alpha and beta activity.

Location 44, Receiving Room Drains - Both drain locations within the receiving room were inaccessible. The north equipment drain header had been refit to accommodate the modified roof drain system. The south drain was designed to receive overpressurization overflow from the fire main header and steam condensate traps. Liquids from these systems were evaluated and no contamination was detected. The characterization results of the building systems is reported in Report BGRR-054, *Characterization Report for Building 701 Above Ground Surfaces, Systems, and Structures* (BNL 2002).

Location 45, Fuel Vault Floor and West Control Rod Drive Mechanism Drains - Adequate scrapings were collected from within the west control rod drive mechanism and the fuel vault floor drains and ISOCS® results indicated 1.9 pCi/g Cs-137. Interference from radioactive materials within the fuel vault area precluded using a portable detector for scanning the drain. The west control rod drive mechanism drain was evaluated using an ESP-2 and no readings exceeding background were observed. Two smears were obtained within the west control rod drive mechanism and one was obtained within the fuel vault drain and all indicated less than MDA for alpha and beta activity. The drain line terminates in a dry well south of Building 701. The drain line and dry well were visually inspected remotely and additional sample locations were added through and around the dry well. No contamination was detected in or near the dry well and these results are in Section 3.0 of this report.

Location 46, West Intake Filter House Floor Drains - A sediment sample was obtained from the floor drains within the west intake structure and ISOCS® results indicated 28.2 pCi/g. A Ludlum

Model 3 with a GM pancake probe was lowered approximately 10 inches into each of the four drains within the intake structure and there was no indication above background. A smear was obtained from within each of the four intake drains and they all indicated less than MDA for alpha and beta activity. The drain line terminates in a dry well west of Building 701. The dry well was located and remotely inspected. Soil samples were collected through and below the dry well and no contamination was detected.

Location 47, Northwest Emergency Shower Drain - Insufficient sediment was available for a sample. An ESP-2 with a GM beta/gamma probe was lowered into the drain approximately 10 inches and no indication above background was observed. Three smears were obtained within the drain line and they all indicated less than MDA for alpha and beta activity.

Canal Walkway Floor Drain - As part of the supplemental investigation of the canal, a debris sample was obtained from the canal walkway floor drain. This system of drains terminates in the highly contaminated walkway sump and significant contamination was expected. High levels of Cs-137 (42,400 pCi/g), Am-241 (278 pCi/g), Pu-239/240 (4,400 pCi/g), and Sr-90 (56,000 pCi/g) were detected.

Table 2-10. Summary Radiological Data for Building 701 Drains

	Cs-137 (ISOCS ®) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Am-241 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Th-234 pCi/g
Pile Gutter Drain (Sample 1)	176.0	206.0	60.0	1.05	0.40	0.44	0.023	3.90	ND	97.2	42.7	ND	158	8.4	0.05	ND
Pile Gutter Drain (Sample 2)	512.0	192.0	48.1	1.51	0.10	0.65	0.056	4.19	0.25	-	56.0	ND	106.0	4.2	0.43	ND
Machine Shop Drain	16.7	41.7	0.038	1.84	0.16	1.65	0.015	2.36	0.28	35.0	36.9	ND	0.38	ND	0.04	ND
Northeast Emergency Shower Drain	955.0	692.0	1.12	30.9	1.42	2.41	0.011	2.22	0.44	16.4	12.5	ND	ND	0.17	0.46	ND
Charging Elevator Drain	78.8	80.0	0.63	0.50	0.048	0.50	0.033	1.41	1.68	193	136.0	ND	0.17	ND	0.07	ND
Passenger Elevator Drain	35.9	49.9	0.40	0.65	0.023	0.52	ND	1.29	ND	16.0	21.5	ND	ND	ND	0.07	ND
West Intake Filter Facility Drain	28.2	21.2	0.045	0.45	ND	0.26	0.50	0.87	ND	5.07	0.19	ND	0.40	0.05	ND	ND
East Intake Filter Facility Drain	81.5	93.0	0.19	2.17	0.11	1.99	0.18	13.9	0.01	52.5	56.0	0.56	0.31	0.06	0.12	ND
West Intake Plenum Floor Drain	394.0	458.0	5.17	0.17	ND	0.1	0.005	0.47	0.12	-	1570.0	ND	0.2	ND	0.08	ND
East Intake Plenum Floor Drain	639.0	442.0	2.40	0.23	ND	0.31	0.069	0.74	0.43	-	1890.0	ND	0.9	ND	ND	ND
East Control Rod Drive Mechanism Drain	28.2	33.8	0.14	0.45	0.016	0.46	0.015	2.26	0.10	45.9	41.8	ND	0.25	0.03	ND	ND
Fuel Vault Drain	1.9	2.8	0.083	17.3	0.74	13.5	0.022	0.37	0.40	2.47	2.54	0.25	0.05	ND	0.05	14.2
Canal Walkway Floor Drain	3,117.0	42,400.0	37.9	210.0	28.0	23.0	150.0	4,400	18.0	-	56,000	278.0	ND	ND	29.0	ND

2.3.4 Secondary Air System

As part of the preparations for characterizing the below-ground ducts, an entry was made into the secondary air inlet vault. A radiological survey was performed on the vault and the seven secondary air lines that are within the vault. Thirty smears were obtained and several indicated beta radioactivity above MDA but below release levels. No smears indicated alpha activity above MDA. It was necessary to remove a section of the secondary air supply line to the North Duct during the below-ground duct characterization. The line was removed, surveyed, and released as clean.

2.3.5 Groundwater

Previous groundwater investigations performed as part of the Operable Unit (OU) III Remedial Investigation identified a plume of Sr-90 groundwater contamination in the vicinity of the Waste Concentration Facility and the BGRR. The previous groundwater investigation associated with the BGRR was conducted between 1995 and 1997 and samples collected from both monitoring wells and Geoprobes®. The detailed results of this groundwater investigation are presented in the OU III Remedial Investigation Report dated March 1, 1999. The results of the OU III groundwater investigation indicated a Sr-90 groundwater plume down gradient from the BGRR, Waste Concentration Facility, and pile fan sump area, see Figure 2-12. The highest Sr-90 concentration detected in 1997, down gradient from the BGRR, was 53.9 picoCuries per liter (pCi/l). Permanent monitoring well 75-201 was installed at this location.

While the BGRR was believed to be a contributor to the Sr-90 groundwater contamination, the precise source within the BGRR complex was not identified. The below-ground ducts and canal were considered as potential sources and twenty-six groundwater samples were obtained in 2001 as part of the below-ground duct investigation and twenty-seven samples were obtained during the remaining soils and Building 701 characterization.

Monitoring well (75-201), located approximately 100 feet down gradient from the below-ground ducts (See Figure 2-13) had shown an increase in Sr-90 concentration from 7.58 pCi/l in November 2000 to 29.7 pCi/l in November 2001. The most recent sample obtained in April 2002 found that the level of Sr-90 had dropped to 2.55 pCi/l indicating that the plume is either very small or shifted away from that permanent well. Figure 2-14 shows the Sr-90 plume contours for the BGRR and Waste Concentration Facility area based upon calendar year 2000 monitoring well data. Figure 2-14 shows the BGRR Sr-90 plume prior to receiving the 2.55 pCi/l analysis results and includes all the Sr-90 results obtained during the below-ground duct characterization. The Sr-90 groundwater contamination at the BGRR/ Waste Concentration Facility and pile fan sump area are currently monitored with a network of 58 monitoring wells.

This section addresses the groundwater samples taken from below Building 701/702 and the remaining soils area west of the facility. The groundwater investigation consisted of 27 samples taken at 26 Geoprobe® boring locations. The Geoprobe® borings were advanced to 70 feet below grade and non-filtered water samples were collected. At Location 30, through the north plenum, water samples were taken at 70 feet and 80 feet below grade. Figure 2-15 shows the groundwater sample locations in relation to the below-ground ducts and Building 701.

Two samples taken from location 30, below the north plenum, exceeded the 8 pCi/L limit for Sr-90. The sample taken at the 40' elevation indicates 12.5 pCi/L and the sample taken at the 30' elevation indicates 12.3 pCi/L. All of the other samples taken during this characterization project indicated radionuclide concentrations below the DOE 5400.5, EPA 40 CFR 141, NYSDEC Title 6, or New York State Department of Health (NYSDOH) Title 10 limits. Table 2-11 summarizes the analytical results and complete off-site laboratory analytical results are in Appendix B. Because none of the samples obtained from below Building 701 have high levels of Sr-90 it can be surmised that the high levels of Sr-90 identified during the below-ground duct characterization were caused by the contaminated water leakage from the ducts.

All of the groundwater data obtained during this characterization effort will be integrated with the groundwater monitoring data collected by the Environmental Management Groundwater Group into one document. This integrated data will be used during the preparation of the Sr-90 Pre-Design Characterization Work Plan and will be submitted to DOE in July 2003.

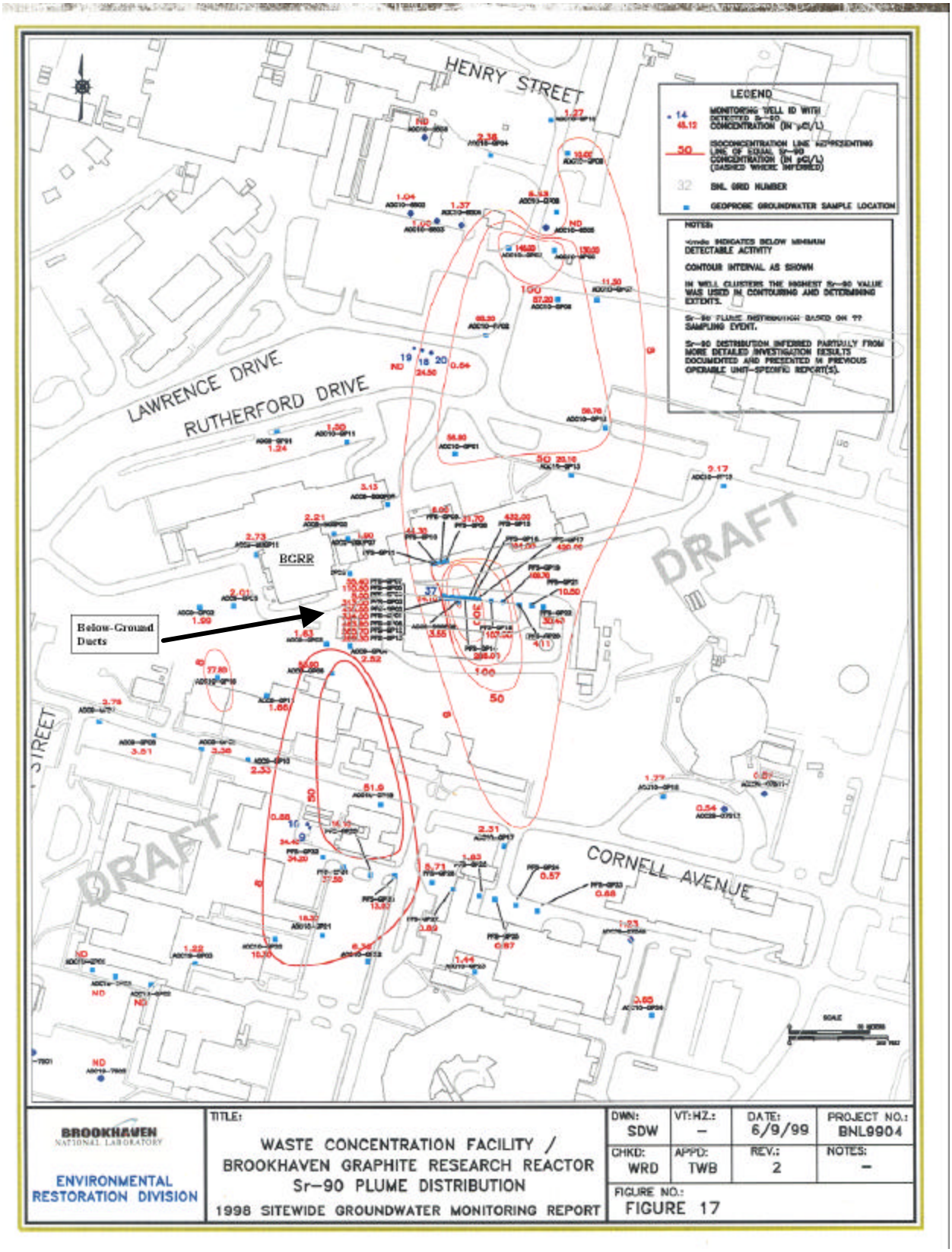


Figure 2-12. 1998 Sitewide Groundwater Monitoring Report, Strontium-90 Plume

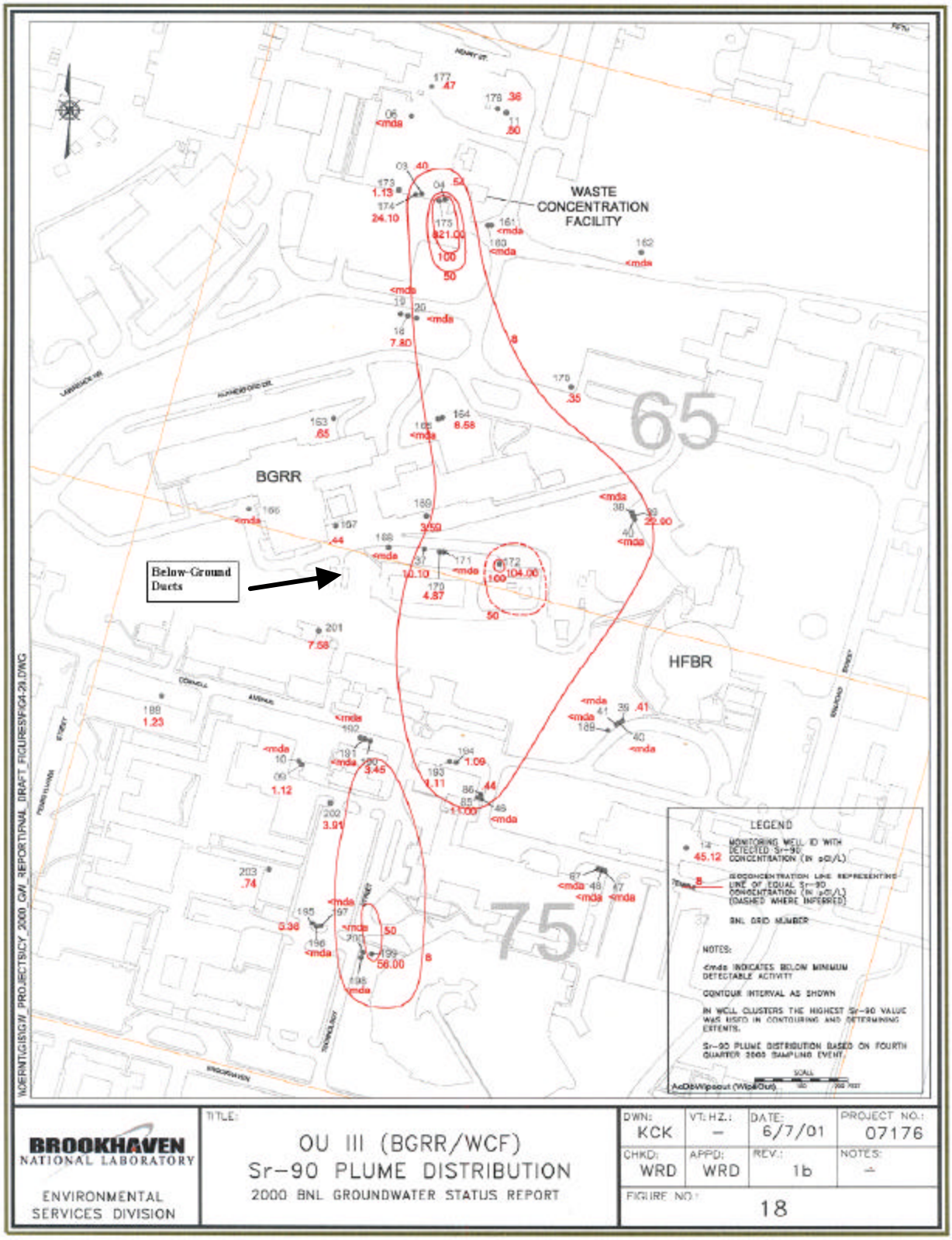


Figure 2-13. 2000 BNL Groundwater Status Report, Strontium-90 Plume

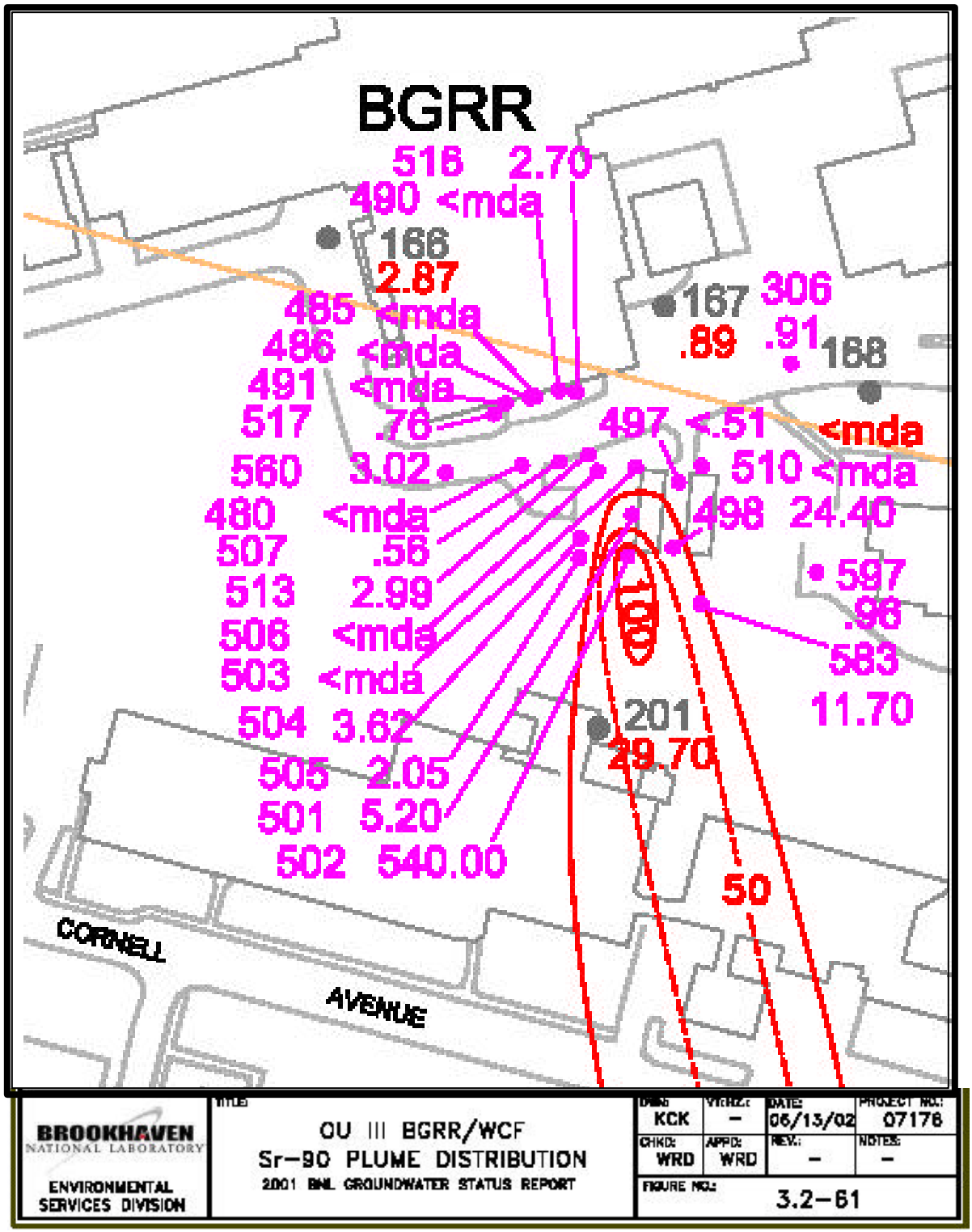


Figure 2-14. 2001 BNL Groundwater Status Report, BGRR Strontium-90 Plume

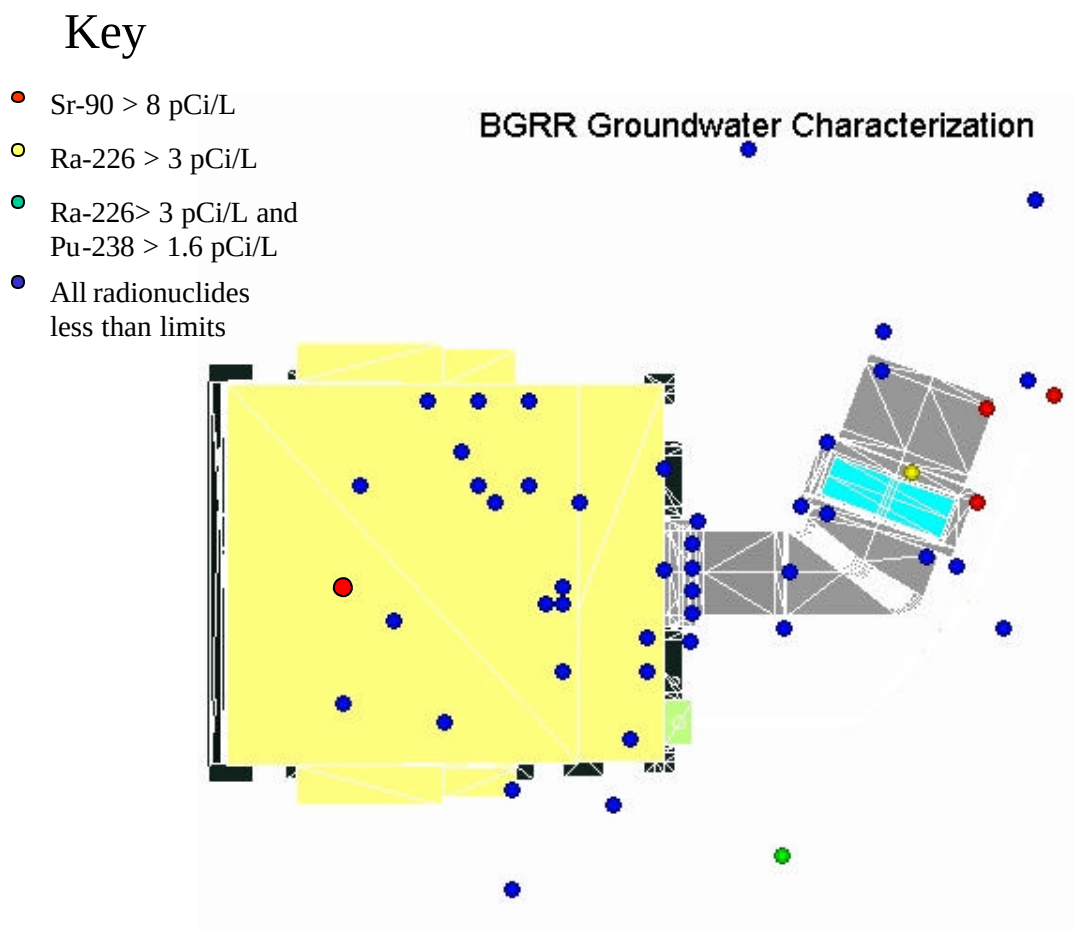


Figure 2-15. BGRR Groundwater Sample Locations

Table 2-11. Summary Radiological Data for BGRR Groundwater Samples

Grid	Cs-137 pCi/L	Co-60 pCi/L	U-233/234 pCi/L	U-235 pCi/L	U-238 pCi/L	Pu-238 pCi/L	Pu-239/240 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Sr-90 pCi/L	Eu-152 pCi/L	Eu-154 pCi/L	Eu-155 pCi/L
RSH6	8.3 (note 1)	2.8 (note 1)	0.52	ND	0.60	0.022	ND	0.57	0.59	ND	8.0 (note 1)	89.0 (note 1)	6.0 (note 1)
RSJ12	ND	ND	0.35	0.032	0.40	ND	ND	0.78	0.94	0.35	20.0 (note 1)	23.0 (note 1)	ND
RSK6	8.2 (note 1)	0.2	0.11	ND	0.06	ND	ND	0.071	1.02	0.54	0.6	35.0 (note 1)	ND
RSK8	ND	7.6 (note 1)	0.60	0.15	0.60	ND	0.026	1.93	3.05	1.24	ND	14.0 (note 1)	4.0 (note 1)
Z16	ND	ND	0.63	0.36	0.65	0.03	0.015	0.96	1.80	0.60	ND	ND	ND
V24	ND	5.1 (note 1)	0.67	0.17	0.56	ND	ND	2.0	4.18	3.02	9.0 (note 1)	ND	3.0
P24	0.1	4.1 (note 1)	0.29	0.15	0.39	ND	0.07	0.191	1.49	1.5	8.0 (note 1)	ND	8.0 (note 1)
Z13	ND	ND	0.14	ND	0.20	ND	ND	0.53	1.28	0.20	32.0 (note 1)	41.0 (note 1)	6.0 (note 1)
Z10	ND	2.5 (note 1)	0.34	ND	0.076	ND	ND	0.63	2.10	0.55	1.0	ND	8.0 (note 1)
G11	1.9 (note 1)	ND	0.35	0.09	0.43	ND	0.021	0.85	1.34	0.77	ND	ND	3.0
U13	ND	ND	0.54	ND	0.57	ND	ND	0.83	2.08	0.62	ND	ND	ND
L23	ND	ND	0.63	0.09	0.74	0.0	0.0	1.88	3.06	1.33	ND	ND	ND
J18	ND	(note 1)	0.20	ND	0.38	ND	ND	1.05	2.01	0.96	ND	13.0 (note 1)	10.0 (note 1)

Table 2-11. Summary Radiological Data for BGRR Groundwater Samples (Cont.)

