



3 4456 0386699 3

ORNL/ER/Sub/87-99053/73



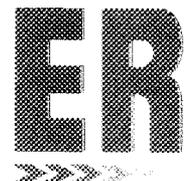
**ENVIRONMENTAL  
RESTORATION  
PROGRAM**

**Site Characterization Report  
for Building 3515 at Oak Ridge  
National Laboratory,  
Oak Ridge, Tennessee**

OAK RIDGE NATIONAL LABORATORY  
CENTRAL RESEARCH LIBRARY  
CIRCULATION SECTION  
ROOM 100N 105  
**LIBRARY LOAN COPY**  
DO NOT TRANSFER TO ANOTHER PERSON  
If you wish someone else to see this  
report, send in name with report and  
the library will arrange a loan.  
NON-TRANSFERABLE

MANAGED BY  
MARTIN MARIETTA ENERGY SYSTEMS, INC.  
FOR THE UNITED STATES  
DEPARTMENT OF ENERGY  
UCM-17562 (8-7-81)

ENERGY SYSTEMS



**Bechtel National, Inc.**

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from 615-576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

ORNL/ER/Sub/87-99053/73

Energy Systems Environmental Restoration Program  
ORNL Environmental Restoration Program

**Site Characterization Report for Building 3515 at Oak Ridge  
National Laboratory, Oak Ridge, Tennessee**

Date Issued—August 1994

Prepared by  
Bechtel National, Inc.  
Oak Ridge, Tennessee  
under subcontract 12B-99053C

Prepared for  
U.S. Department of Energy  
Office of Environmental Restoration and Waste Management  
under budget and reporting code EW 20

Environmental Restoration and Waste Management Programs  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee 37831-6285  
managed by  
MARTIN MARIETTA ENERGY SYSTEMS, INC.  
for the  
U.S. DEPARTMENT OF ENERGY  
under contract DE-AC05-84OR21400



3 4456 0386699 3

# CONTENTS

FIGURES .....	iv
TABLES .....	vi
ACRONYMS .....	vii
EXECUTIVE SUMMARY .....	viii
1. INTRODUCTION .....	1-1
2. SITE DESCRIPTION .....	2-1
2.1 LOCATION .....	2-1
2.2 SOURCES OF INFORMATION .....	2-1
2.3 BACKGROUND .....	2-4
2.4 BUILDING EXTERIOR .....	2-6
2.4.1 North Side .....	2-6
2.4.2 East Side .....	2-10
2.4.3 South Side and Building Slab .....	2-10
2.4.4 West Side .....	2-13
2.4.5 Roof .....	2-13
2.5 NORTH CELL INTERIOR .....	2-13
2.6 SOUTH CELL INTERIOR .....	2-21
3. CHARACTERIZATION METHODS .....	3-1
3.1 INSPECTIONS .....	3-1
3.2 SAMPLING AND ANALYSIS .....	3-1
3.3 RADIOLOGICAL MEASUREMENTS .....	3-4
3.4 FIELD QUALITY CONTROL .....	3-4
4. CHEMICAL SAMPLING AND ANALYSIS .....	4-1
4.1 DATA PRESENTATION .....	4-1
4