Grid	Cs-137 pCi/L	Co-60 pCi/L	U-233/234 pCi/L	U-235 pCi/L	U-238 pCi/L	Pu-238 pCi/L	Pu-239/240 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Sr-90 pCi/L	Eu-152 pCi/L	Eu-154 pCi/L	Eu-155 pCi/L
O18	ND	ND	0.53	0.05	0.60	0.02	0.014	1.90	2.42	0.33	ND	ND	7.0 (note 1)
M8-01 (elevation 40')	1.7 (note 1)	ND	0.27	0.08	0.50	0.04	0.015	1.29	3.8	12.5	ND	ND	ND
M8-02 (elevation 30')	4.0 (note 1)	6.3 (note 1)	0.37	0.012	0.27	0.02	ND	1.90	2.01	12.3	32	ND	2 (note 1)
N17	ND	ND	0.48	0.09	0.12	0.016	0.021	0.12	2.37	0.89	0.28	ND	ND
U16	4.1 (note 1)	ND	0.40	0.006	0.52	ND	ND	1.02	1.43	0.94	ND	24.0 (note 1)	8.0 (note 1)
T14	0.2	ND	0.89	0.18	0.57	ND	ND	0.63	1.37	0.84	ND	ND	1.0
W12	ND	5.0 (note 1)	0.41	0.045	0.64	ND	0.055	0.68	1.71	0.63	24.0 (note 1)	ND	ND
U6	ND	ND	0.31	0.021	0.21	ND	0.044	0.45	1.28	1.06	2.0	31.0 (note 1)	ND
J23	ND	0.04	0.18	ND	0.24	ND	0.05	0.61	0.98	1.06	ND	14 (note 1)	3 (note 1)
T19	1.1	2.7 (note 1)	0.58	ND	0.33	ND	0.010	1.76	2.46	0.99	ND	ND	ND
N18	ND	ND	1.04	0.05	0.83	ND	0.011	4.63	5.71	1.06	38 (note 1)	ND	ND
O5	2.4 (note 1)	4.8 (note 1)	0.48	0.083	0.86	0.11	0.051	3.23	3.34	3.0 (note 1)	17 (note 1)	ND	10 (note 1)
H5	ND	ND	0.25	ND	0.29	0.05	0.076	2.17	1.30	0.62	2 (note 1)	ND	15 (note 1)
F22	ND	6.2 (note 1)	0.47	0.08	0.22	ND	ND	2.49	3.42	1.94	27.0 (note 1)	ND	1.0

Note 1. MDC is greater than the reported result

2.3.5 Hazardous Analysis

The hazardous material that could be present at the BGRR is diverse. Hazardous materials exist in past construction materials, insulating materials, paints, and system components. As such, material samples must be collected much in the same way as radiological samples to adequately characterize a facility. The soils and groundwater were characterized in accordance with the organic and inorganic Contaminants of Potential Concern (COPC) provided in the Tables 1-4 and 1-5 presented in Section 1.0 of this report. The following is a summary of the hazardous material assessment. A complete listing of the hazardous analysis results is contained in Appendix C.

Soil beneath Building 701

A total of four deep soil samples were analyzed for inorganic metals, volatile organic compounds (VOCs), semi-VOCs, and polychlorinated biphenyls (PCBs). The sample obtained from the pipe trench, Grid Q5, has elevated levels of calcium and zinc and the sample taken from below the deep pit, Grid T14, has elevated levels of cobalt, silver, and thallium. Tables 2-12 through 2-15 provide a summary of the non-radioactive contaminants detected in the soils.

Building 701 Drains

A total of eleven building drain samples were analyzed for inorganic metals, VOCs, semi-VOCs, and PCBs. Multiple drains have elevated levels of contaminants. Tables 2-16 through 2-19 provide a summary of the non-radioactive contaminants detected in the building drains.

Groundwater

Six groundwater samples were analyzed for COPCs, including inorganic metals, VOCs, semi-VOCs, and PCBs.

The samples were screened for 25 metals of which 19 had detectable concentrations. The metals that exceeded MCLs with their highest detection were: aluminum (31,200 micrograms per liter [µg/l]), chromium (197 µg/l), iron (55,700 µg/l), lead (46.6 µg/l), manganese (1750, and sodium (30,900 µg/l). Five of the 6 metals that exceeded groundwater MCLs had their highest detection at the location beneath the deep pit, Grid T14.

Seven VOCs had detectable concentrations with none exceeding the limits. There was no detectable concentration of semi-VOCs or PCBs in any of the groundwater samples taken during the characterization of the remaining soils and below Building 701. Tables 2-20 and 2-21 provide a summary of the inorganic metals and VOCs detected.

Table 2-12. Summary of Metals Detected in Soils beneath Building 701

Analyte	Number Of Samples	Number of Detects	Clean-up Action Limit TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Aluminum	4	4	16,491	2180	N	Q5DS-01 (4'-4.5')	185	N	O18BDS-01 (36'-40')	
Antimony	4	0	13.1			Q5DS-01 (4'-4.5')	ND		Multiple	
Arsenic	4	4	7.5	.96	B	Q5DS-01 (4'-4.5')	.17	B	T14DS-01 (35'-39')	
Barium	4	4	300	18.2	B	Q5DS-01 (4'-4.5')	3.4	B	O18BDS-01 (36'-40')	
Beryllium	4	3	0.43	.12	B	Q5DS-01 (4'-4.5')	ND		O18BDS-01 (36'-40')	
Cadmium	4	1	1.5	1.3		Q5DS-01 (4'-4.5')	ND		Multiple	
Calcium	4	4	434	**5040**		Q5DS-01 (4'-4.5')	82.4		O18BDS-01 (36'-40')	1
Chromium	4	4	14.2	6.9		T14DS-01 (35'-39')	.45		O18BDS-01 (36'-40')	
Cobalt	4	4	30	**106**	N	T14DS-01 (35'-39')	.84	B	U16DS-01 (35'-39')	1
Copper	4	4	25	25.7		Q5DS-01 (4'-4.5')	2.9	B	O18BDS-01 (36'-40')	
Chromium VI	4	0	14.2			Q5DS-01 (4'-4.5')	ND		Multiple	
Cyanide	4	0	N/A*			Q5DS-01 (4'-4.5')	ND		Multiple	
Iron	4	4	14429	5540	N	Q5DS-01 (4'-4.5')	1080	N	O18BDS-01 (36'-40')	
Lead	4	4	400	60.8	N	Q5DS-01 (4'-4.5')	1.0	J	O18BDS-01 (36'-40')	
Magnesium	4	4	2122	662		Q5DS-01 (4'-4.5')	66.7	B	O18BDS-01 (36'-40')	
Manganese	4	4	148	102	N	Q5DS-01 (4'-4.5')	10.4	B	O18BDS-01 (36'-40')	
Mercury	4	2	1.84	.27		Q5DS-01 (4'-4.5')	ND		Multiple	
Nickel	4	3	13	4.0	B	Q5DS-01 (4'-4.5')	ND		O18BDS-01 (36'-40')	
Potassium	4	4	628	252	B	Q5DS-01 (4'-4.5')	119	B	O18BDS-01 (36'-40')	
Selenium	4	2	2	.41	B	Q5DS-01 (4'-4.5')	ND		Multiple	
Silver	4	1	2	**11.3**	N	T14DS-01 (35'-39')	ND		Multiple	1
Sodium	4	3	196	50.9	B	U16DS-01 (35'-39')	ND		O18BDS-01 (36'-40')	
Thallium	4	1	0.35	**.5**	B	T14DS-01 (35'-39')	ND		Multiple	1
Vanadium	4	4	150	5.4		Q5DS-01 (4'-4.5')	3.3		O18BDS-01 (36'-40')	
Zinc	4	4	22.4	**108**		Q5DS-01 (4'-4.5')	2.9		O18BDS-01 (36'-40')	1

* Not Available - Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable.

Table 2-13. Summary of Volatiles Detected in Soils beneath Building 701

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Dichloromethane (Meth Chl)	75-092	4	3	0.1	0.0039	J,B	T14DS-01 (35'-39')	ND		Q5DS-01 (4'-4.5')	
2-Propanone (Acetone)	67-64-1	4	2	0.2	0.02	J,B	T14DS-01 (35'-39')	ND		Multiple	
Toluene	108-88-3	4	31	1.5	0.00098	J,B	T14DS-01 (35'-39')	ND		Multiple	

Table 2-14. Summary of Semi-Volatiles Detected in Soils beneath Building 701

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Fluoranthene	206-44-0	4	1	50	.180	J	Q5DS-01 (4'-4.5')	ND		Multiple	
Pyrene	129-00-0	4	1	50	.140	J	Q5DS-01 (4'-4.5')	ND		Multiple	
Chrysene	218-01-9	4	1	0.4	.110	J	Q5DS-01 (4'-4.5')	ND		Multiple	
Bis(2-ethylhexyl)phtalate	117-81-7	4	1	50	1.1		T14DS-01 (35'-39')	ND		Multiple	
Di-n-butylphthalate	84-74-2	4	1	8.1	.140	J	Q5DS-01 (4'-4.5')	ND		Multiple	

Table 2-15. Summary of PCBs Detected in Soils beneath Building 701

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Total PCBs	1336-36-3			1.0 Surface 10.0 Subsurface							
PCB-1260	11096-82-5	4	1	NL	0.140		Q5DS-01 (4'-4.5')	ND		MULTIPLE	

Table 2-16. Summary of Metals Detected in Building 701 Drains

Analyte	Number Of Samples	Number of Detects	Clean-up Action Limit TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Aluminum	11	11	16,491	**35,800**	N	P23	155	B,N	V10	1
Antimony	11	11	13.1	**3240**	N	M7	3.0	N	T17	4
Arsenic	11	11	7.5	**148**		V10	3.8		T17	8
Barium	11	10	300	**421**		P23	ND		V10	3
Beryllium	11	4	0.43	**2.1**	B	P23	ND		Multiple	1
Cadmium	11	9	1.5	**307**	N,E	M7	ND		Multiple	9
Calcium	11	11	434	**104,000**	N	H23	2010		W8	11
Chromium	11	11	14.2	**1450**	N	P23	22.1	N	T17	11
Cobalt	11	11	30	**49.7**	B	V10	5.4		T17	4
Copper	11	11	25	**7900**	N	P23	250		Q17	11
Chromium VI	11	0	14.2				ND		Multiple	
Cyanide	11	9	N/A*	1.0		H10	ND		Multiple	
Iron	11	11	14429	**487,000**	N	H10	25,900	N	T17	11
Lead	11	11	400	**10,000**	N	P23	6514	J	V10	8
Magnesium	11	10	2122	**24,000**		H23	ND		V10	6
Manganese	11	11	148	**2460**	N	M7	255	N	T17	11
Mercury	11	11	1.84	**169**	N	P23	.039		H10	5
Nickel	11	11	13	**823**	N	P23	14.1	N	T17	11
Potassium	11	10	628	**12,600**		H10	ND		M7	9
Selenium	11	11	2	**18.7**		M7	.67		T17	9
Silver	11	3	2	**61.3**	N	P23	ND		Multiple	3
Sodium	11	11	196	**118,000**		W8	259	B,N	M7	11
Thallium	11	10	0.35	**64.2**		W8	ND		P20	10
Vanadium	11	11	150	149		V10	8.5	N	T17	
Zinc	11	11	22.4	**41,500**	N	P23	90.4	N	H10	11

* Not Available - Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable.

Table 2-17. Summary of Volatiles Detected in Building 701 Drains

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Dichloromethane(Meth Chl)	75-092	11	11	0.1	.0097	B	Q17	.0014	J,B	RSL5	
2-Propanone (Acetone)	67-64-1	11	6	0.2	**.72**	B	P20	ND		Multiple	1
Benzene	71-43-2	11	1	0.06	**.016**		P23	ND		Multiple	1
Toluene	108-88-3	11	11	1.5	.016		W8	.0018	J	RSL5	
2-Butanone	79-93-3	11	3	0.3	**.64**	E	P20	ND		Multiple	1
2-Hexanone	591-78-6	11	1	NL	1.2	E	P23	ND		Multiple	
4-Methyl-2-pentanone	108-10-1	11	2	1	.045	J	P20	ND		Multiple	

Table 2-18. Summary of Semi-Volatiles Detected in Building 701 Drains

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Diethyl phthalate	84-66-2	11	1	7.1	.160	J	W8	ND		Multiple	
Phenanthrene	85-01-8	11	4	50	.59	J,D	Y11	ND		Multiple	
Anthracene	120-12-7	11	1	50	.099	J	RSL5	ND		Multiple	
Fluoranthene	206-44-0	11	3	50	.8	J,D	Y11	ND		Multiple	
Pyrene	129-00-0	11	2	50	.95		RSL5	ND		Multiple	
Benzo(a)anthracene	56-55-3	11	1	.224 or MDL	**.25**	J	RSL5	ND		Multiple	1
Chrysene	218-01-9	11	4	0.4	**16**	J,D	T17	ND		Multiple	2
Bis(2-ethylhexyl)phtalate	117-81-7	11	9	50	**160**	D	T17	ND		Multiple	2
Benzo(b)fluoranthene	205-99-2	11	2	1.1	.36	J	RSL5	ND		Multiple	
Benzo(k)fluoranthene	207-08-9	11	1	1.1	.38		RSL5	ND		Multiple	
Benzo(a)pyrene	50-32-8	11	2	.061 or MDL	**.26**	J	RSL5	ND		Multiple	2
4-methylphenol	106-44-5	11	2	0.9	.14	J	W8	ND		Multiple	
Pentachlorophenol	87-86-5	11	1	1.0 or MDL	.67	J	W8	ND		Multiple	
Di-n-buttylphthalate	84-74-2	11	6	8.1	**40**	D	P20	ND		Multiple	3
Butylbenzylphthalate	85-68-7	11	8	50	43	D	T17	ND		Multiple	
N-Nitrosodiphenylamine	86-30-6	11	1	NL	.32	J	Q17	ND		Multiple	

Table 2-19. Summary of PCBs Detected in Building 701 Drains

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Total PCBs	1336-36-3			1.0 Surface 10. Subsurface							
PCB-1254	11097-69-1	11	7	NL	**79**		T17	ND		Multiple	2
PCB-1260	11096-82-5	11	1	NL	.074		V10	ND		Multiple	

Table 2-20. Summary of Volatiles Detected in Groundwater Associated with Building 701

Analyte	Chemical abstract services number (CAS#)	EPA/DEC MCLs mg/l	Number of Samples	Number of Detects	Maximum Concentration (mg/l)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/l)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Chloromethane	74-87-3		6		1.2	J	O18	ND		Multiple	
Dichloromethane (Meth Chloride)	75-09-2	5/5	6		5.2	B	T14	ND		Multiple	
2-Propanone (Acetone)	67-64-1	50	6		9.7	J,B	RSK6	ND		Multiple	
1,1-Dichloroethane	75-34-3	5/5	6		.69	J	T14	ND		Multiple	
Chloroform	67-66-3	100/7	6		3.2	J	RSH6	ND		Multiple	
1,1,1-Trichloroethane	71-55-6	200/5	6		1.3	J	T14	ND		Multiple	
Toluene	108-88-3	1,000/5	6		.48	J,B	T14	ND		Multiple	

Table 2-21. Summary of Metals Detected in Groundwater Associated with Building 701

Analyte	EPA MCLS µg/l	NYSDEC MCLS µg/l	Number of Samples	Number of Detects	Maximum Concentration (µg/l)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (µg/l)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Aluminum	200	100	6		**31,200**		O18	957		T14	5
Antimony	6	3	6					ND		Multiple	
Arsenic	50	25	6		144		O18	ND		Multiple	
Barium	2,000	1,000	6		269		O18	32.5	B	RSK6	
Beryllium	4	3	6		65	B	O18	ND		Multiple	
Cadmium	5	5	6					ND		Multiple	
Calcium			6		22,200		T14	7930		RSH6	
Chromium	100	50	6		**197**		RSJ12	18.9		T14	3
Cobalt			6		23.7	B	O18	ND		Multiple	
Copper	1300	200	6		45.1	B	O18	10.3	B	RSK6	
Chromium VI			6							Multiple	
Cyanide	200	200	6							Multiple	
Iron	300	300	6		**55,700**		O18	3080	N	T14	5
Lead	15	25	6		**46.6**		O18	ND		RSK6	1
Magnesium		35000	6		**11,100**	B	RSJ12	3540	B	RSK6	1
Manganese		300	6		1750		O18	83.5		T14	
Mercury	2	0.7	6		.064	B	RSJ12	ND		Multiple	
Nickel	100	100	6		97.4		RSJ12	18.2		RSK6	
Potassium			6		8510	B	O18	2080	B	RSK6	
Selenium	50	10	6		22	B	T14	ND		Multiple	
Silver	100	50	6					ND		Multiple	
Sodium		20,000	6		**30,900**		T14	14,000		RSH6	3
Thallium	2	.5	6					ND		Multiple	
Vanadium			6		101		O18	3.3	B	RSK6	
Zinc	5000	2000	6		274		RSH6	16.2	B	T14	

3.0 BUILDING 702 - REACTOR PILE CHARACTERIZATION

3.1. Pile Description

The Pile was a heterogeneous, enriched, uranium-fueled graphite-moderated and reflected, thermal neutron, air-cooled research facility. The reactor consists of a 25-foot graphite cube weighing approximately 700 tons, built in two halves separated by a vertical gap running east and west. Filtered cooling air was brought into the gap and flowed through the individual channels removing heat from the fuel and the graphite. Fuel elements were charged and discharged through the south face by means of suitable openings in the shielding which matched the graphite channel openings. In the south face, unused fuel channels could be used for experimental irradiation purposes. Reactor operations were controlled by the position of 16 control rods that penetrate the reactor horizontally in directions parallel to the diagonals of the reactor base.

The shape of the core was a horizontal octagonal prism, 9 feet on a side by 16 feet 7 inches long in the north-south direction. In the core region, there are 613 fuel channels of 2.67-inch diameter by 16 feet 7 inches effective length, symmetrically arranged on eight-inch centers in square array. The moderator is 255 tons of graphite formed in four-inch by four-inch machined blocks of varying lengths. The reflector is 445 tons of graphite. The graphite is built up of 75 layers of blocks four inches by four inches of various lengths up to 45 inches long, laid horizontally.

There are a total of 1,368 fuel channels that run north–south, 30 experimental ports that run east-west, removable shield plugs on the top of the reactor along with two scanner slots on the south side, and one scanner slot on the north side. The scanner slots are open to the exit air-cooling areas between the biological shield wall and the graphite pile steel shroud and were used for observing fuel handling via periscopes and they. The underside of the pile has an animal tunnel and an instrument tunnel that traverses the pile in the east-west directions.

Five grades of graphite were used during the construction of the pile. The reactor cube is divided into four concentric zones, A, B, C, and D. The best graphite, the graphite with the longest diffusion length, was used in the center.

Tabulation of the graphite zones:

Zone	Weight in pounds
AA (grade)	13,060
A	179,820
B	170,390
C	147,105
D	953,175
Total	1,463,550 pounds

The density of graphite is 140 pounds per cubic foot; the stacking density range is from 98 to 120 pounds per cubic foot.

3.2 Historical Review of the Pile and Biological Shield

The reactor was designed for 32 megawatts, with a design-operating limit of 28 megawatts. The reactor normally operated at approximately 20 megawatts. The facility operated from 1950 to 1969. Between 1969 and 1972, the graphite was annealed, the control rods were inserted, their drives were cut and the rods were capped at the external steel plate of the biological shield wall, the fuel was removed and disposed of off site, and the pile was closed.

A pile negative pressure system has been operating for several years. The system consists of a high-efficiency particulate air (HEPA) filter installed on the pile in the east air intake to keep a slightly negative pressure on the pile by using a fan operating at approximately 3000 cubic feet per minute (cfm). The system draws air in reverse to the normal primary cooling airflow of the pile. Since installation, the only time positive pressure has been detected on the HEPA filter system is when there has been intrusive work being performed in the air flow path.

It was expected that materials within the biological shield wall are highly contaminated and/or activated as a result of reactor operations.

The initial fueling utilized aluminum fuel elements that were 11 feet long and contained 33 natural uranium fuel slugs each. During the operation with the natural uranium fuel, there were 28 fuel failures. These fuel failures have been recorded and the fuel channels identified. In 1958, the natural uranium fuel was replaced with enriched uranium fuel that was clad with aluminum. Each enriched fuel element was 24 inches long.

3.3 The Biological Shielding Description

The protective shield is made of high-density concrete containing scrap iron and limonite, a mineral with a high content of water hydration, which completely surrounds the graphite. The concrete is rated at 350 pounds per cubic foot and is four feet, three inches thick on four sides plus the top. The shielding weighs approximately 5,000 tons.

The overall dimension of the pile with the shielding is 55 feet long north and south, by 37 feet 6 inches wide east and west, and 33 feet 7 inches high. The biological shielding extends from elevation 106 feet 9 inches (three feet three inches below the main floor elevation of 110 feet) to elevation 140 feet 4 inches.

Proceeding from the graphite outward, the shield consists of six inches of steel plate (in some places it is two separate plates), four feet three inches of high-density concrete, and an outer casing of three inches of steel plate. The six inches of steel plate is supplemented with a band of 12 inches thick by 20 inches wide steel girdling the graphite around the gap.

The east and west faces of the graphite are covered with a close-fitting membrane of quarter-inch steel, and the top face is covered with eighth-inch aluminum plate that provides a seal between the inlet air and the seams in the graphite. Three-inch thick steel plates cover the north and south faces.

The top of the biological shield contains an area of 20 square feet that contains removable shield plugs for experimental purposes. The shield is penetrated by a number of openings that were required either for loading or unloading the fuel elements (south plenum wall) or for experimental purposes (primarily in the east and west faces). The penetrations in the pile align with the penetrations in the biological shield wall.

3.4 Historical Review of the Biological Shielding

The penetrations in the biological shield were sealed in 2000.

All of the equipment has been removed from the biological shield wall including the cooling water lines on the west side at the lower experimental penetrations. The Chemo-Nuclear Loop experiment piping and lines are the only remaining lines in place near the biological shield wall on the southwest side.

3.5 Survey Areas of the Pile and Associated Equipment

The majority of the pile characterization was completed during July and August 2000. This report contains the survey and characterization data that was collected then and also the additional data that was collected to completely characterize the pile, biological shield, and associated equipment. Tables 3-1, 3-2, and 3-3 are taken from the SAP and they summarize the survey and sampling associated with the pile and associated equipment characterization.

3.5.1 South Face

The graphite pile, a 25-foot cube, was designed for optimal operation in a symmetrical configuration. This is demonstrated in the placement of the octagon fuel loading of 613 channels of the 1,368 channels that penetrate the graphite and the placement of the 16 control rods that diagonally cross the fuel, eight from the southeast corner and eight from the southwest corners of the pile. Additionally, the fuel that was loaded into the north half of the pile was loaded from the south face with the same spacing being maintained north and south along the octagon fuel loading channels. The core shape is described as a horizontal octagonal prism.

There were 28 fuel failures affecting 26 fuel channels during the operation of the reactor. These failed fuel channels were characterized, including the north and south halves of the pile.

3.5.2 North Face

The north face of the pile contains channel holes too small to insert characterization equipment. Therefore all channel characterization was performed from the south face.

There are eleven pneumatic transfer tubes, and six of these tubes were characterized along with the irradiation port D-0-8.

3.5.3 West and East Faces

There are 30 experimental ports that run east and west through the pile. Each experimental port is four inches by four inches. Experimental port #30 runs through the gap between the north and south halves of the pile. The experimental ports are arranged in a square matrix 16 feet on a side. Eighteen of the 30 experimental ports were characterized from the east to west or west to east through the length of the pile.

There are eight instrumentation ports, four on the west side and four on the east side. One instrumentation port was characterized on each side of the pile.

3.5.4 Bottom of Pile

There are two tunnels, the animal tunnel and the instrument tunnel, which traverse beneath the pile from east to west, below the 110-foot floor elevation. Both of these tunnels were characterized.

3.5.5 Graphite Sampling

Four different purity grades and amounts of graphite were used to construct the pile, and a fifth grade was used to manufacture the graphite plugs. Each type of graphite was placed into the pile symmetrically from the purest graphite in the center to the least pure on the outside areas of the cube. Each of the purity grades of graphite will be sampled. There were eight samples, two for each grade, taken and analyzed. Also, one sample of the graphite plugs was sampled and analyzed.

3.5.6 Biological Shield Components

There were eight core bores made through the biological shield wall at the locations described in Table 3-3. The locations were chosen to obtain representative samples from areas exposed to both high and low levels of neutron flux.

Table 3-1. Pile Characterization Summary

Face	Description	Number to be characterized	Total number available	%
South	Failed fuel channels	26	26	100
South	Fuel and non-fuel channels, symmetrical	49	1,342	4
North	Pneumatic transfer tubes	6	11	55
North	Irradiation port	1	1	100
East & west	Experimental ports	18	30	60
East & west	Instrumentation ports	2	8	25
Bottom of pile	Animal tunnel	1	1	100
Bottom of pile	Instrument tunnel	1	1	100
Graphite samples	Four types of graphite	9	-	N/A
Biological shield wall	Core bore	8	-	N/A
Steel inside biological shield	Drilling sample	8	-	N/A
Biological shield Wall	Penetrations	83	1,398	6
Between biological shield wall and pile	Debris	As designated	-	N/A
In-pile area	Debris	As designated	-	N/A
Southeast corner	Control rod	1	8	13
Southwest corner	Control rod	1	8	13

Table 3-2. Radiological Characterization of Pile Channels and Openings
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SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma	Internal Contact	Direct Contamination	Beta Correction Factor	Removable Contamination (Smears)		
		Dose Rate	Beta Dose Rate	Measurement Gross Beta	From TLD Step 5.3	Gross Beta	Gross Alpha	Gamma
	S A-1-0 FFC	a,b	a,b	a,b		c	c	c
	S A-1-1 FFC	a,b	a,b	a,b		c	c	c
	S A-1-3 FFC	a,b	a,b	a,b		c	c	c
	S A-2-4 FFC	a,b	a,b	a,b		c	c	c
	S A-3-1 FFC	a,b	a,b	a,b		c	c	c
	S A-3-3 FFC	a,b	a,b	a,b		c	c	c
	S A-3-4 FFC	a,b	a,b	a,b		c	c	c
	S A-5-2 FFC	n/a	n/a	n/a		c	c	c
	S B-0-5 FFC	a,b	a,b	a,b		c	c	c
	S B-2-5 FFC	a,b	a,b	a,b		c	c	c
	S B-3-5 FFC	a,b	a,b	a,b		c	c	c
	S B-5-5 FFC	a,b	a,b	a,b		c	c	c
	S B-6-5 FFC	a,b	a,b	a,b		c	c	c
	S C-1-0 FFC	a,b	a,b	a,b		c	c	c
	S D-0-3 FFC	a,b	a,b	a,b	d	c	c	c
	S D-1-1 FFC	a,b	a,b	a,b				
	S B-0-1 FFC	a,b	a,b	a,b		c	c	c
	S C-4-13 FC	a,b	a,b	a,b		c	c	c
	S D-5-7 FC	a,b	a,b	a,b		c	c	c
	S B-11-14 NFC	a,b	a,b	a,b		c	c	c
	S C-6-14 NFC	a,b	a,b	a,b				
	S D-13-13 NFC	a,b	a,b	a,b		c	c	c

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma	Internal Contact	Direct Contamination	Beta Correction Factor	Removable Contamination (Smears)		
		Dose Rate	Beta Dose Rate	Measurement Gross Beta	From TLD Step 5.3	Gross Beta	Gross Alpha	Gamma
	S C-4-14 NFC	a,b	a,b	a,b				
	S B-17-7 NFC	a,b	a,b	a,b				
	S B-17-14NFC	a,b	a,b	a,b				
	S D-13-5 FC	a,b	a,b	a,b				
	S B-17-14 NFC	a,b	a,b	a,b		c	c	c
	S B-5-14 FC	a,b	a,b	a,b		c	c	c
	S A-2-14 FC	a,b	a,b	a,b		c	c	c
	S A-8-14 NFC	a,b	a,b	a,b		c	c	c
	S A-14-14 NFC	a,b	a,b	a,b		c	c	c
	S B-11-8 FC	a,b	a,b	a,b		c	c	c
	S B-5-8 FC	a,b	a,b	a,b		c	c	c
	S A-2-8 FC	a,b	a,b	a,b		c	c	c
	S A-8-8 FC	a,b	a,b	a,b		c	c	c
	S A-14-8 NFC	a,b	a,b	a,b		c	c	c
	S B-17-2 NFC	a,b	a,b	a,b		c	c	c
	S B-11-2 FC	a,b	a,b	a,b		c	c	c
	S B-5-2 FC	a,b	a,b	a,b		c	c	c
	S A-2-2 FC	a,b	a,b	a,b		c	c	c
	S A-8-2 FC	a,b	a,b	a,b		c	c	c
	S A-14-2 NFC	a,b	a,b	a,b		c	c	c
	S C-17-5 NFC	a,b	a,b	a,b		c	c	c
	S C-11-5 FC	a,b	a,b	a,b		c	c	c
	S C-5-5 FC	a,b	a,b	a,b		c	c	c
	S D-8-5 FC	a,b	a,b	a,b		c	c	c
	S D-13-5 NFC	a,b	a,b	a,b		c	c	c
	S D-2-5 FC	a,b	a,b	a,b		c	c	c

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma Dose Rate	Internal Contact Beta Dose Rate	Direct Contamination Measurement Gross Beta	Beta Correction Factor From TLD Step 5.3	Removable Contamination (Smears) Gross Beta	Gross Alpha	Gamma
	S C-17-11 NFC	a,b	a,b	a,b		c	c	c
	S C-11-11 NFC	a,b	a,b	a,b		c	c	c
	S C-5-11 FC	a,b	a,b	a,b		c	c	c
	S D-2-11 FC	a,b	a,b	a,b		c	c	c
	S D-8-11 FC	a,b	a,b	a,b		c	c	c
	S D-14-11 NFC	a,b	a,b	a,b		c	c	c
	S C-17-17 NFC	a,b	a,b	a,b		c	c	c
	S D-2-17 NFC	a,b	a,b	a,b		c	c	c
	S D-8-17 NFC	a,b	a,b	a,b		c	c	c
	S D-14-17 NFC	a,b	a,b	a,b		c	c	c
	S C-10-17 NFC	a,b	a,b	a,b		c	c	c
	S C-3-17 NFC	a,b	a,b	a,b		c	c	c
	Bio wall exp and instrument ports							
	110' W-12	a,b	a,b	a,b		c	c	c
	110' W-15	a,b	a,b	a,b		c	c	c
	110' W-16	a,b	a,b	a,b		c	c	c
	110' W-30	a,b	a,b	a,b		c	c	c
	116' W-31	a,b	a,b	a,b		c	c	c
	124' W-32	a,b	a,b	a,b		c	c	c
	116' W-36	a,b	a,b	a,b		c	c	c
	124' W-39	a,b	a,b	a,b		c	c	c
	123' W-42A	a,b	a,b	a,b		c	c	c
	123' W-42	a,b	a,b	a,b		c	c	c
	123' W-46	a,b	a,b	a,b	d	c	c	c
	127' W-51	a,b	a,b	a,b		c	c	c
	127' W-54	a,b	a,b	a,b		c	c	c

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma Dose Rate	Internal Contact Beta Dose Rate	Direct Contamination Measurement Gross Beta	Beta Correction Factor From TLD Step 5.3	Removable Contamination (Smears) Gross Beta	Gross Alpha	Gamma & Alpha Isotopic
	127' W-56	a,b	a,b	a,b		c	c	c
	110' E-26	a,b	a,b	a,b	d	c	c	c
	114' E-23	a,b	a,b	a,b		c	c	c
	114' E-24	a,b	a,b	a,b		c	c	c
	118' E-30	a,b	a,b	a,b	d	c	c	c
	110' I-2	a,b	a,b	a,b		c	c	c
	127' I-5	a,b	a,b	a,b		c	c	c
	110' W. Animal Transfer West lift gate	a,b	a,b	a,b		c	c	c
	110' W. Animal Transfer East Lift gate	a,b	a,b	a,b		c	c	c
	110' W. Instr. Transfer drive mechanism pit	a,b	a,b	a,b		c	c	c
	110' W. Instr. Transfer cart pit	a,b	a,b	a,b		c	c	c
	110' W. Instr. Transfer West lift gate	a,b	a,b	a,b		c	c	c
	110' W. Instr. Transfer East Lift gate	a,b	a,b	a,b		c	c	c
	Animal tunnel with access from the east side pit	a,b	a,b	a,b	d	c	c	c
	110' E. Animal Transfer drive mechanism pit	a,b	a,b	a,b		c	c	c
	110' E. Animal transfer cart pit	a,b	a,b	a,b		c	c	c
	110' E. Animal Transfer West lift gate	a,b	a,b	a,b		c	c	c
	110' E. Animal Transfer East Lift gate	a,b	a,b	a,b		c	c	c

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma	Internal Contact	Direct Contamination	Beta Correction Factor	Removable Contamination (Smears)		
		Dose Rate	Beta Dose Rate	Measurement / Gross Beta	From TLD Step 5.3	Gross Beta	Gross Alpha	Gamma & Alpha Isotopic
	Instrument tunnel access from the west side pit	a,b	a,b	a,b	d	c	c	c
	Pneumatic Tube PN 2	a	a	a		c	c	c
	Pneumatic Tube PN 3	a	a	a		c	c	c
	Pneumatic Tube PN 4	a	a	a		c	c	c
	Pneumatic Tube PN 5	a	a	a		c	c	c
	Pneumatic Tube PN 6	a	a	a		c	c	c
	Pneumatic Tube PN 8	a	a	a		c	c	c
	N B-4-5 FFC	a,b	a,b	a,b		c	c	c
	N C-1-1 FFC	a,b	a,b	a,b		c	c	c
	N C-3-3 FFC	a,b	a,b	a,b		c	c	c
	N C-4-0 FFC	a,b	a,b	a,b		c	c	c
	N B-2-7 FFC	a,b	a,b	a,b		c	c	c
	N D-8-3 FFC	a,b	a,b	a,b		c	c	c
	N D-9-1 FFC	a,b	a,b	a,b		c	c	c
	N D-10-3 FFC	a,b	a,b	a,b		c	c	c
	S D-0-8 FFC	a,b	a,b	a,b		c	c	c
	N A-8-4 FC	a,b	a,b	a,b		c	c	c
	N B-7-1 FC	a,b	a,b	a,b		c	c	c
	N C-4-10 FC	a,b	a,b	a,b	d	c	c	c
	N D-6-9 FC	a,b	a,b	a,b		c	c	c

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION						
Sample Number	Sample Location & Description*	Internal/ External Gamma Dose Rate	Internal Contact Beta Dose Rate	Direct Contamination Measurement Gross Beta	Beta Correction Factor From TLD Step 5.3	Removable Contamination (Smears) Gross Beta	Gross Alpha	Gamma
	N C-7-14 NFC	a,b	a,b	a,b		c	c	c
	N D-11-13 NFC	a,b	a,b	a,b		c	c	c
	S B-5-14 FC	a,b	a,b	a,b		c	c	c
	West Bank Top North Control Rod No. 1	a,b	a,b	a,b		c	c	c
	East Bank Top North Control Rod No.10	a,b	a,b	a,b		c	c	c

Notes for Table 3-2:

a. Take measurements along the channel of the biological shield wall every foot.
b. Take measurements at a maximum of one-foot intervals along the channel or port being characterized.
c. Perform analysis on composite of all smears/sediment/scrape samples taken in or along the channel, port, or control rod. If in the biological shield wall opening, take sample as close to the pile as possible. If in Pile, obtain graphite materials at the greatest radiological results.
d. Obtain TLD readings to obtain correction factor as follows:
   1) Insert TLDs into the designated survey area;
   2) Leave TLDs in area for an exposure period specified by the BGRR Environmental Safety, Health, and Quality (ESH&Q) Manager/designee
   3) After TLDs have been analyzed, the beta correction factor will be determined by the BGRR ESH&Q Manager/designee

x. Perform this activity as required

* FC = Fuel Channel

FFC = Failed Fuel Channel

NFC = Non-Fuel Channel

Table 3-3. Characterization of Graphite Samples and Biological Shield Core Bores

SAMPLE INFORMATION		RADIOLOGICAL CHARACTERIZATION				HAZARDOUS CHARACTERIZATION				
Sample Number	Sample Location & Description	Bulk Sample from Core Bore, Scraping or Sediment				Bulk Sample from Core Bore, Scraping or Sediment				
		Gross alpha, gross beta	Gamma Isotopic	Beta and x-ray	Other isotopic	TCLP	PH and flash point	Total PCBs	Reactive cyanide & react. sulfide	Other
	North Face Bio Shield near B3-3		a, f							
	North Face Bio Shield near C15-15		a							
	West Face Bio Shield near W 33		a							
	West Face Bio Shield near W 51		a							
	West Face Bio Shield north of W 16 (outside core)		a							
	East Face Bio Shield near E 25		a							
	East Face Bio Shield near E 30		a							
	Top of Bio Shield near core center		a							
	Steel and Alum inside No. Face Bio Shield near B3-3		a							
	Steel plate closest to pile inside North face Bio Shield near B3-3		a							
	Steel inside West Face Bio Shield near W 51		a							
	Steel inside East Face Bio Shield near E 30		a							
	Graphite Samples (d)									
	W-12-AA-1	x	x	x	x	x	x	x	x	
	W-32-B-2	x	x	x	x	x	x	x	x	
	W-32-C-3	x	x	x	x	x	x	x	x	
	W-32-D-4	x	x	x	x	x	x	x	x	
	W-35-A	x	x	x	x	x	x	x	x	
	W-35-B				e					e
	W-35-C				e					e
	W-35-D				e					e
	W-32-A				e					e

Notes for Table 3-3:

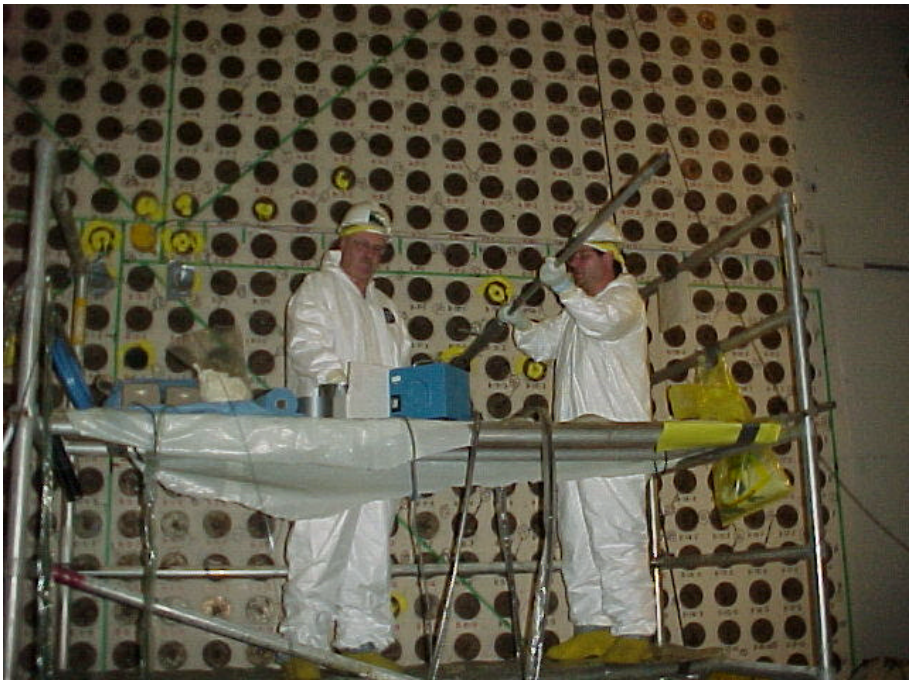
a. Gamma isotopic of concrete and/or metal drilling materials. Perform analysis for Fe-55, Ni-63, unless no Co-60 is detected in the gamma isotopic analysis.
b. Analyze for tritium, Tc-99, C-14, Ni-63, and Fe-55
c. Analyze for Th-232, Ra-226, I-129, Am-241, Isotopic Uranium, and Isotopic Plutonium
d. Collect graphite samples at areas of highest radiological results.
e. Perform additional analyses as necessary to comply with 10 CFR 61 requirements and disposal site requirements.
f. QC Analyses: A minimum of 5 percent of ISOCS® samples will be sent to independent laboratory for QC confirmation purposes.
x. Perform this activity as required.

3.6 Characterization Results

The radiological characterization results are addressed per survey area. Summary data tables are included in the following sections and complete survey and sample analytical results are included in Appendix F, "Fuel Channel Surveys", Appendix G, "Experimental and Instrumentation System Surveys", and Appendix H, "Pile and Biological Shield Components Off-Site Analysis".

3.6.1 North and South Penetrations Characterization

A total of seventy-five fuel channels, including the twenty-six where fuel failures occurred, were inspected and surveyed. The access to all the inspected fuel channels was performed from the south biological shield and the setup was established on the charging elevator. Photograph 3-1 shows the set-up and workers performing the video inspection of a fuel channel. Modular scaffolding was erected and used to reach the elevated fuel channels.



Photograph 3-1. Video Inspection of Fuel Channels

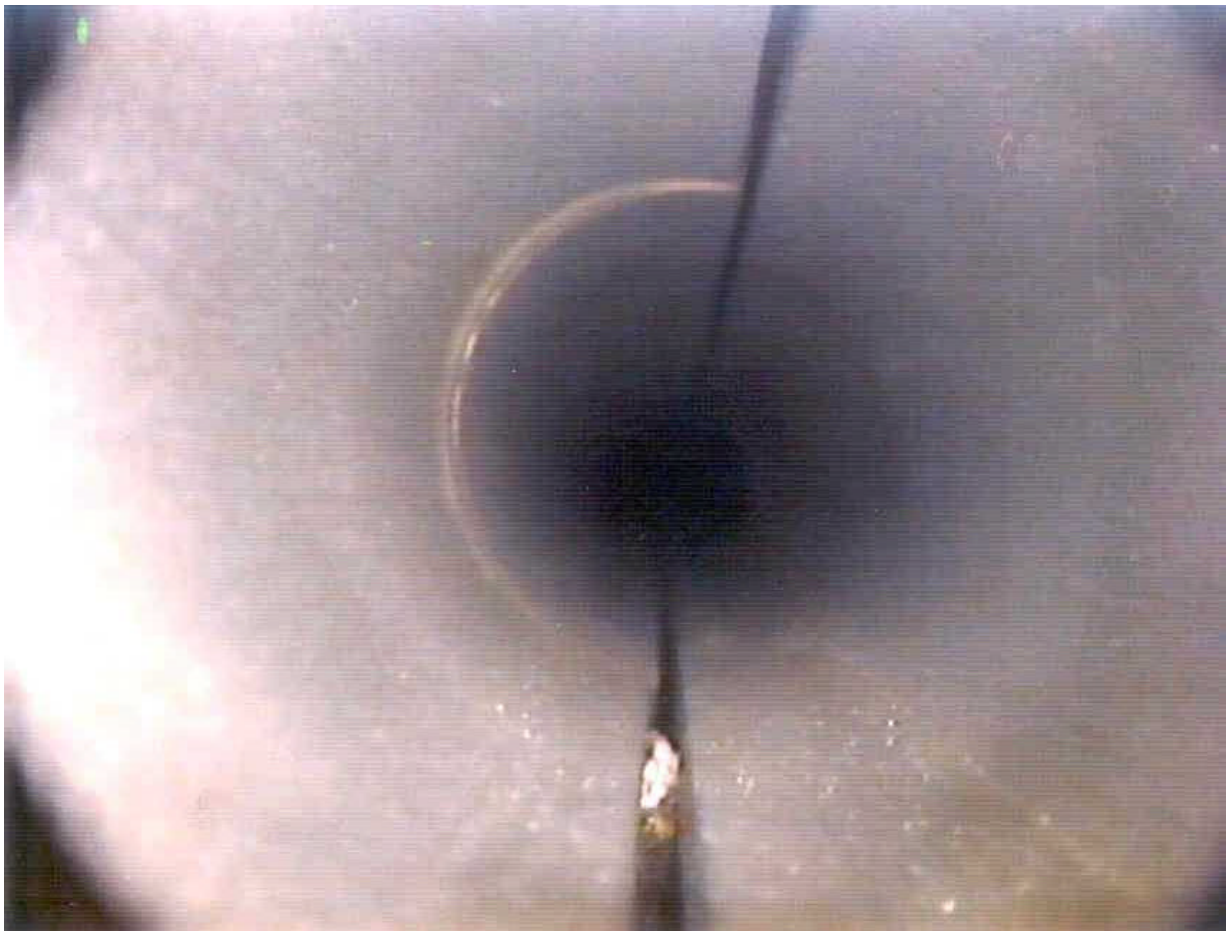
For each penetration, the steel cover plate was removed and the biological shield plugs were withdrawn. The two inner graphite plugs were removed with a long-reach extension. Then a twenty-foot bridge tube was inserted into the penetration to span the plenum gap. The internal three-inch steel plate supported the inner end of the bridge tube. The fuel channels were accessed by removing the fuel anchors that were installed after the last defueling. The non–fuel channels were accessed by removing the retaining clips, springs, and graphite plugs. Table 3-4 lists the ISOCS® results for a fuel anchor, two retaining springs, and several other components.

Table 3-4. Activity Concentration on Samples from Plenum Access - BGRR Graphite Pile Characterization
Gamma Spectrum Analysis with the ISOCS® Instrument

BGRR Pile Sample Identification	P-1a	P-2	P-3	P-4	P-5	P-6	P-7
Description	Fine graphite powder in 500 ml bottle West Control-Rod Drive Top Plate	Plug Retainer Spring, West side South Plenum	Plug Retainer Spring Scanner Slot #4 North Plenum	Graphite Plug Scanner Slot #4 North Plenum	Fuel Anchor Portion (Hot end only, in 1L bottle)	Thermocouple wire, folded in 1L bottle scanner slot #4 North Plenum	Particulate debris from removable core plate, sample and rust
Sample Mass	~ 1 g	136.5 g	71.6 g	316.5 g	45.1 g	31.6 g	25.9 g
ASTD Sample No	IG01253	IG01248	IG01251	IG01246	IG01247	IG01245	IG01254
Radionuclide	Activity Concentration (pCi/g)						
Am-241	ND [74,000]	ND [5,300]	ND [79,100]	ND [184]	ND [4,200]	ND [69,400]	2,900 ± 1,500 [2,380]
Cs-137	22,000,000 [51,000]	5,200 ± 800 [1,050]	7,800 ± 7,100 [11,800]	9,000 ± 820 [123]	7,600 ± 1,700 [2,470]	ND [7,670]	202,000 ± 18,000 [2,190]
Co-60	578,000 ± 29,600 [21,000]	230,000 ± 9,000 [763]	3,000,000 ± 120,000 [11,000]	1,370 ± 98 [115]	732,000 ± 29,000 [2,110]	2,800,000 ± 100,000 [5,530]	225,000 ± 9,000 [1,350]
Eu-152	ND [42,000]	ND [574]	ND [9,000]	270 ± 88 [170]	ND [2,240]	ND [5,330]	ND* [2,000]
Eu-154	ND [34,000]	ND [1,260]	ND [19,200]	ND [132]	ND [3,830]	ND [8,750]	ND [2,120]

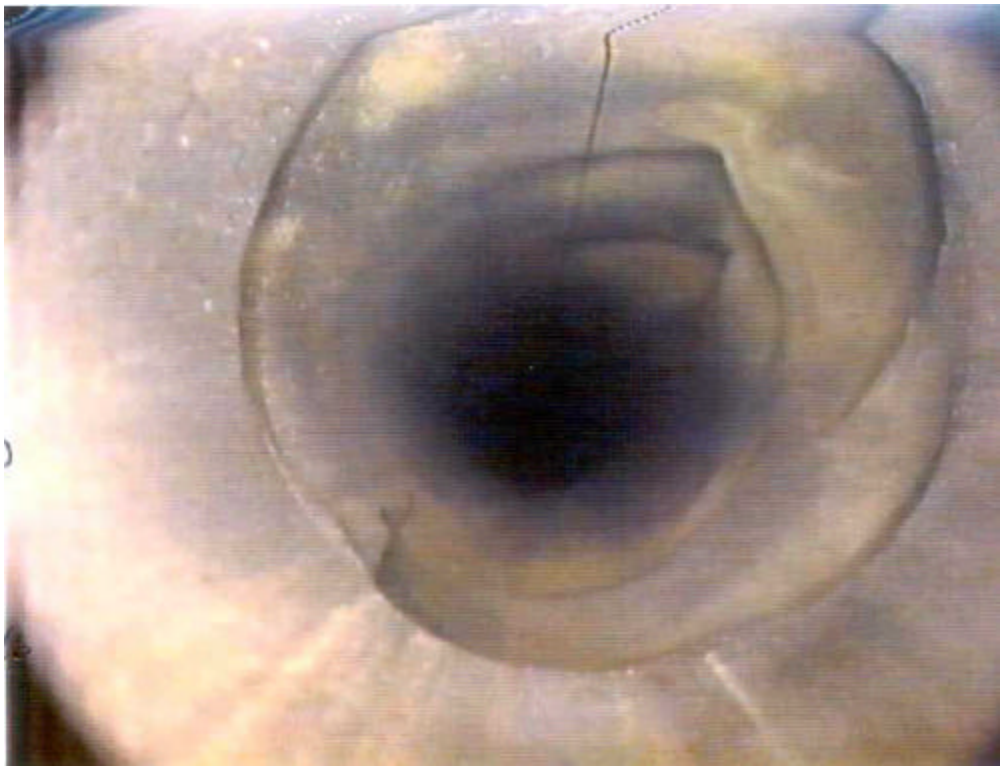
ND = Not Detected
* = Indications of the presence of the radionuclide at non-quantifiable levels near the MDA
[ ] = Minimum Detectable Concentration in pCi/g

The accessed fuel channels were video inspected for graphite abnormalities and to verify that nothing remained in the channels following the final defueling. Photograph 3-2 is from failed-fuel channel B-0-1. The separation of the two halves of graphite and a piece of debris can be clearly seen.

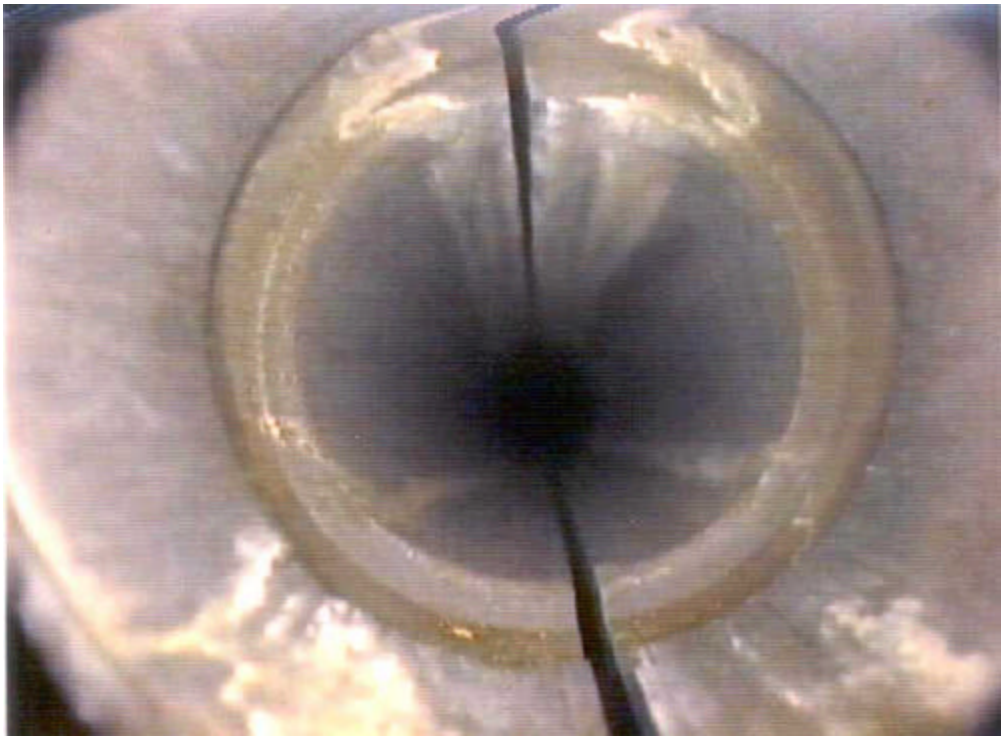


Photograph 3-2. Failed-Fuel Channel B-0-1

The following two photographs, 3-3 and 3-4, were taken from inside failed-fuel channel C-1-0. Overheating and deformity of the graphite as well as separation of the two halves is visible. The separation of the graphite probably allowed some fission products to fall into the experimental channels below the fuel channels.

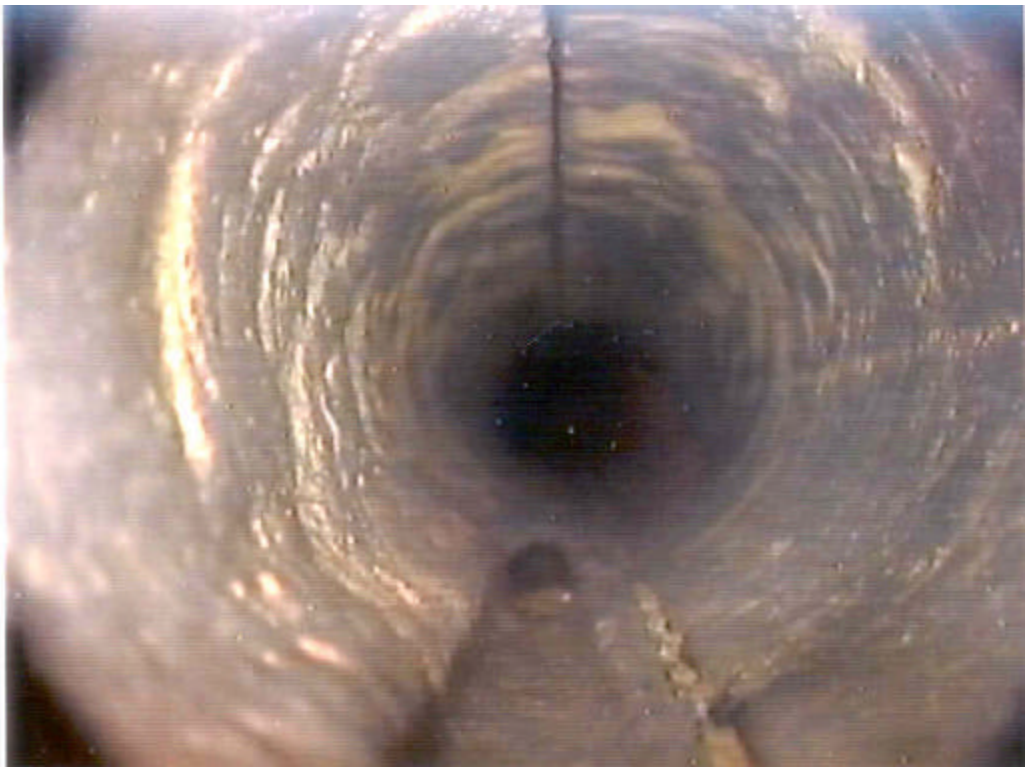


Photograph 3-3. Failed-Fuel Channel C-1-0 Deformity



Photograph 3-4. Failed-Fuel Channel C-1-0 Separation

The following photograph shows the effects of a fuel failure in channel B-4-5. The groove at the bottom of the channel was a result of having to drill out the failed fuel element that had become lodged in the channel.



Photograph 3-5. Fuel Channel B-4-5

Following the video inspection, radiological dose-rate profiles were recorded at one-foot intervals using beta-gamma instrumentation. The highest gamma dose rate was in channel B-4-5 at 9.74 roentgens per hour (R/hr). Dose-rate surveys for all the fuel channels were performed; smears were taken from areas with elevated dose-rate readings using a long-reach interlocking pole. Those results are also in Appendix F.

The following six visualizations were produced from the beta and gamma dose rate readings taken during the fuel channel surveys. Each colored dot represents a one-foot increment where the dose rates were recorded. Of particular note are the high dose rates at the bottom of the pile. These are probably the result of the twenty-eight failed fuel elements and the method of defueling the reactor. All fuel change-outs occurred on the south side of the pile. Therefore any failed fuel from the north side had to pass over the three-inch air gap that spanned the pile. This provided the opportunity for fission products to fall into the air gap and accumulate at the base of the pile. Analytical results for debris samples obtained in the north air plenum, Section 2.3.2 of this report, indicate high levels of Cs-137, Sr-90, Pu-239/240, Pu-238, Co-60, U-234, and U-235; it is expected that similar radionuclides are at the base of the Pile. See Figures 3-1 through 3-6 for gamma and beta profiles of the pile.

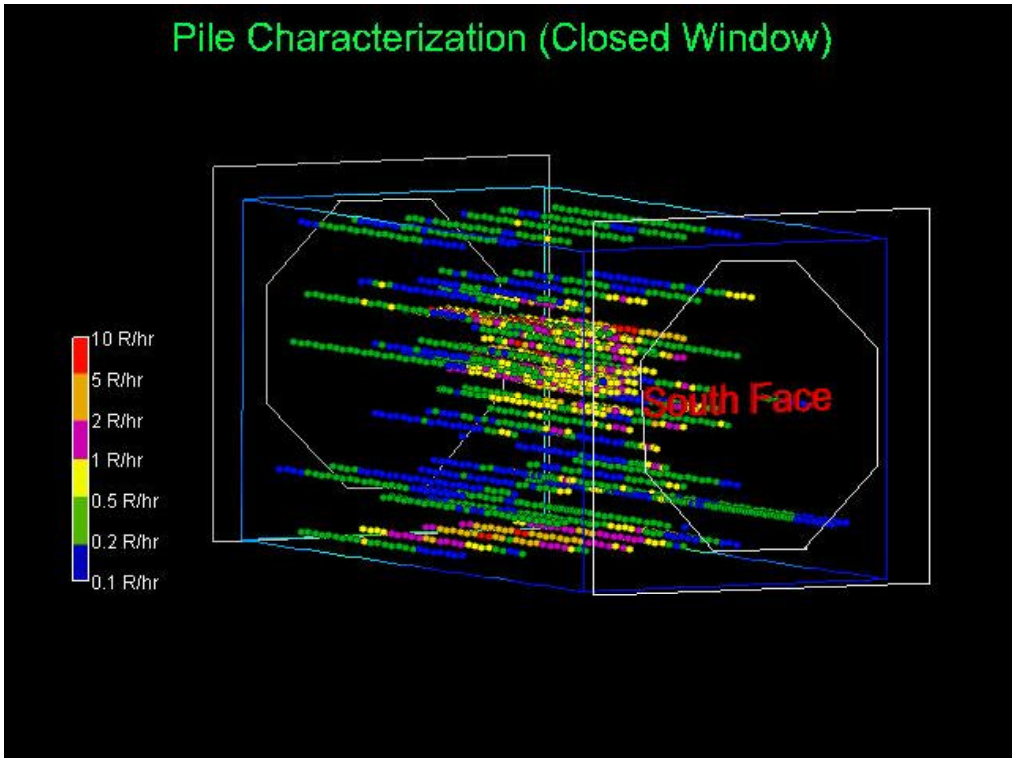


Figure 3-1. Gamma Data Points

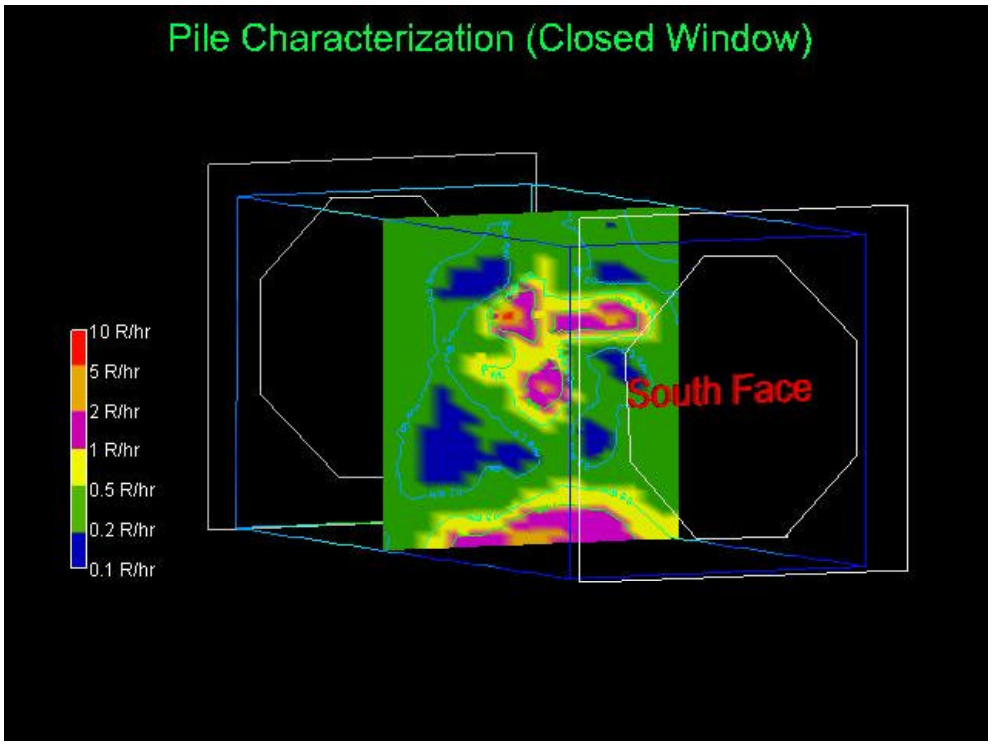


Figure 3-2. Gamma Profile

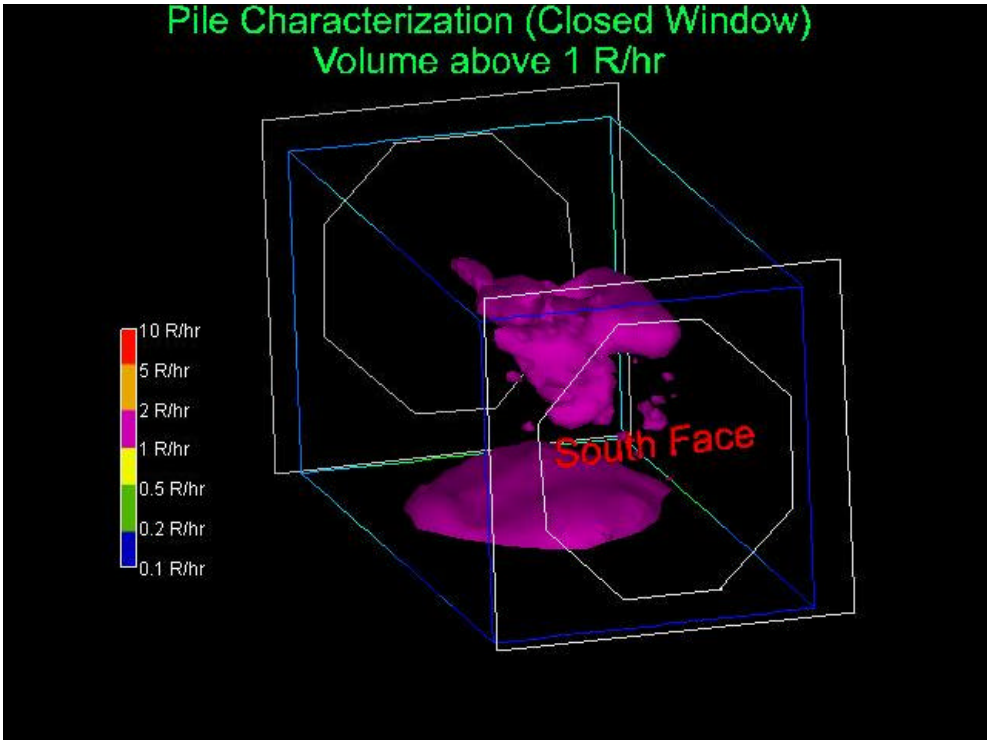


Figure 3-3. Gamma 3-D Visualization

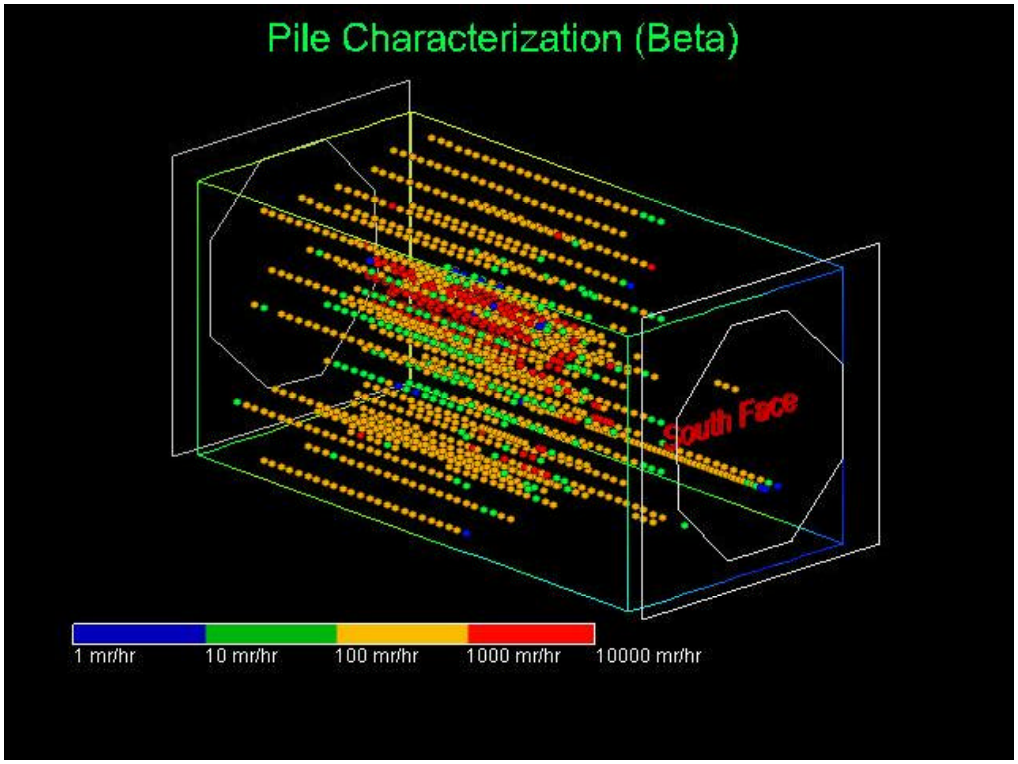


Figure 3-4. Beta Data Points

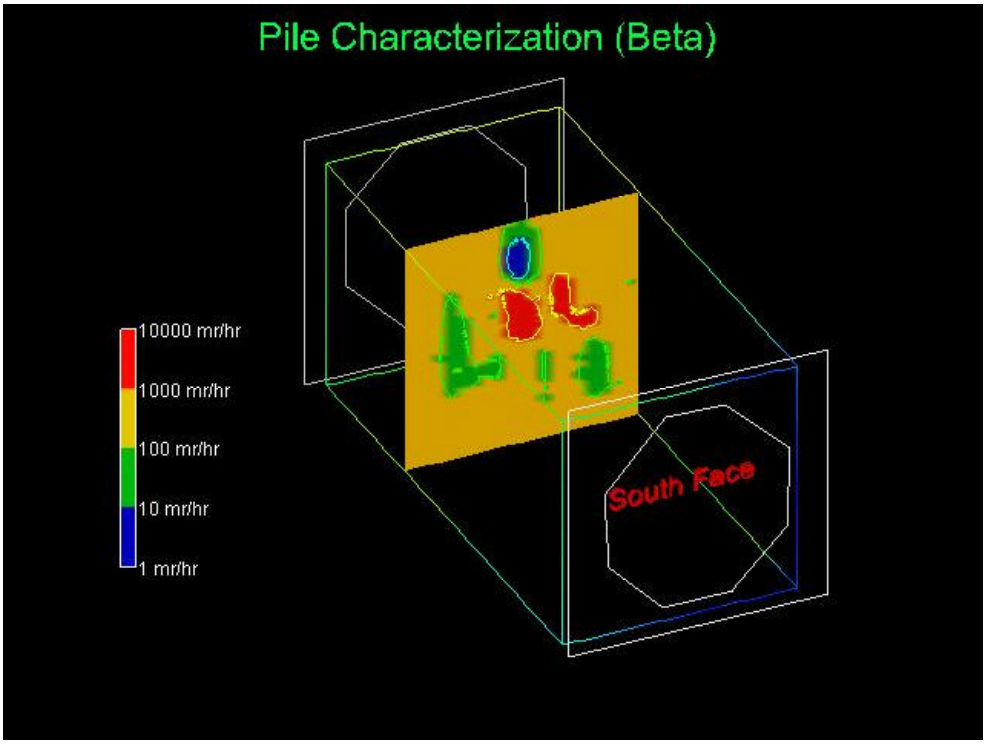


Figure 3-5. Beta Profile

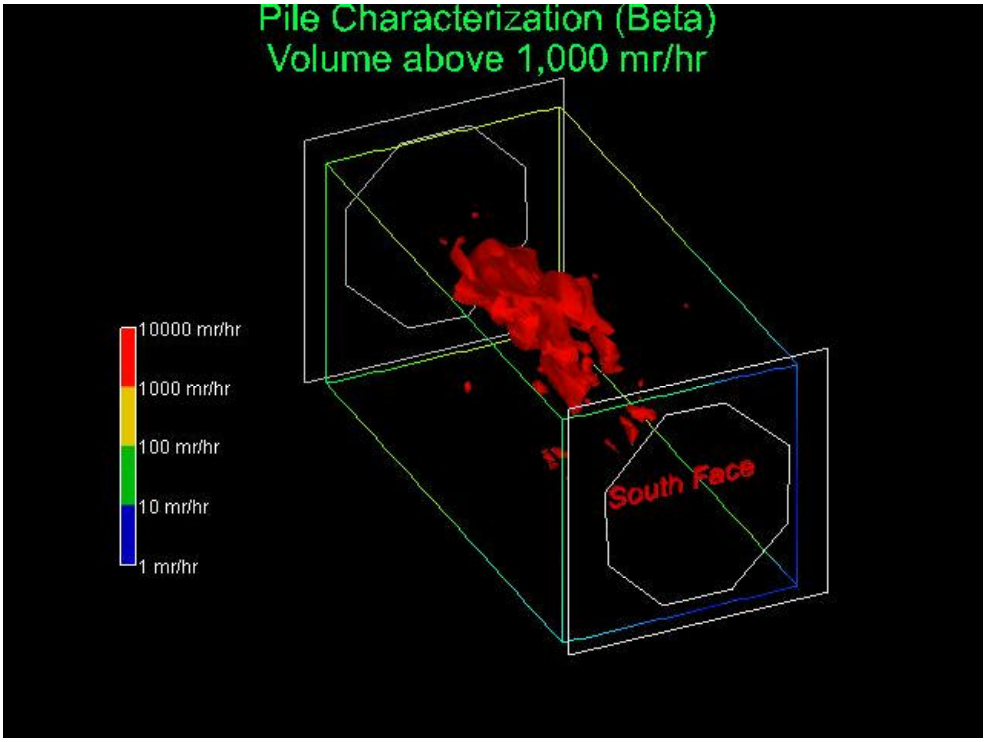


Figure 3-6. Beta 3-D Visualization

3.6.2 East and West Penetrations Characterization

The BGRR was primarily a research instrument and thirty experimental ports extend through the graphite from east to west. The neutron fluxes in the ports ranged from the maximum in E-30 to about eight percent of that value at the core edge experimental ports.

At each experimental port the cover plate was removed and the biological shield plugs were withdrawn. The graphite plugs were removed with long-reach extension interlocking rods. The experimental ports accessed from the west side were characterized up to the east side biological shield wall plugs. The process was repeated for the east biological shield experimental port penetrations.

The instrumentation ports are short in length and they were inspected up to their respective termination points.

The experimental and instrumentation ports were visually inspected to detect any abnormalities and to verify that all experimental components were removed. Seven miscellaneous samples were taken from the experimental ports; the results are in Table 3-5.

Table 3-5. Activity Concentration on samples from West Face Penetrations - BGRR Graphite Pile Characterization
Gamma Spectrum Analysis with the ISOCS® Instrument

BGRR Pile Sample Identification	EXPW-31	EXPW-36	EXPW-42	EXPW-42	EXPW-12	EXPW-30	EXPW-30
Description	Solid Graphite channel piece 4"x4"x24"	Hollow Graphite channel piece 4"x4"x24"	Conveyor Sample Cup #364	Conveyor Sample Cup #368	U-shape graphite channel piece	Irregular graphite piece	Two small graphite pieces from #8 Fuel Channel
Sample Mass	9,672 g	7,662 g	147 g	142 g	6,188 g	150.8 g	2.1 g
ASTD Sample No.	IG01186	IG01188	IG01191	IG01192	IG01196	IG01201	IG01203
Radionuclide	Activity Concentration (pCi/g)						
Am-241	160 ± 156 [256]	ND [214]	104 ± 100 [167]	98 ± 102 [169]	ND [300]	ND [481]	ND* [8,080]
Cs-137	1500 ± 250 [350]	700 ± 100 [114]	1,800 ± 170 [101]	920 ± 140 [178]	ND [134]	300 ± 180 [290]	6,760 ± 6,750 [6,700]
Co-60	42,000 ± 1,600 [119]	1,600 ± 78 [52]	5,900 ± 245 [63]	2,500 ± 116 [60]	205 ± 30 [38]	7,800 ± 375 [185]	53,200 ± 5,300 [620]
Eu-152	ND [146]	14,000 ± 400 [220]	3,300 ± 171 [203]	6,800 ± 260 [198]	30,000 ± 750 [311]	33,000 ± 1,000 [530]	ND* [12,600]
Eu-154	475 ± 70 [159]	26,700 ± 600 [143]	31,300 ± 750 [222]	30,600 ± 700 [211]	28,200 ± 1000 [347]	32,700 ± 990 [354]	ND* [8,930]

ND = Not Detected
* = Indications of the presence of the radionuclide at non-quantifiable levels near the MDA
[ ] = Minimum Detectable Concentration in pCi/g

Following the video inspection, a radiological dose rate profile was obtained using beta-gamma instrumentation that was inserted into the channel with data recorded at one-foot intervals. The highest gamma dose rate observed was 9.59 R/hr in Experimental Port E-30. Smears were taken remotely with a long-reach interlocking pole setup in the areas of elevated dose rate readings. Survey results for the experimental and instrumentation ports are in Appendix G.

Photograph 3-6 shows the BGRR staff performing the characterization of an experimental port on the west reactor face. Photograph 3-7 is from inside Experimental Channel W-32. The debris visible in the photograph was collected and the 4.6 gram sample indicated 32 mR/hr on contact. ISOCS® analysis was performed detecting Co-60 at 124 million pCi/g and Cs-137 at 3.36 million pCi/g.

Photograph 3-6. West Experimental Port Characterization

Photograph 3-7. Experimental Port W-32

3.6.3 Animal and Instrumentation Tunnel Characterization

The experimental openings in the graphite structure are limited in size by the lattice requirements. In order to expose large samples to radioactivity, two chambers were provided underneath the reactor. One of these, known as the "animal tunnel", was employed to irradiate small animals. The other, known as the "instrument tunnel," was employed to irradiate miscellaneous large samples. The two tunnels are located in the layer of concrete between the top of the buttresses and the bottom of the I-beams supporting the pile.

The two tunnels are similar in design and are symmetrically located with respect to the east-west reactor centerline. The samples for these tunnels were placed on a four-wheeled cart and transported to the target area at the midpoint of the tunnel. The target area was an opening cut through the bed plates, the flanges of the I-beams, the concrete, and the roof at the tunnel lining.

The animal tunnel was accessed from the east side of the pile. The driving mechanism and door interlock system was placed into service with temporary supply air and the drive chain system was advanced with a manual crank. During characterization, the tunnel cart was used to carry the video camera and a visual inspection was performed. Dose rate instruments were attached to a flexible fiber rod and inserted the full tunnel length. Radiological dose rate profiles were obtained using beta-gamma instrumentation and recorded at one-foot intervals. The highest dose rate was at thirteen feet indicating .19 mR/hr gamma with no detectable beta. Smears were taken with a long-reach interlocking pole setup. TLDs were placed in the bottom of the tunnel floor to assess cumulative dose and relative energy levels. The smear results indicate no alpha activity above MDA and a single smear obtained from the pile centerline indicated beta contamination greater than MDA. Complete survey results are in Appendix G.

The instrument tunnel was accessed from the west operating station. The same surveying and sampling approach utilized for the animal tunnel was implemented for the instrument tunnel and the results are also similar. Complete survey results are in Appendix G.

When the surveying and sampling of the tunnels was completed, the irradiation ports were sealed and the tunnel openings closed. Photograph 3-8 depicts the animal tunnel and irradiation port. Photograph 3-9 is a close-up of the irradiation port. ISOCS® analyses were performed on debris samples taken from the animal and instrumentation tunnels and are detailed in Table 3-6.

Photograph 3-8. Animal Tunnel and Irradiation Port

Photograph 3-9. Irradiation Port

Table 3-6. Activity Concentration in Debris Samples - BGRR Graphite Pile Characterization

Gamma Spectrum Analysis with the ISOCS® Instrument

Description	Debris from Animal Tunnel	Debris from Instrument Tunnel
ASTD Sample No	IG01324	IG01325
Radionuclide	**Activity Concentration (pCi/g)**	
Cs-137	128 ± 39 [60.0]	46 ± 13 [18.4]
Co-60	2,590 ± 153 [24.6]	584 ± 28 [12.9]
Eu-152	581 ± 44 [42.5]	1,150 ± 50 [40.5]
Eu-154	ND [44.2]	ND* [2.0]

ND = Not Detected
* = Indications of the presence of the radionuclide at non-quantifiable levels near the MDA
[ ] = Minimum Detectable Concentration in microCuries per foot (µCi/ft)

3.6.3 Graphite Characterization

The reactor graphite cube is divided into four concentric zones, A, B, C and D as shown in Figure 3-7. The four zones reflect the four grades of graphite with the highest grade being "A" and the lowest "D". Samples of each grade of graphite were collected, including a sample of grade "AA" used in manufacturing the graphite plugs.

The tool used in obtaining the samples was a right–angled air-operated die grinder with a ball-end center–cutting mill. The assembly was positioned in the box so that it could be gradually rotated on axis to mill out the graphite sample. To collect the samples, the sampling device was inserted in the experimental port and positioned for the specific graphite type. The operation was performed with long extension poles and monitored with a remote video camera. Photographs 3-10 and 3-11 show the sampling assembly in a test mock-up. Photograph 3-12 was taken from inside the experimental port and shows where the graphite was sampled. Table 3-7 represents the ISOCS® analysis of the graphite samples and the full radiological and hazardous analysis results from an off-site laboratory are in Appendix H.

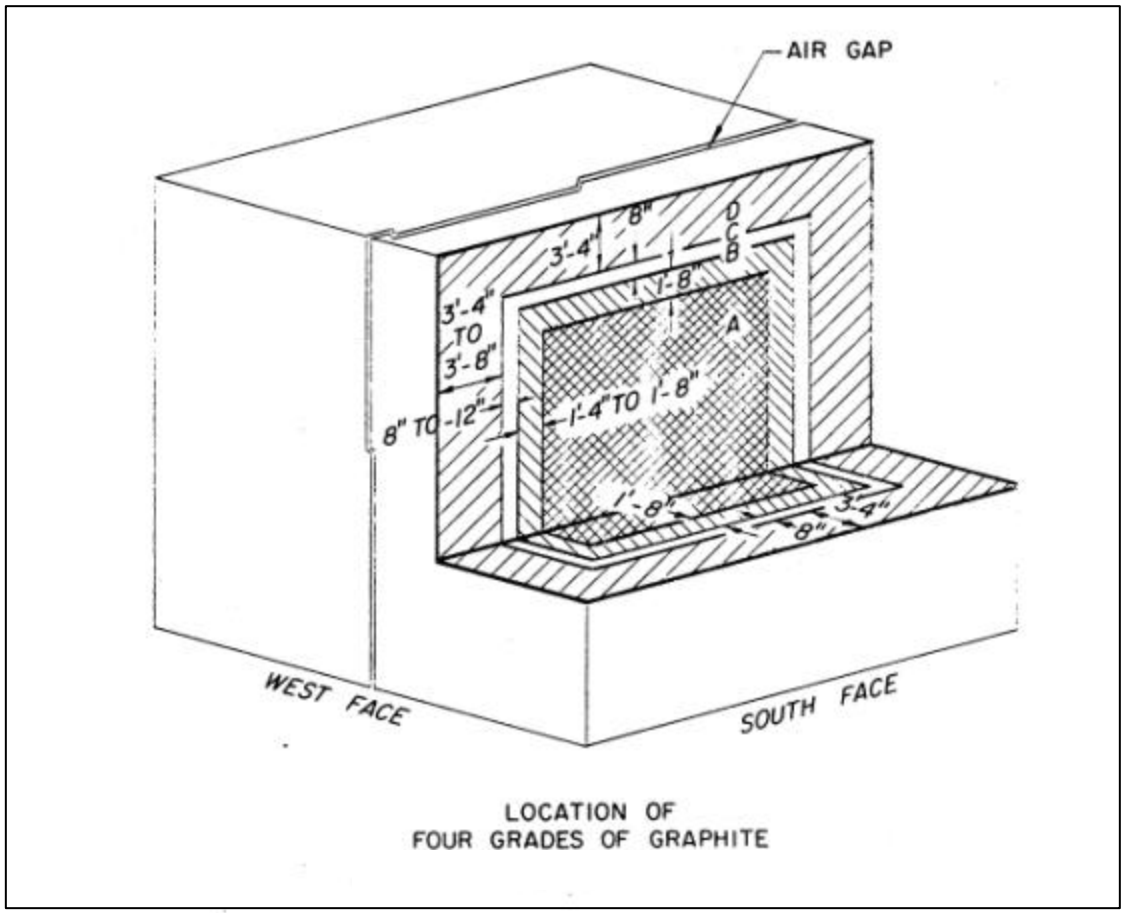
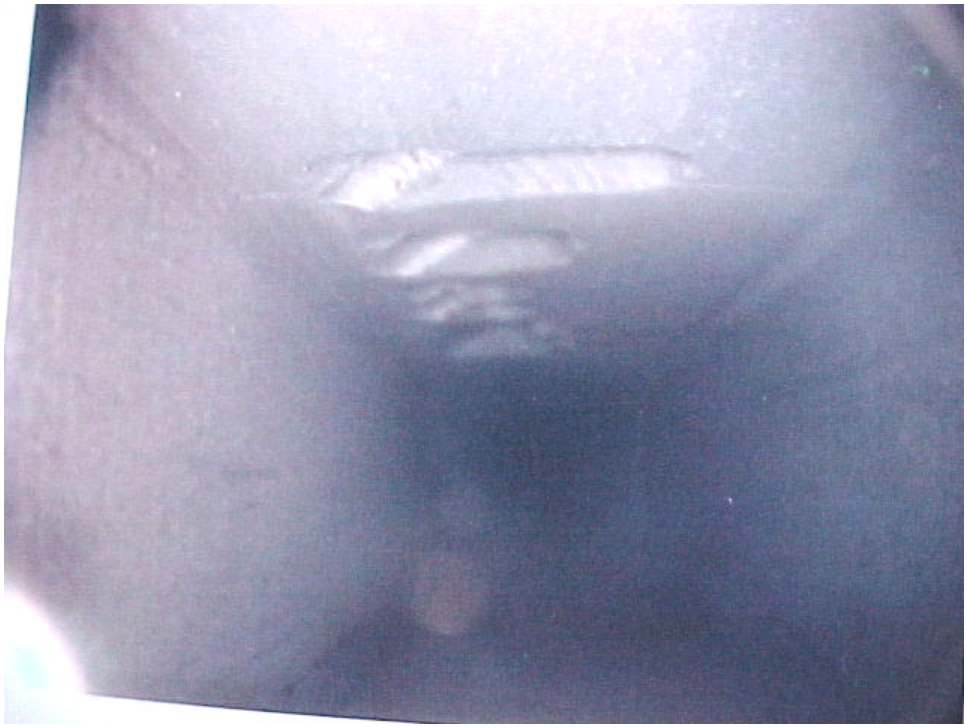


Figure 3-7. Four Grades of Pile Graphite

Photographs 3-10 and 3-11. Graphite Sampling Tool in Mock-up Assembly



Photograph 3-12. Graphite Sampling Area Post-Sampling

Table 3-7. Activity Concentration in Graphite Dust Samples - BGRR Graphite Pile Characterization
Gamma Spectrum Analysis with the ISOCS® Instrument

Description	Graphite Dust Sample							
BGRR Sample No	W-32-B-2	W-32-C-3	W-32-D-4	W-35-C-2	W-35-3-B(a)	W-35-1-D	W-32-A	W-35-A
Mass (g)	94.2	93.0	104.3	57.3	62.5	57.4	60.0	93.9
ASTD File No	IG01307	IG01308	IG01309	IG01310	IG01312	IG01313	IG01314	IG01315
Radionuclide	**Activity Concentration (pCi/g)**							
Co-60	40,800 ± 1,550 [155]	9,400 ± 380 [83]	23,800 ± 910 [122]	3,860 ± 180 [62]	3,310 ± 155 [85]	1,670 ± 94 [69]	14,000 ± 560 [120]	4,990 ± 210 [76]
Ba-133	480 ± 90	560 ± 90	680 ± 105	254 ± 62	634 ± 87	361 ± 68	2,510 ± 230	1,100 ± 120
Cs-137	2,700 ± 290 [250]	760 ± 120 [150]	1,200 ± 160 [190]	400 ± 77 [101]	1,620 ± 176 [128]	970 ± 135 [152]	4,520 ± 440 [236]	2,650 ± 260 [126]
Eu-152	ND [250]	ND [205]	670 ± 110 [165]	ND* [278]	ND [215]	705 ± 125 [244]	ND [221]	ND [165]
Eu-154	14,000 ± 560 [230]	21,300 ± 660 [144]	20,900 ± 590 [190]	13,600 ± 470 [167]	18,500 ± 605 [189]	25,400 ± 665 [200]	10,800 ± 426 [170]	13,000 ± 440 [136]
Eu-155	1,400 ± 200 [118]	2,100 ± 175 [119]	1,900 ± 200 [106]	1,600 ± 230 [193]	2,300 ± 230 [177]	2,550 ± 315 [193]	1,325 ± 165 [184]	1,375 ± 240 [118]
Am-241	234 ± 122 [190]	154 ± 94 [150]	198 ± 96 [150]	ND [95]	184 ± 101 [157]	ND [108]	ND [123]	ND [104]
Ag-108m	ND [105]	ND [105]	ND [105]	195 ± 112 [100]	ND [105]	ND [105]	ND [105]	119 ± 41 [89]

ND = Not Detected
* = Indications of the presence of the radionuclide at non-quantifiable levels near the MDA (one or more, but not all, gamma lines observed)
[ ] = Minimum Detectable Concentration in pCi/g

3.6.4 Biological Shield Characterization

A total of eight cores were made through the biological shield outer steel plate, concrete, and inner steel linings to determine the extent of activation in the components. The extremely heavy concrete required the project to have special drill bits manufactured to core through the concrete and iron punchings. Photograph 3-13 shows the coring machine set-up on the biological shield outer steel plate. Cooling water was pumped into the drill region and vacuumed out in a recirculation system that minimized the volume of wastewater produced. Two cores were made through the east face, three from the west, two from the north, and one from the top. The locations were chosen to fully understand the extent of activation in high and low flux regions. The following are summaries from each location.

Photograph 3-13. Biological Shield Core Bore Set-up

Biological Shield Location E-30 (Grid H119-R11)

This location was chosen due to its proximity to the three-inch air gap that splits the pile into two halves. The neutron flux was highest at this location due to the air gap and the lack of moderation from the graphite. The biological shield construction is slightly different at this location due to the higher flux. The inner steel liner at the air gap consists of six three-inch steel plates versus the typical arrangement of two three-inch plates. The core at E-30 allowed for the sampling of the innermost liner that was exposed to the highest flux. All six inner steel plates have detectable levels of activation with the inner plate having 300,900 pCi/g of Co-60. This indicates that a significant level of Co-60 remains even after eight half-lives of radioactive decay. Steel shavings from the inner steel plate were sent to an off-site laboratory for full radiological and hazardous analysis and the results are in Appendix H. Carbon-14, Fe-55, Ni-59, Ni-63, and Co-60 are the principle radionuclides detected. The inner one-foot of concrete had slight Co-60 and Eu-152 activation and the outer two feet were less than MDA. The concrete and steel ISOCS® results are listed in Table 3-8. Photograph 3-14 details the significant amount of iron in the concrete.

Table 3-8. Location E-30 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H119-R11ST-01	IG01988	2,036	Steel	0.0-0.25	ND	2.3	ND	2.9	ND	7.4	ND	43.2
H119-R11CC-01	SAM04438	2,348	Concrete	0.25-1.0	ND	0.3	ND	0.2	ND	0.4	ND	0.4
H119-R11CC-02	SAM04439	1,519	Concrete	1.0-1.25	ND	0.4	ND	0.4	ND	0.6	ND	0.5
H119-R11CC-03	SAM04440	3,086	Concrete	1.25-2.25	ND	0.2	ND	0.4	ND	0.5	ND	0.6
H119-R11CC-04	SAM04441	1,184	Concrete	2.25-2.5	1.0 ± 0.2	0.3	ND	0.4	ND	0.9	ND	0.6
H119-R11CC-05	SAM04442	1,979	Concrete	2.5-3.25	32.8 ± 1.4	0.8	ND	1.2	47 ± 2	2.5	ND	2.0
H119-R11CC-06[1]	SAM04443	1,422	Concrete	3.25-3.5	198 ± 7.0	2.0	ND	2.5	103 ± 5	5.3	ND	3.7
H119-R11ST-02	IG01993	779	Steel	3.5-3.75	620 ± 36.7	24.4	ND	34.0	ND	67.5	ND	418
H119-R11ST-03	IG01994	784	Steel	3.75-4.0	1,007 ± 52.9	17.4	ND	37.7	ND	45.9	ND	458
H119-R11ST-04	IG01995	106	Steel	4.0-4.25	1,550 ± 124	110	ND	125	ND	297	ND	1,090
H119-R11ST-05[2]	IG01964	337	Steel	4.0-4.25	912 ± 32.5	3.6	ND	3.3	ND	4.3	ND	9.0
H119-R11ST-04B[3]	IG01972	433	Steel	4.0-4.25	2,264 ± 86.6	21.4	ND	37.3	ND	48.2	ND	139
H119-R11ST-05B[3]	IG01973	537	Steel	4.0-4.25	6,418 ± 236	37.4	ND	59.5	ND	47.1	ND	260
H119-R11ST-06B[3]	IG01974	602	Steel	4.25-4.5	300,900 ± 11,685	779.0	ND	1,480	ND	807	ND	11,210

[1] *Na-22 Detected: 2.6 ± 0.9 pCi/g, MDA 1.5 pCi/g*

[2] *Steel core was drilled-out through the center of cylinder (similar to a pipe geometry)*

[3] *COC # 14445 and the center of these steel cores were drilled-out (similar to a pipe geometry)*

Photograph 3-14. Location E-30 Concrete Sample

Biological Shield Location E-25 (Grid H116-R11)

This location is near the core edge and was chosen to identify the level of activation in a region of lower flux. The construction at this location is typical of the biological shield: starting from the outside is a three-inch plate, four and one-quarter foot of concrete, and then two three-inch steel plates. The innermost six-inches of concrete is slightly activated with 12.5 pCi/g of Co-60 and 34.9 pCi/g of Eu-152. The two steel plates both contain Co-60 with the inner plate at 68,300 pCi/g. The concrete and steel ISOCS® results are listed in Table 3-9.

Table 3-9. Location E-25 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H116-R11ST-01	IG01985	2,047	Steel	0.0-0.25	ND	2.3	ND	2.6	ND	5.8	ND	26.7
H116-R11CC-01	SAM04397	1,891	Concrete	0.25-0.75	ND	0.3	ND	0.2	ND	0.3	ND	0.1
H116-R11CC-02	SAM04398	2,575	Concrete	0.75-1.25	ND	0.3	ND	0.2	ND	0.3	ND	0.3
H116-R11CC-03	SAM04399	1,894	Concrete	1.25-1.75	ND	0.3	ND	0.2	ND	0.4	ND	0.3
H116-R11CC-04	SAM04400	2,957	Concrete	1.75-2.75	ND	0.3	ND	0.2	ND	0.4	ND	0.3
H116-R11CC-05	SAM04401	1,880	Concrete	2.75-3.25	ND	0.3	ND	0.2	ND	0.4	ND	0.3
H116-R11CC-06	SAM04403	2,362	Concrete	3.25-3.75	ND	0.4	ND	0.2	ND	0.5	ND	0.3
H116-R11CC-07	SAM04404	1,274	Concrete	3.75-4.25	1.7 ± 0.3	0.4	ND	0.4	ND	0.9	ND	0.7
H116-R11CC-08[1]	IG01963	1,153	Concrete	4.25-4.5	12.5 ± 0.6	0.4	ND	0.6	34.9 ± 2	1.4	ND	1.1
H116-R11ST-02	IG01986	777	Steel	4.5-4.75	248 ± 11.6	3.4	ND	5.3	ND	5.0	ND	3.0
H116-R11ST-03	IG01976	865	Steel	4.75-5.0	68,300 ± 2,700	347	ND	687	ND	484	ND	6,540

[1] *Na-22 Detected: 0.7 ± 0.2 pCi/g, MDA 0.4 pCi/g*

Biological Shield Location W-51 (Grid H130-K12)

This location is near the upper core edge and is also in a region of lower neutron flux. As with location E-25, location W-51 has the typical biological shield construction detailed in Figure 3-8. Trace amounts of Co-60 were found within the inner one-foot of concrete and both inner steel plates contain C0-60. The inner plate has 15,260 pCi/g of the Co-60. The concrete and steel ISOCS® results are listed in Table 3-10.

Table 3-10. Location W-51 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H130-K12ST-01	IG01990	2,057	Steel	0.0-0.25	ND	2.2	ND	2.6	ND	6.9	ND	48.2
H130-K12CC-01	SAM04374	1,075	Concrete	0.25-0.75	ND	0.2	ND	0.2	ND	0.4	ND	0.4
H130-K12CC-02	SAM04375	1,653	Concrete	0.75-1.25	ND	0.2	ND	0.2	ND	0.4	ND	0.2
H130-K12CC-03	SAM04376	670	Concrete	1.25-1.5	ND	0.4	ND	0.4	ND	0.6	ND	0.4
H130-K12CC-04	SAM04377	1,157	Concrete	1.5-2.0	ND	0.2	ND	0.1	ND	0.3	ND	0.3
H130-K12CC-05	SAM04378	2,178	Concrete	2.0-2.5	ND	0.3	ND	0.2	ND	0.4	ND	0.4
H130-K12CC-06	SAM04379	1,195	Concrete	2.5-3.0	ND	0.5	ND	0.4	ND	0.6	ND	0.5
H130-K12CC-07	SAM04380	1,880	Concrete	3.0-3.5	ND	0.3	ND	0.2	ND	0.4	ND	0.3
H130-K12CC-08	SAM04381	2,589	Concrete	3.5-4.5	1.1 ± 0.2	0.2	ND	0.3	ND	0.6	ND	0..4
H130-K12ST-02	IG01961	747	Steel	4.5-4.75	78.1 ± 3.0	0.8	ND	1.0	ND	2.0	ND	4.4
H130-K12ST-03	IG01991	773	Steel	4.75-5.0	15,260 ± 593	39.7	ND	71.3	ND	42.1	ND	531

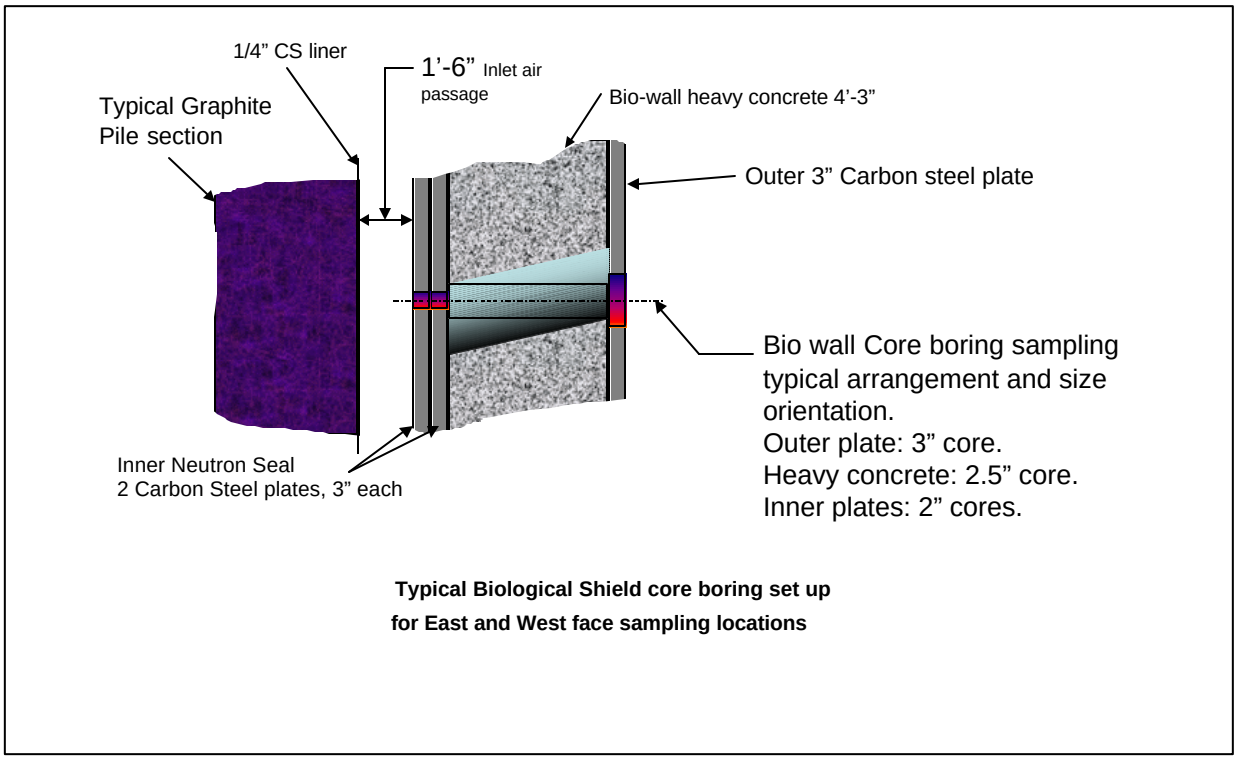


Figure 3-8. Typical Biological Shield Set-up

Biological Shield Location W-33 (Grid H121-K11)

This location is near the core center of the west face and was chosen to evaluate the level of activation in a region of moderate neutron flux. Location W-33 has the typical biological shield construction previously described. The inner one-foot of concrete contains Co-60 and Eu-152 activation with levels of 312 pCi/g and 915 pCi/g respectively. The core sample of the inner steel plate was dropped and could not be retrieved. The first three-inch plate has Co-60 at 3,711 pCi/g. The concrete and steel ISOCS® results are listed in Table 3-11.

Table 3-11. Location W-33 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H121-K11ST-01	IG01945	2,113	Steel	0.0-0.25	ND	22.4	ND	37.4	ND	120	ND	692
H121-K11CC-01	IG01946	1,654	Concrete	0.25-1.0	ND	20.6	ND	29.7	ND	78.9	ND	110
H121-K11CC-02	IG01947	1,375	Concrete	1.0-1.5	ND	27.0	ND	38.0	ND	108	ND	147
H121-K11CC-03	IG01939	1,541	Concrete	1.5-2.0	ND	23.5	ND	31.6	ND	93.0	ND	121
H121-K11CC-04	IG01951	710	Concrete	2.0-2.25	ND	49.2	ND	71.0	ND	191	ND	248
H121-K11CC-05	IG01941	2,420	Concrete	2.25-3.0	ND	16.1	ND	20.9	ND	56.8	ND	95
H121-K11CC-06	IG01942	1,157	Concrete	3.0-3.5	ND	44.8	ND	49.6	ND	150	ND	201
H121-K11CC-07	IG01943	1,584	Concrete	3.5-4.0	137 ± 19.2	23	ND	42.8	433 ± 49.9	95.8	ND	166
H121-K11CC-08	IG01944	2,122	Concrete	4.0-4.5	312 ± 24.5	24.0	ND	37.9	915 ± 57.2	88.0	ND	120
H121-K11ST-02	IG01938	801	Steel	4.5-4.75	3,711 ± 186	84	ND	135	ND	245	ND	1,400

Biological Shield Location W-16 (Grid H113-R11)

This location is near the bottom core edge in a region of lower neutron flux. Trace amounts of C0-60 were detected within the inner nine inches of concrete. Co-60 was also detected on both inner steel plates with the highest level of 10,500 pCi/g found within the 4.75'-5.0' steel sample. The concrete and steel ISOCS® results are listed in Table 3-12.

Table 3-12. Location W-16 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H113-K11ST-01	IG01982	2,064	Steel	0.0-0.25	ND	2.5	ND	2.4	ND	5.6	ND	23.7
H113-K11CC-01	SAM04343	2,050	Concrete	0.25-0.75	0.2 ± 0.07	0.03	ND	0.2	ND	0.4	ND	0.3
H113-K11CC-02	SAM04344	2,390	Concrete	0.75-1.25	ND	0.2	ND	0.2	ND	0.4	ND	0.3
H113-K11CC-03	SAM04346	1,522	Concrete	1.25-2.0	ND	0.3	ND	0.2	ND	0.4	ND	0.3
H113-K11CC-04	SAM04347	2,093	Concrete	2.0-2.75	ND	0.3	ND	0.2	ND	0.3	ND	0.4
H113-K11CC-05	SAM04348	2,404	Concrete	2.75-3.75	ND	0.4	ND	0.3	ND	0.7	ND	0.6
H113-K11CC-06	SAM04349	2,390	Concrete	3.75-4.5	6.8 ± 0.5	0.3	ND	10.9	ND	21.3	ND	70.9
H113-K11ST-02	IG01983	395	Steel	4.5-4.75	126 ± 10.7	10.2	ND	0.6	ND	0.7	ND	0.4
H113-K11ST-03	IG01984	911	Steel	4.75-5.0	10,500 ± 410	34.6	ND	50.3	ND	34.6	ND	226

Biological Shield Location B-3-3 (Grid H120-N7)

This location is near the center of the north face in a region of high neutron flux. The core at this location was made to include the collection of liner and thermal shield samples from within the north air plenum. The biological shield construction and sampling notes are detailed in Figure 3-9. Small amounts of Co-60 were detected throughout the concrete and this is most likely due to neutron streaming from the fuel channels. The highest levels of activation products were within the innermost three inches of concrete with 763 pCi/g of Co-60 and 4065 pCi/g of Eu-152. The innermost three-inch concrete sample was also sent to an off-site laboratory with H-3 and Eu-152 the predominant radionuclides detected. Complete radiological and hazardous analysis results are in Appendix H. The biological shield north face only has one inner three-inch steel plate and it has 22,270 pCi/g of Co-60. The aluminum thermal shield has detectable amounts Co-60, Cs-137,

Eu-152, and Am-241. The thermal binding plate, the plate that forms the wall of the north plenum, has 25,635 pCi/g of Co-60. A steel sample obtained from the three-inch pile support plate indicated 62,900 pCi/g of Co-60 and 154,600 pCi/g of Cs-137. The concrete, steel, and aluminum ISOCS® results are listed in Table 3-12. Photograph 3-15 shows the three-inch steel sample taken from the inner carbon steel plate.

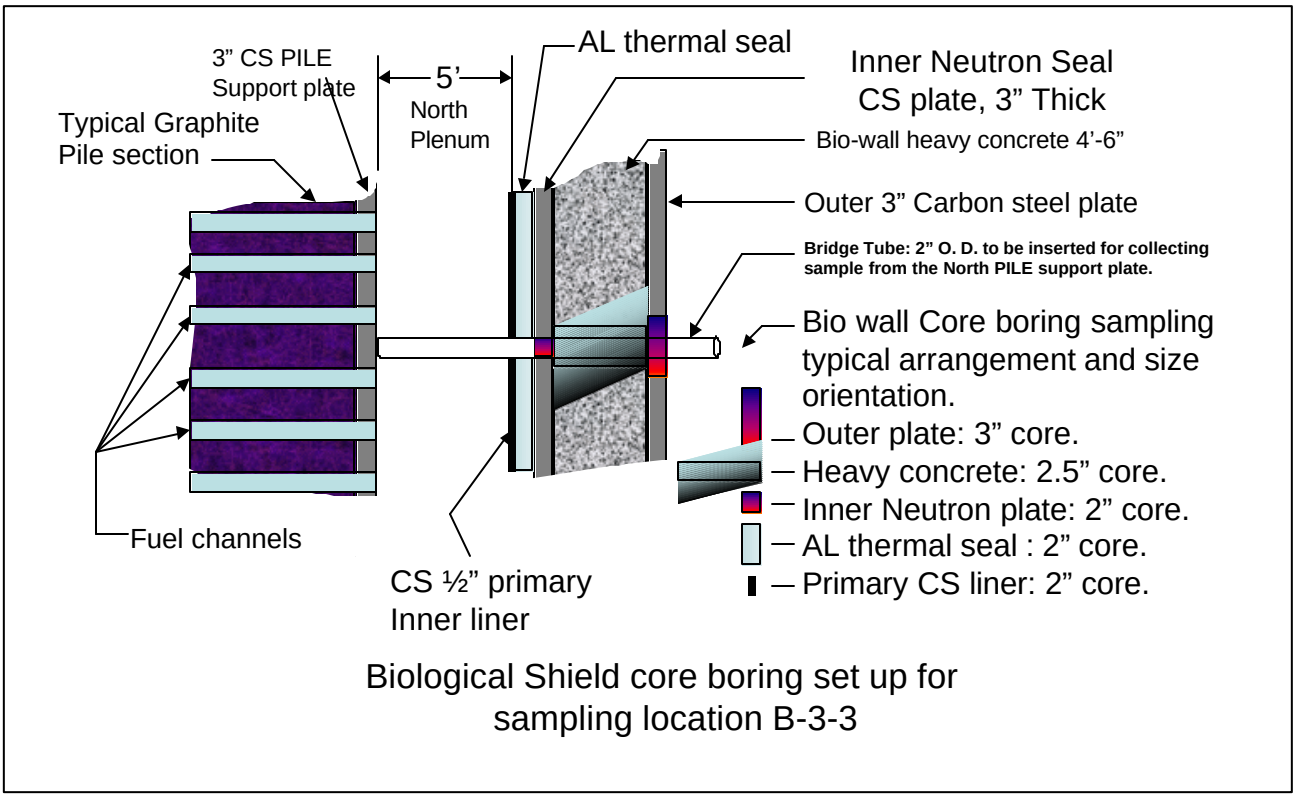


Figure 3-9. Biological Shield Construction at Location B-3-3

Table 3-13. Location B-3-3 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H120-N7ST-01	IG01989	2,056	Steel	0.0-0.25	ND	2.2	ND	2.9	ND	7.9	ND	46.0
H120-N7CC-01	SAM04325	545	Concrete	0.25-0.5	3.0 ± 0.3	0.4	ND	0.2	ND	0.7	ND	0.1
H120-N7CC-02	SAM04326	1,373	Concrete	0.5-0.75	0.3 ± 0.1	0.1	ND	0.1	ND	0.6	ND	0.1
H120-N7CC-03	SAM04327	983	Concrete	0.75-1.0	15.7 ± 0.8	0.6	ND	0.6	ND	0.8	ND	0.8
H120-N7CC-04	SAM04328	1,582	Concrete	1.0-1.5	3.8 ± 0.3	0.3	ND	0.3	ND	0.4	ND	0.4
H120-N7CC-05	SAM04329	2,532	Concrete	1.5-2.25	ND	0.4	ND	0.2	ND	0.3	ND	0.2
H120-N7CC-06	SAM04331	1,650	Concrete	2.25-2.75	0.6 ± 0.2	0.3	ND	0.4	ND	0.7	ND	0.6
H120-N7CC-07	SAM04332	1,778	Concrete	2.75-3.25	70.5 ± 2.7	1.0	ND	1.2	ND	1.5	ND	1.6
H120-N7CC-08	SAM04333	1,496	Concrete	3.25-3.5	14.1 ± 0.8	0.5	ND	0.7	ND	0.9	ND	0.8
H120-N7CC-09	SAM04334	2,047	Concrete	3.5-4.0	15.2 ± 0.8	0.5	ND	0.8	13.6 ± 1.1	1.7	ND	1.4
H120-N7CC-10	SAM04335	2,189	Concrete	4.0-4.5	213 ± 13.0	7.4	ND	13.2	130 ± 14	21.1	ND	25.2
H120-N7CC-11[1]	SAM04336	650	Concrete	4.5-4.75	763 ± 45.3	28	ND	63.7	4065 ± 167	91.2	ND	125
H120-N7ST-02	IG01996	747	Steel	4.75-5.0	22,270 ± 890	136	ND	226	ND	152.0	ND	2,480
H120-N7ST-03	IG01968	80.8	Steel	NA	25,635 ± 885	150	ND	230	ND	215	ND	516
H120-N7ST-04	IG01969	76.1	Steel	NA	62,900 ± 2,100	299	154,600 ± 11,900	660	ND	359	ND	1,250
H120-N7ST-03AL-B[2]	SAM04339	34.2	Aluminum	NA	1,480 ± 52.4	13.0	5,680 ± 435	23.8	204 ± 18	19.6	26.1 ± 9	13.0
H120-N7ST-03AL-T[3]	IG01979				2,800 ± 156	97	8,800 ± 720	158	ND	265	ND	143

NA - not applicable

[1] Na-22 Detected: 52.4 ± 19.5 pCi/g, MDA 27.2 pCi/g

[2] Ag-108m Detected: 218 ± 12.8 pCi/g, MDA 12.4 pCi/g, Ag-108m Half-life = 127 yr, (B = Bottom of Aluminum discs counted)

[3] Ag-108m Detected: 521 ± 56.4 pCi/g, MDA 101 pCi/g, Ag-108m Half-life = 127 yr, (T = Top of Aluminum discs counted)

Photograph 3-15. Location B-3-3 Inner Steel Plate Sample

Biological Shield Location C-15-15 (Grid H112-O7)

This location is in the non-fuel region of the pile, an area of relatively low neutron flux. The construction of the biological shield at Location C-15-15 is the same as Location B-3-3 with a single inner three-inch steel plate (Figure 3-9). Samples were collected from the biological shield components and did not include materials from the north air plenum liner. Small amounts of Co-60 and Eu-152 were detected on the inner nine inches of concrete. The inner steel plate indicated 1,310 pCi/g of Co-60. The concrete and steel ISOCS® results are listed in Table 3-14. Photograph 3-16 illustrates the density of iron within the concrete core.

Table 3-14. Location C-15-15 ISOCS® Results

Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
H112-07ST-01	IG01980	1,667	Steel	0.0-0.25	ND	0.1	0.08 ± 0.06	0.09	ND	0.3	ND	1.3
H112-07CC-01	SAM04385	2,376	Concrete	0.25-1.0	ND	0.3	ND	0.3	ND	0.4	ND	0.5
H112-07CC-02	SAM04386	2,444	Concrete	1.0-1.5	ND	0.3	ND	0.2	ND	0.3	ND	0.3
H112-07CC-03	SAM04387	2,174	Concrete	1.5-2.25	0.4 ± 0.1	0.1	ND	0.2	ND	0.3	ND	0.3
H112-07CC-04	SAM04388	2,557	Concrete	2.25-2.75	ND	0.3	ND	0.2	ND	0.3	ND	0.4
H112-07CC-05	SAM04389	2,231	Concrete	2.75-3.25	ND	0.3	ND	0.2	ND	0.3	ND	0.3
H112-07CC-06	SAM04390	2,387	Concrete	3.25-4.0	0.7 ± 0.1	0.2	ND	0.2	ND	0.4	ND	0.3
H112-07CC-07	SAM04391	1,849	Concrete	4.0-4.5	13.3 ± 0.7	0.4	ND	0.5	7.3 ± 0.7	1.2	ND	0.9
H112-07CC-08[1]	SAM04392	1,085	Concrete	4.5-4.75	90.0 ± 3.3	1.4	ND	1.5	115 ± 4.6	3.4	ND	2.0
H112-07ST-02	IG01981	751	Steel	4.75-5.0	1,310 ± 55.3	2.0	ND	2.6	ND	4.6	ND	11.8

[1] *Na-22 Detected: 1.9 ± 0.7 pCi/g, MDA 1.2 pCi/g*

Photograph 3-16. Location C-15-15 Concrete Sample

Biological Shield Location Reactor Top (Grid 141-N11)

This location was cored through the center removable plug on the top of the graphite pile. The concrete was cored through and the samples collected and analyzed. Small quantities of Cs-137 and Eu-152 were detected in the inner eighteen inches of concrete with peak concentrations of 107 pCi/g and 314 pCi/g respectively. The inner steel plate sample was cored but was not retrievable. The concrete ISOCS® results are listed in Table 3-15.

Table 3-15. Location Reactor Top ISOCS® Results

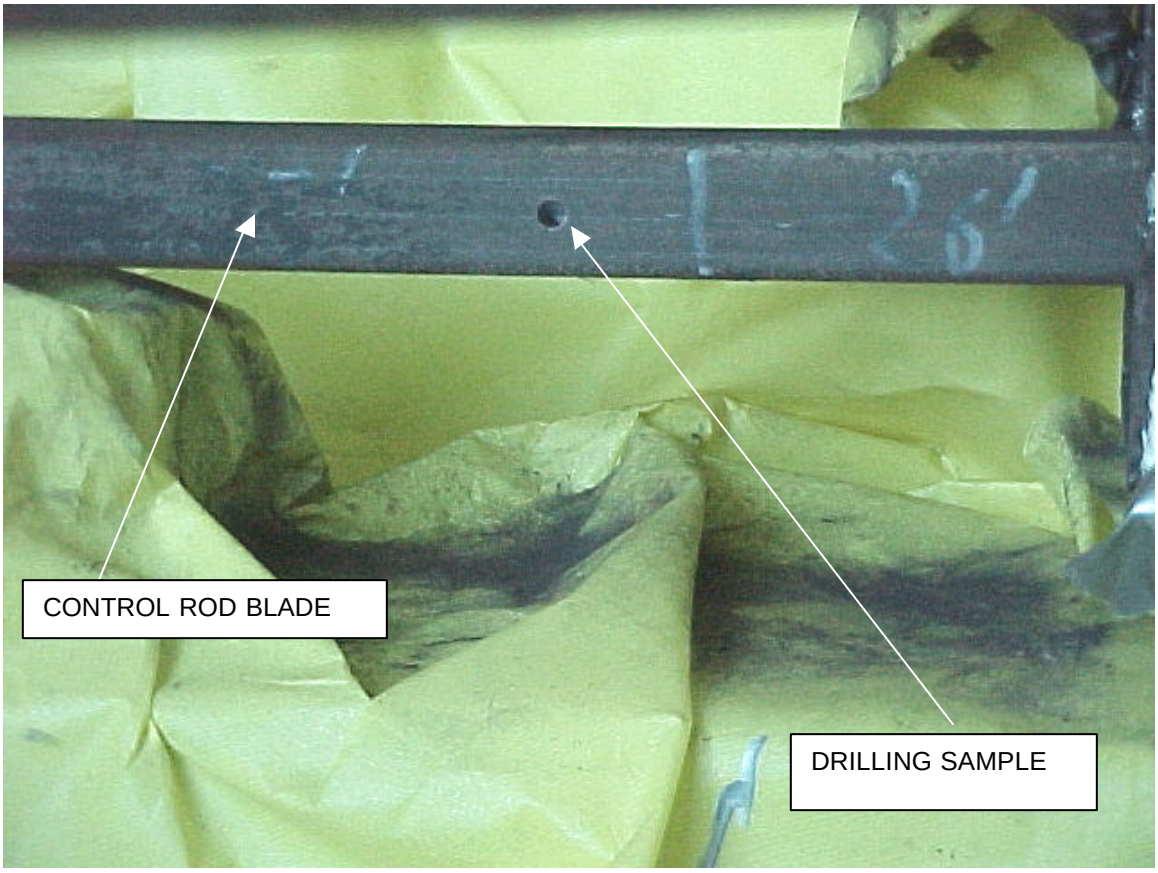
Sample ID	Spectrum File Name	Summary of Radionuclides of Concern (pCi/gram)										
		Sample			Co-60		Cs-137		Eu-152		Am-241	
		Mass, g	Core Type	Depth, ft	Result	MDC	Result	MDC	Result	MDC	Result	MDC
141-N11CC-01	SAM04468	836	Concrete	0.0-0.25	ND	0.3	ND	0.2	ND	0.4	ND	0.4
141-N11CC-02	SAM04469	2,746	Concrete	0.25-1.0	ND	0.4	ND	0.2	ND	0.3	ND	0.3
141-N11CC-03	SAM04470	2,505	Concrete	1.0-1.5	ND	0.2	ND	0.2	ND	0.3	ND	0.3
141-N11CC-04	SAM04471	1,476	Concrete	1.5-2.25	ND	0.3	ND	0.2	ND	0.4	ND	0.3
141-N11CC-05	SAM04472	1,966	Concrete	2.25-2.75	2.2 ± 0.3	0.3	ND	0.3	ND	0.6	ND	0.5
141-N11CC-06[1]	SAM04473	498	Concrete	2.75-3.0	73.7 ± 3.0	1.7	ND	2.3	314 ± 10.0	4.7	ND	2.7
141-N11CC-07	SAM04474	503	Concrete	3.0-3.5	64.0 ± 2.5	1.1	ND	1.1	ND	1.1	ND	0.9
141-N11CC-08[2]	SAM04476	911	Concrete	3.5-4.25	107 ± 3.8	1.2	ND	1.5	111 ± 4.1	3.2	ND	1.9

[1] *Na-22 Detected: 3.1 ± 0.9 pCi/g, MDA 1.3 pCi/g*
[2] *Na-22 Detected: 1.9 ± 0.7 pCi/g, MDA 1.0 pCi/g*

3.6.6 Control Rod Characterization

The BGRR was controlled by sixteen horizontal boron-steel control rods. The rods are two inches square and extend twenty-five feet six inches into the graphite structure. The rods penetrate the pile from the southeast and southwest corners with eight rods in each bank. Two control-rod blades were characterized: No. 1 from the southwest bank and No. 10 from the southeast bank. All sixteen rods have been disconnected from their control-rod-drive mechanisms and are fully inserted in the pile.

The respective control-rod drive mechanism racks were manually driven all the way out of the lead block shielded area. The control-rod blades were latched with a special fabricated flat-stock, bar-type assembly and manually removed from the pile. As the control-rod blades were withdrawn from the biological shield penetration, dose rates were recorded at one-foot intervals for fifteen feet. The highest recorded gamma dose rate was 70 mR/hr. In addition, contamination smears were obtained on the control-rod blades. Results of the radiological surveys are contained in Appendix E. A small amount of control-rod material was obtained by drilling the rod and collecting the metal shavings (see Photograph 3-17). ISOCS® analysis was performed on the sample and is detailed in Table 3-16.



Photograph 3-17. Retracted Control Rod Blade

Table 3-16. Activity Concentration in Pile Control Rods - BGRR Graphite Pile Characterization

Gamma Spectrum Analysis with the ISOCS® Instrument

Description	2' section of exposed control rod marked 25' and 26' Southeast Corner	2' section of exposed control rod marked 19' Southeast Corner	2' section of exposed control rod marked 25' and 26' Southwest Corner	2' section of exposed control rod marked 10' to 12" Southwest Corner
ASTD Sample No	IG01352	IG01354	IG01356	IG01358
Radionuclide	**Activity per foot of exposed rod (mCi/ft)**			
Am-241	ND [62]	ND [27]	ND [37]	ND [3.3]
Cs-137	ND [4.3]	ND [1.8]	ND [2.3]	0.142 ± 0.123 [0.20]
Co-60	813 ± 31.5 [2.23]	245 ± 9.6 [0.95]	175 ± 7.0 [1.1]	7.4 ± 0.3 [0.12]
Eu-152	ND [2.1]	ND [0.74]	ND [1.2]	ND [0.16]
Eu-154	ND [4.4]	ND [2.0]	ND [2.5]	ND [8,7500.30]

ND = Not Detected
* = Indications of the presence of the radionuclide at non-quantifiable levels near the MDA
[ ] = Minimum Detectable Concentration in µCi/ft

4.0 REMAINING SOILS CHARACTERIZATION

4.1 General Area Description

Much of the soil associated with the BGRR was included in the characterizations of the pile fan sump, canal, and below-ground duct projects. The soils that were characterized during this campaign are those predominantly located to the west and southwest of Building 701.

Building 701A, a small building formerly located to the west of 701, had been used as a hot lab. All that remains of Building 701A is a concrete pad, and floor and sink drains that lead to a pit beside Building 703.

The off-gas monitoring instrumentation from one of the BGRR experiments, termed the "Chemo-Nuclear Loop", is also located in a vault adjacent to the 701A pad.

The known, potentially contaminated items of interest in the area include the 701A pad and drains, soil around the 701A pad, the chemo-nuclear off-gas instrumentation vault, the collection cell beside Building 703, and a transfer line from the collection cell through Building 701. An out-of-service de-energized transformer pad sits at the southwest corner of Building 701. The surface soil within this area was analyzed for hazardous contaminants.

The land area described above was subdivided into a five-meter by five-meter sampling grid. A plan view of the area is shown in Figure 4-1 with the grid overlaid. The grid is labeled with unique alphanumeric tags for every square to aid in sample tracking. Sample grid numbers are A-1, J-11, etc. The southwest corner of the remaining soils area was truncated due to the path of the accelerator tunnel traveling from the Tandem Van de Graff accelerator to the Alternating Gradient Synchrotron facility.

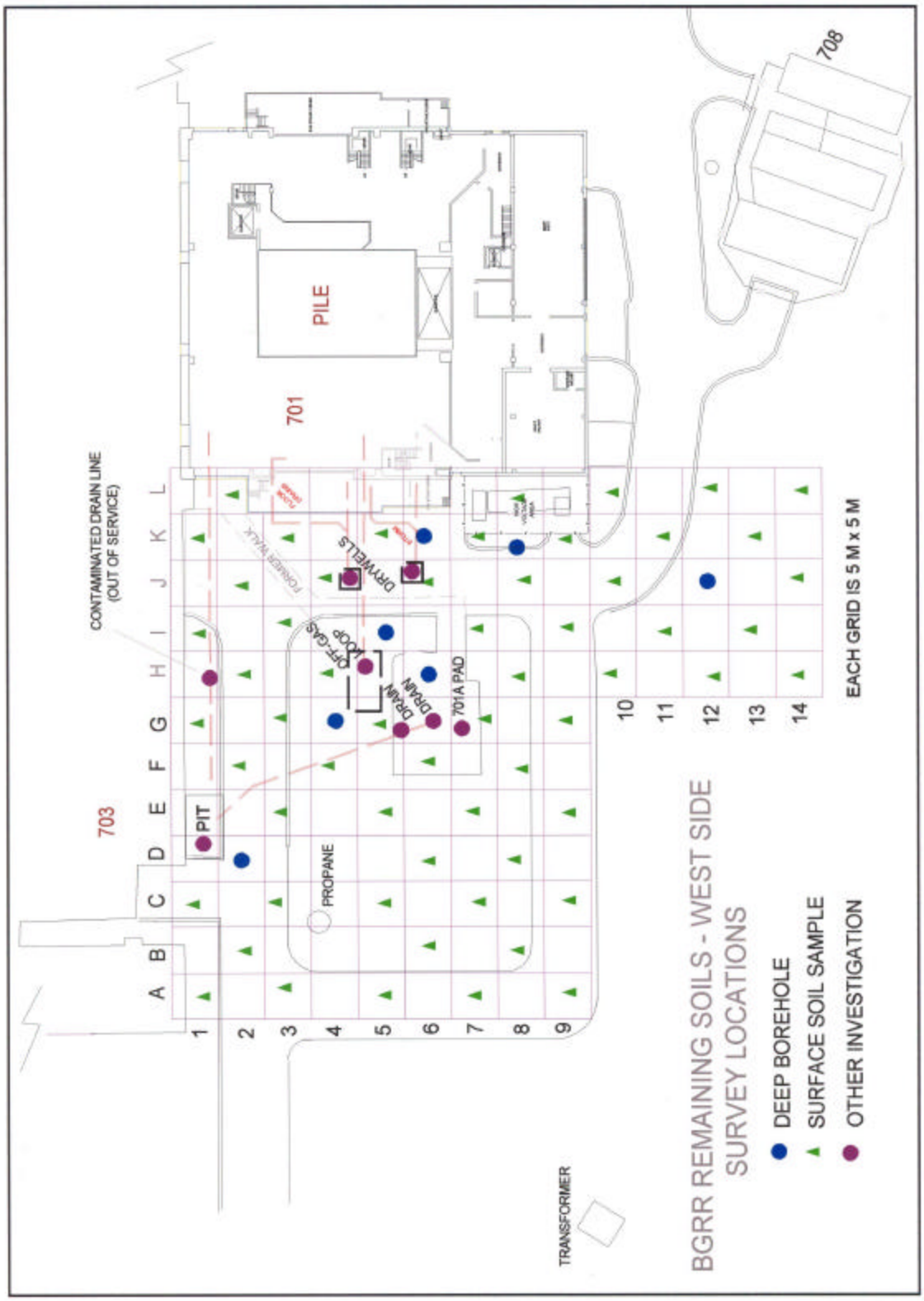


Figure 4-1. Locations of Surface and Deep Soil Samples for 701 Remaining Soils Area

4.2 Survey Areas

4.2.1 Surface Soil

The entire surface of the remaining soils was scanned using a gamma scintillation detector per procedure EM-OPM-4.18. At the location of the maximum scanning reading in each grid square, a surface and general area exposure rate measurement was performed and recorded.

Surface soil sampling was performed by sampling the first six inches (0-6") of exposed soil or soil directly below a material covering, such as concrete, asphalt, etc. Random sample locations are designated as "shallow boreholes" in Figure 4-1. Samples at these locations were collected in every other grid square at the point of the maximum gamma scan reading. All surface soil samples were analyzed with the ISOCS® and BetaScint™ instruments and five percent of the samples were sent off-site for verification and isotopic analysis.

Biased locations were also identified for surface soil samples. The locations identified are at each doorway to Building 701, at joints or cracks in the concrete or asphalt within a given grid area, or at other locations at the surveyor's discretion. These samples were analyzed for radiological and hazardous constituents (excluding samples directly under asphalt). A surface sample was collected from under the transformers in the high-voltage area and analyzed for radiological and hazardous constituents.

4.2.2 Deep Soil

Deep soil sampling is defined to be sampling below the surface soil, at depths of six inches below exposed soil or six inches below a material covering. Deep sampling extends to refusal of the probe, bit, or auger, or until groundwater was reached.

Deep boreholes were drilled using coring bits and macro-bore samplers to refusal or groundwater using a Geoprobe® sampling rig. Soil and concrete core samples were collected and composited in six-inch intervals for the first twenty-four inches, and from four-foot lifts for deeper soil cores. The four-foot lifts were split into 24-inches samples with ISOCS® gamma scans performed on alternating 24-inch sections. However, all 24-inch sections were archived for future counting. Five percent of the samples were sent off-site for verification and isotopic analysis.

Additional sampling locations were added when facility drywells were located. Deep soil sampling was added in Grid L-10 for the fuel vault floor drain drywell and Grid K-4 for the west intake filter facility floor drains drywell.

Additional samples were also added in Grids D-1, E-1, and E-2 to determine if the soil beneath the Building 703 F-waste collection cell was contaminated with hazardous constituents that were found inside the cell.

4.2.3 Vaults, Embedded Pipes, and 701A Pad

The condition of the Chemo-Nuclear Loop Vault was unknown. Readings were performed and samples collected on surfaces, within drains, and inside the remaining system piping. A video inspection and sampling was also performed on the adjacent tank vault.

The former F-waste collection cell beside Building 703 was thoroughly inspected and characterized. A survey of the cell was performed and samples were taken of the floor debris and pipe scrapings. Samples were composited and analyzed for radiological and hazardous contaminants. A vacuum test was performed on the F-waste transfer line to determine its integrity.

The former Building 701A pad was surveyed, samples were collected and analyzed from the drains, and deep soil sampling was performed through the concrete and underlying soil.

4.2.4 Groundwater

Groundwater samples were collected at designated deep soil borehole locations when the sampler reached the water table. Borehole locations H-6, J-12, and K-6, and K-8 were selected for radiological analysis. Groundwater samples collected at grid locations H-6, J-12, and K-6 were also analyzed for hazardous materials due to their proximity to the electrical transformers and building entryways. All the groundwater radiological results for this project are collectively presented in Section 2.3.7 of this report. All groundwater hazardous results are presented in Section 2.3.8.

4.3 Characterization Results

The radiological characterization results are discussed in survey areas and a separate section addresses the hazardous analysis. Summary data tables are included in the following sections and complete ISOCS®, BetaScint™, and off-site laboratory analytical results are included in Appendices A, B, C, and E.

4.3.1 Surface Soil

The purpose of characterizing the surface soils was to determine the amount of contamination resulting from BGRR stack emissions and facility operations. A total of fifty surface soil, five asphalt, and three concrete samples were taken from the area west of Building 701. All sample results indicate levels less than 50 percent of the investigation level for Cs-137 (11 pCi/g) and Sr-90 (7.5 pCi/g). Most of the samples are less than 1 pCi/g for Cs-137 and Sr-90 with the highest level of 6.8 pCi/g of Cs-137 detected in Grid K-7.

4.3.2 Deep Soil

A total of 299 deep soil samples were taken, 166 were analyzed and 133 were archived for additional analysis if required. All sample results indicated less than 50 percent of the investigation level for Cs-137 (11 pCi/g) and Sr-90 (7.5 pCi/g). Most of the samples are less than 1 pCi/g for Cs-137 and Sr-90 with the highest level of 1.4 pCi/g of Cs-137 detected in Grid K-7. Summary results for samples sent to an off-site laboratory for ISOCS® verification and isotopic alpha, beta, and gamma analyses are presented in Table 4-1. Photograph 4-1 depicts the Geoprobe® sampling in Grid D-1.

Photograph 4-1. Geoprobe® Soil Sampling at Location D-1

Table 4-1. Summary Radiological Data for Remaining Soils

	Cs-137 (ISOCS) pCi/g	Cs-137 (off-site) pCi/g	Co-60 pCi/g	U-233/234 pCi/g	U-235 pCi/g	U-238 pCi/g	Pu-238 pCi/g	Pu-239/240 pCi/g	Ra-226 pCi/g	Ra-228 pCi/g	Sr-90 pCi/g	Eu-152 pCi/g	Eu-154 pCi/g	Eu-155 pCi/g	Notes
RSK7SS-01 (0'-.5')	6.8	5.21	0.005	0.34	ND	0.45	ND	0.105	0.50	0.77	0.64	ND	0.13	0.018	Th-232 0.26pCi/g
RSI11SS-01 (0'-.5')	0.2	0.36	ND	0.71	0.031	0.58	0.003	0.027	1.21	1.52	0.79	0.13	ND	0.148	Th-232 0.57 pCi/g
RSL12SS-01 (0'-.5')	0.8	0.82	0.028	0.68	0.039	0.70	ND	0.036	0.98	1.71	0.80	0.19	ND	0.026	Th-232 0.39 pCi/g
RSA7SS-01 (0'-.5')	ND	0.186	ND	0.33	ND	0.37	0.055	0.025	0.76	0.81	0.14	ND	ND	ND	
RSL8SS-01 (0'-.5')	ND	ND	-	-	-	-	-	-	-	-	0.04	-	-	-	
RSK6DS-02 (1'-1.5')	ND	0.017	0.0007	0.13	0.037	0.24	ND	ND	0.20	0.46	0.33	ND	0.09	ND	
RSK4DS-02 (8'-10")	ND	0.01	ND	0.19	ND	0.19	ND	ND	0.37	2.02	0.42	ND	ND	0.034	
RSK7DS-02 (1'-1.5')	0.5	0.48	-	-	-	-	-	-	-	-	0.14	-	-	-	
RSL2DS-02 (1'-1.5')	ND	0.026	-	-	-	-	-	-	-	-	ND	-	-	-	
RSJ12DS-30 (54'-56')	ND	0.027	0.008	0.29	0.03	0.075	ND	ND	0.18	0.12	0.82	ND	ND	0.061	
RSL10aDS-05 (8'-10')	ND	0.023	0.032	0.16	ND	0.19	0.071	0.014	0.34	0.58	0.07	0.08	0.15	0.016	
RSL10bDS-05 (8'-10')	ND	ND	ND	0.155	0.01	0.144	ND	ND	0.52	0.45	0.18	ND	ND	0.02	
RSL10cDS-05/06 (8'-12')	ND	0.012	ND	0.28	0.013	0.18	ND	0.010	0.31	0.67	0.12	ND	ND	0.032	
RSL10dDS-05/06 (8'-12')	ND	ND	0.011	0.51	0.004	0.24	0.056	ND	0.33	0.38	0.04	0.008	ND	0.019	
RSL10eDS-05 (8'-10')	0.2	0.109	ND	0.125	0.032	0.16	0.018	0.058	1.33	1.16	0.12	0.35	0.25	0.032	
RSL10eDS-06 (10'-12')	ND	ND	ND	0.13	ND	0.41	0.002	ND	0.27	0.16	0.15	0.02	0.11	ND	

4.3.3 Vaults, Embedded Pipes, and 701A Pad

Building 703 F Waste Collection Cell - The purpose of this cell was to house the collection tank, drain pipes, and the transfer pumps and piping for F waste that was collected from Buildings 703 and 701A. Three pipes went into the collection tank: two drain lines from Building 703 laboratories and a floor drain from Building 701A. Previously, the drain piping was cut, electrical service to the pumps was disconnected, and the tank was removed. In 1998 water was discovered inside the vault because the concrete cover was severely degraded; a steel weather enclosure was constructed to prevent additional water intrusion.

A section of the steel enclosure cover was removed to provide access to the cell. Facility support technicians entered the cell and performed a radiological survey of the interior; no contamination was detected. A composite debris sample was obtained from the floor sump and three drain lines. Photograph 4-2 shows the two drain lines from Building 703 that were sampled. The drain lines were capped when sampling was completed. ISOCS® analysis of the sample indicated no detectable activity. The sample was sent to an off-site laboratory for hazardous contaminant analysis. Levels exceeding the TAGM limits were detected for sixteen metals, four semivolatiles, and Aroclor 1254. The results are summarized in Tables 4-2 through 4-5.

Based on these results and the historical presence of water in the cell, additional sampling of the soil beneath the concrete was performed. Three locations were added and the Geoprobe® was angled to obtain soil from beneath the concrete and a total of six samples were obtained. All sample results were below the TAGM limits for hazardous contaminants. Appendix C contains the off-site laboratory results for these samples. Photograph 4-3 shows the Geoprobe® being angled to obtain the soil samples.

Photograph 4-2. F Waste Laboratory Drains

Table 4-2. Summary of Metals Detected in Building 703 F Waste Collection Cell

Analyte	TAGM Limit (mg/kg)	Concentration (mg/kg)	EPA Qualifier		Analyte	TAGM Limit (mg/kg)	Concentration (mg/kg)	EPA Qualifier
Aluminum	16,491	3360	N		Lead	400	**2780**	
Antimony	13.1	**34.2**	N		Magnesium	2122	2110	
Arsenic	7.5	**8.0**			Manganese	148	**804**	N
Barium	300	142			Mercury	1.84	**384**	
Beryllium	0.43	ND			Nickel	13	**623**	
Cadmium	1.5	**7050**			Potassium	628	ND	
Calcium	434	**5440**			Selenium	2	**6.2**	
Chromium	14.2	**2410**			Silver	2	**829**	
Cobalt	30	15.5			Sodium	196	**405**	B
Copper	25	**1620**			Thallium	0.35	**6.1**	
Chromium VI	14.2	ND			Vanadium	150	40.7	
Cyanide	N/A*	ND			Zinc	22.4	**3580**	
Iron	14429	**114,000**	N					

* Not Available - Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable.

Table 4-3. Summary of Volatiles Detected in Building 703 F Waste Collection Cell

Analyte	Chemical abstract serviœs number (CAS#)	TAGM Limit (mg/kg)	Concentration (mg/kg)	EPA Qualifier
Dichloromethane(Meth Chl)	75-092	0.1	.006	B
2-Propanone (Acetone)	67-64-1	0.2	.018	J,B
Benzene	71-43-2	0.06	.0016	J
Toluene	108-88-3	1.5	.00042	J
4-Methyl-2-pentanone	108-10-1	1	.0025	J

Table 4-4. Summary of PCBs Detected in Building 703 F Waste Collection Cell

Analyte	Chemical abstract services number (CAS#)	TAGM Limit (mg/kg)	Concentration (mg/kg)
Total PCBs	1336-36-3	1.0 Surface 10. Subsurface	
PCB-1254	11097-69-1	NL	79

Table 4-5. Summary of Semi-Volatiles Detected in Building 703 F Waste Collection Cell

Analyte	Chemical abstract services number (CAS#)	TAGM Limit (mg/kg)	Concentration (mg/kg)	EPA Qualifier
Naphthalene	91-20-3	13	2.8	
2-Methylnaphthalene	91-57-6	36.4	.410	
Acenaphthene	83-32-9	50	.16	
Dibenzofuran	132-64-9	6.2	.25	J
Diethyl phthalate	84-66-2	7.1	2	
Fluorene	86-73-7	50	.24	J
Phenanthrene	85-01-8	50	1.5	
Anthracene	120-12-7	50	.24	J
Carbazole	86-74-8	NL	.17	J
Fluoranthene	206-44-0	50	1.3	
Pyrene	129-00-0	50	2.6	
Benzo(a)anthracene	56-55-3	.224 or MDL	**.6**	
Chrysene	218-01-9	0.4	**.82**	
Bis(2-ethylhexyl)phtalate	117-81-7	50	5.3	
Benzo(b)fluoranthene	205-99-2	1.1	.92	
Benzo(k)fluoranthene	207-08-9	1.1	**1.2**	
Benzo(a)pyrene	50-32-8	.061 or MDL	**.83**	
Indeno(1,2,3-cd)pyrene	193-39-5	3.2	.42	
Benzo(ghi)perylene	191-24-2	50	.37	
4-methylphenol	106-44-5	0.9	.18	J
Phenol	108-95-2	0.03	**.3**	J
Di-n-buttylphthalate	84-74-2	8.1	4.1	
Isophone	78-59-1	4.4	.13	J

Photograph 4-3. Soil Sampling beneath F Waste Collection Cell

The F-waste transfer pipe exits the cell and runs underground to the BGRR where it enters the piping trench in the north end of Building 701. The transfer line runs through the entire length of the trench. It originally exited the building on the east side and terminated in Building 811. As part of the canal remediation, the transfer pipe was cut in the trench and the entire length to Building 811 was removed. To evaluate the integrity of the remaining pipe, a vacuum test was performed. Figure 4-2 depicts the vacuum test assembly that was used. The transfer line was sealed at both ends and the vacuum pump evacuated the line to a negative pressure of 25 inches of mercury. The pump was secured and the pressure was monitored for a period of thirty minutes. The pressure remained constant at negative 25 inches of mercury throughout the thirty minutes indicating that the line integrity was intact.

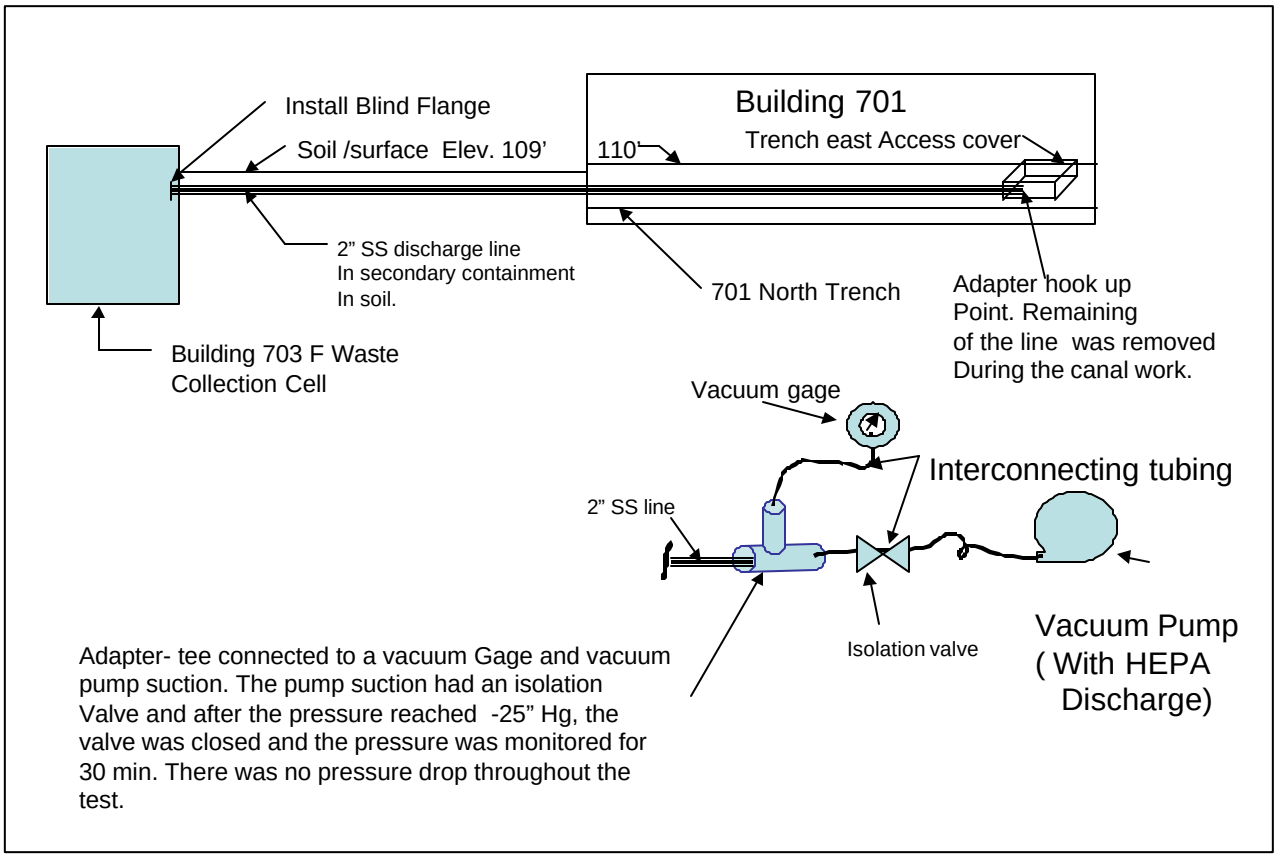


Figure 4-2. F Waste Transfer Line Test Assembly

Chemo-Nuclear Off-gas Loop Vault - The purpose of the Brookhaven Chemo-Nuclear In-Pile Research Loop was to provide a facility for investigating chemo-nuclear reactions under flow conditions. The system is primarily located within and adjacent to the graphite pile, but a portion of the off-gas loop is located underground, west of Building 701. The off-gas loop was used to

hold the process gases vented for sampling and decay of the fission products. The underground vault is divided into two sections, one side that is easily accessible and one that is not. The accessible portion of the vault contains two outlet iodine traps, vacuum pumps, and appropriate valving. The other side of the vault contains the six vent tanks.

An entry was made into the accessible side of the vault and a radiation survey was performed. Dose rate readings in the vault were equal to background. Direct frisk readings were performed around system piping, on the floor, and in contact with the iodine filters and they all indicate less than 100 corrected counts per minute (ccpm). The system piping to the iodine filter was opened and four smears were obtained, all indicating less than MDA for alpha and beta activity. These results verify the intent and design of the loop in that only short-lived gaseous radionuclides would be vented from the system into the tanks.

The section of the vault that contains the vent tanks was remotely inspected with a video camera. The tanks and piping are in good condition but several inches of water are present inside the vault. A sample was obtained and indicated no elevated levels of hazardous or radiological contaminants.

The portion of the Chemo-Nuclear Loop inside Building 701 was characterized as part of the interior characterization. A filter sample was obtained from the point where the gas leaves the in-pile section. The analytical results are in Appendix B and Co-60 was the predominant radionuclide with a concentration of 651 pCi/g.

701A Pad - The remaining concrete pad and floor drains were surveyed and sampled. The walk-over survey found no areas to be above background. Dose rate readings on the drains also indicate less than or equal to background. Direct frisk readings indicate less than 100 ccpm, and six smears were taken of the two drains and they all indicate less than MDA for alpha and beta activity. A composite debris sample was obtained from the two drains and indicates 4.2 pCi/g of Cs-137. Geoprobe® soil sampling was performed below the concrete pad and all samples indicate less than 1 pCi/g for both Cs-137 and Sr-90.

4.3.4 Hazardous Analysis

Four surface soil and eight deep soil samples were sent off-site for hazardous contaminant analysis. The surface soil samples were taken from biased locations near the transformers and building entryways. The results are summarized in Tables 4-6 through 4-9. The deep soil samples were taken from below the F-waste collection cell and from below the fuel vault and west intake facility floor drains dry wells. The results are summarized in Tables 4-10 through 4-12. Complete analytical results are in Appendix C.

Table 4-6. Summary of Metals Detected in Surface Soils

Analyte	Number Of Samples	Number of Detects	Clean-up Action Limit TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Aluminum	4	4	16,491	5600	N	RSK6SS-01 (0.5'-1.0')	2330	N	RSL8SS-01 (0.5'-1.0')	
Antimony	4	3	13.1	0.52	B,N	RSL8SS-01 (0.5'-1.0')	ND		RSK6SS-01 (0.5'-1.0')	
Arsenic	4	4	7.5	3.1		RSK6SS-01 (0.5'-1.0')	0.91	B	RSL8SS-01 (0.5'-1.0')	
Barium	4	4	300	11.3	B	RSL2SS-01 (0.5'-1.0')	6.6	B	RSL8SS-01 (0.5'-1.0')	
Beryllium	4	3	0.43	0.2	B	RSL2SS-01 (0.5'-1.0')	ND		RSK7SS-01 (0.5'-1.0')	
Calcium	4	4	434	**1360**	B,N	RSK7SS-01 (0.5'-1.0')	96.1		RSL8SS-01 (0.5'-1.0')	2
Chromium	4	4	14.2	7.7		RSL2SS-01 (0.5'-1.0')	2.9		RSK6SS-01 (0.5'-1.0')	
Cobalt	4	4	30	2.4	B	RSL2SS-01 (0.5'-1.0')	1.3	B	RSK7SS-01 (0.5'-1.0')	
Copper	4	4	25	**57.2**		RSL8SS-01 (0.5'-1.0')	3.7	N	RSK6SS-01 (0.5'-1.0')	1
Iron	4	4	14429	**17,400**	N	RSK6SS-01 (0.5'-1.0')	3500	N	RSL8SS-01 (0.5'-1.0')	1
Lead	4	4	400	33.1		RSK7SS-01 (0.5'-1.0')	6.9		RSK6SS-01 (0.5'-1.0')	
Magnesium	4	4	2122	1760		RSK6SS-01 (0.5'-1.0')	468	B	RSK7SS-01 (0.5'-1.0')	
Manganese	4	4	148	**363**	N	RSK6SS-01 (0.5'-1.0')	52.2	N	RSL8SS-01 (0.5'-1.0')	1
Mercury	4	1	1.84	0.014	B	RSK6SS-01 (0.5'-1.0')			Multiple	
Nickel	4	4	13	4.7		RSL2SS-01 (0.5'-1.0')	1.5	B,N	RSK6SS-01 (0.5'-1.0')	
Potassium	4	4	628	596		RSK6SS-01 (0.5'-1.0')	20.1	B	RSK7SS-01 (0.5'-1.0')	
Silver	4	1	2	0.12	B	RSK7SS-01 (0.5'-1.0')	ND		Multiple	
Sodium	4	2	196	42.2	B	RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Thallium	4	2	0.35	0.33	B	RSK6SS-01 (0.5'-1.0')	ND		Multiple	
Vanadium	4	4	150	11.3		RSL2SS-01 (0.5'-1.0')	4.0		RSK6SS-01 (0.5'-1.0')	
Zinc	4	4	22.4	**79.9**		RSK7SS-01 (0.5'-1.0')	12.6		RSL2SS-01 (0.5'-1.0')	3

- Not Available - Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable.

Table 4-7. Summary of Volatiles Detected in Surface Soils

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Dichloromethane(Meth Chl)	75-092	4	4	0.1	0.0099	J,B	RSL8SS-01 (0.5'-1.0')	0.0011	J,B	RSK6SS-01 (0.5'-1.0')	
2-Propanone (Acetone)	67-64-1	4	3	0.2	0.0066	J,B	RSL2SS-01 (0.5'-1.0')	ND		RSK6SS-01 (0.5'-1.0')	
Toluene	108-88-3	4	1	1.5	0.031	B	RSK6SS-01 (0.5'-1.0')	ND		Multiple	

Table 4-8. Summary of Semi-Volatiles Detected in Surface Soils

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Naphthalene	91-20-3	4	1	13	1.4		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
2-Methylnaphthalene	91-57-6	4	1	36.4	0.57		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Acenaphthylene	208-96-8	4	1	41	0.27	J	RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Acenaphthene	83-32-9	4	1	50	2.8		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Dibenzofuran	132-64-9	4	1	6.2	1.9		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Fluorene	86-73-7	4	1	50	3.1		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Phenanthrene	85-01-8	4	2	50	17	E	RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Anthracene	120-12-7	4	1	50	6.3	E	RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Carbazole	86-74-8		1	NL	3.1		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
Fluoranthene	206-44-0	4	3	50	21	E	RSL2SS-01 (0.5'-1.0')	ND		RSL8SS-01 (0.5'-1.0')	
Pyrene	129-00-0	4	3	50	17	E	RSL2SS-01 (0.5'-1.0')	ND		RSL8SS-01 (0.5'-1.0')	
Benzo(a)anthracene	56-55-3	4	3	.224 or MDL	**15**	E	RSL2SS-01 (0.5'-1.0')	ND		RSL8SS-01 (0.5'-1.0')	2
Chrysene	218-01-9	4	3	0.4	**14**	E	RSL2SS-01 (0.5'-1.0')	ND		RSL8SS-01 (0.5'-1.0')	2
Bis(2-ethylhexyl)phtalate	117-81-7	4	1	50	0.38		RSL8SS-01 (0.5'-1.0')	ND		Multiple	
Benzo(b)fluoranthene	205-99-2	4	2	1.1	**14**	E	RSL2SS-01 (0.5'-1.0')	ND		Multiple	1
Benzo(k)fluoranthene	207-08-9	4	2	1.1	**3.3**		RSL2SS-01 (0.5'-1.0')	ND		Multiple	1
Benzo(a)pyrene	50-32-8	4	3	.061 or MDL	**9.8**	E	RSL2SS-01 (0.5'-1.0')	ND		RSL8SS-01 (0.5'-1.0')	3
Indeno(1,2,3-cd)pyrene	193-39-5	3.2	2	3.2	**3.9**		RSL2SS-01 (0.5'-1.0')	ND		Multiple	1
Dibenz(a,h)anthracene	53-70-3		2	.014 or MDL	**3**		RSL2SS-01 (0.5'-1.0')	ND		Multiple	1
Benzo(ghi)perylene	191-24-2	50	1	50	3		RSL2SS-01 (0.5'-1.0')	ND		Multiple	

Table 4-9. Summary of PCBs Detected in Surface Soils

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Total PCBs	1336-36-3			1.0 Surface 10. Subsurface							
PCB-1248	12672-29-6	4	1	NL	0.2		RSL2SS-01 (0.5'-1.0')	ND		Multiple	
PCB-1260	11096-82-5	4	3	NL	0.2		RSL2SS-01 (0.5'-1.0')	ND		RSK6SS-01 (0.5'-1.0')	

Table 4-10. Summary of Metals Detected in Deep Soils

Analyte	Number Of Samples	Number of Detects	Clean-up Action Limit TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Aluminum	8	8	16,491	1820		RSE1DS-01 (12'-14')	379		RSE2DS-01 (12'-14')	
Antimony	8	1	13.1	0.29	B	RSE1DS-01 (12'-14')	ND		Multiple	
Arsenic	8	8	7.5	3.7		RSE1DS-02 (14'-16')	0.15	B	RSE2DS-01 (12'-14')	
Barium	8	8	300	6.5	B	RSK4DS-02 (8'-10')	2.0	B	RSE2DS-01 (12'-14')	
Beryllium	8	8	0.43	0.11	B	RSE2DS-02 (14'-16')	0.27	B	RSE1DS-02 (14'-16')	
Calcium	8	8	434	**752**		RSD1DS-01 (12'-14')	36.9	B	RSE2DS-01 (12'-14')	1
Chromium	8	8	14.2	4.7		RSD1DS-01 (12'-14')	2.0		RSE2DS-01 (12'-14')	
Cobalt	8	8	30	1.4	B	RSE1DS-01 (12'-14')	0.69	B	RSD1DS-02 (14'-16')	
Copper	8	8	25	3.9		RSE1DS-01 (12'-14')	1.3	B	RSE2DS-01 (12'-14')	
Cyanide	8	1	N/A*	0.15	B	RSL10DS-02 (8'-12')	ND		Multiple	
Iron	8	8	14429	3040		RSE1DS-01 (12'-14')	1060		RSE2DS-01 (12'-14')	
Lead	8	8	400	3.1		RSE1DS-01 (12'-14')	0.67		RSE2DS-01 (12'-14')	
Magnesium	8	8	2122	406	B	RSK4DS-02 (8'-10')	74.0	B	RSE2DS-01 (12'-14')	
Manganese	8	8	148	52.2		RSE1DS-01 (12'-14')	15.2		RSE2DS-01 (12'-14')	
Nickel	8	8	13	2.1	B	RSK4DS-02 (8'-10')	0.8	B	RSE2DS-02 (14'-16')	
Potassium	8	5	628	240	B	RSK4DS-02 (8'-10')	ND		Multiple	
Selenium	8	5	2	0.26	B	RSE1DS-02 (14'-16')	ND		Multiple	
Sodium	8	5	196	38.1	B	RSK4DS-02 (8'-10')	ND		Multiple	
Thallium	8	2	0.35	0.26	B	RSE2DS-02 (14'-16')	ND		Multiple	
Vanadium	8	8	150	6.7	B	RSD1DS-01 (12'-14')	1.5	B	RSE2DS-01 (12'-14')	
Zinc	8	8	22.4	17.3		RSE1DS-01 (12'-14')	3.4	B	RSE2DS-01 (12'-14')	

* Not Available - Some forms of Cyanide are complex and very stable while other forms are pH dependent and hence are very unstable.

Table 4-11. Summary of Volatiles Detected in Deep Soils

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Dichloromethane(Meth Chl)	75-092	8	8	0.1	0.0096	B	RSK4DS-02 (8'-10')	0.0011		RSE1DS-01 (12'-14')	
2-Propanone (Acetone)	67-64-1	8	2	0.2	0.0069	J,B	RSD1DS-01 (12'-14')	ND		Multiple	
Toluene	108-88-3	8	3	1.5	0.006	J	RSK4DS-02 (8'-10')	ND		Multiple	

Table 4-12. Summary of Semi-Volatiles Detected in Deep Soils

Analyte	Chemical abstract services number (CAS#)	Number of Samples	Number of Detects	Cleanup Goal TAGM (mg/kg)	Maximum Concentration (mg/kg)	EPA Qualifier	Location of Maximum Concentration	Minimum Concentration (mg/kg)	EPA Qualifier	Location of Minimum Concentration	# Above TAGM
Acenaphthylene	208-96-8	8	1	41	0.39		RSK4DS-02 (8'-10')	ND		Multiple	
Acenaphthene	83-32-9	8	1	50	1.5		RSK4DS-02 (8'-10')	ND		Multiple	
Dibenzofuran	132-64-9	8	1	6.2	0.73		RSK4DS-02 (8'-10')	ND		Multiple	
Fluorene	86-73-7	8	1	50	1.4		RSK4DS-02 (8'-10')	ND		Multiple	
Phenanthrene	85-01-8	8	1	50	20	E	RSK4DS-02 (8'-10')	ND		Multiple	
Anthracene	120-12-7	8	1	50	7	E	RSK4DS-02 (8'-10')	ND		Multiple	
Carbazole	86-74-8	8	1	NL	0.47		RSK4DS-02 (8'-10')	ND		Multiple	
Fluoranthene	206-44-0	8	2	50	3.2	E	RSK4DS-02 (8'-10')	ND		Multiple	
Pyrene	129-00-0	8	2	50	27	E	RSK4DS-02 (8'-10')	ND		Multiple	
Benzo(a)anthracene	56-55-3	8	2	.224 or MDL	22	E	RSK4DS-02 (8'-10')	ND		Multiple	
Chrysene	218-01-9	8	3	0.4	21	E	RSK4DS-02 (8'-10')	ND		Multiple	
Bis(2-ethylhexyl)phtalate	117-81-7	8	4	50	0.28	J	RSE1DS-01 (12'-14')	ND		Multiple	
Benzo(b)fluoranthene	205-99-2	8	2	1.1	25	E	RSK4DS-02 (8'-10')	ND		Multiple	
Benzo(k)fluoranthene	207-08-9	8	1	1.1	29	E	RSK4DS-02 (8'-10')	ND		Multiple	
Benzo(a)pyrene	50-32-8	8	2	.061 or MDL	9.4	E	RSK4DS-02 (8'-10')	ND		Multiple	
Indeno(1,2,3-cd)pyrene	193-39-5	8	1	3.2	0.11	J	RSL10DS-02 (8'-12')	ND		Multiple	
Dibenz(a,h)anthracene	53-70-3	8	1	.014 or MDL	1.5		RSK4DS-02 (8'-10')	ND		Multiple	

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40 CFR 261- 262 *Hazardous Waste*

40 CFR 761 *Polychlorinated Biphenyls (PCBs)*

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Brookhaven National Laboratory Procedures:

EM-SOP-109	Chain-of-Custody Procedure
EM-SOP-204	Radiochemical Data Verification
EM-SOP-305	Collection of Groundwater Samples from Temporary Wells
EM-SOP-600	Sediment Sampling
EM-SOP-601	Collection of Soil Samples
EM-OPM-4.0	Modification Procedure
EM-OPM-4.6	Hazardous Material Assessment, Analysis, and Mitigation for Decommissioning and Remediation Activities
EM-OPM-4.15	Analysis of Gamma Spectrum Files using Canberra ISOCS® System
FS-SOP-1000	Radiation Survey Techniques
FS-SOP-1001	Contamination Survey Techniques
FS-SOP-1005	Release of Materials from Areas, Controlled for Radiological Purposes
FS-SOP-2010	Periodic Instrument Response Check
FS-SOP-2020	Ludlum Floor Model 239-1F, Set-Up and Operation
FS-SOP-2051	Operation of the Tennelec Low Background Counting Equipment
FS-SOP-4031	Radiological Work Permit
RM-SOP-70	Nuclide Specific Actinide Analysis using Frisch Grid Detection
BSS-4000	Protective Clothing and Equipment, Industrial Hygiene and Safety

Environment, Safety, and Health Standards

ESH 1.3.6	Work Planning and Control for Operations
ESH 2.2.4	Confined Spaces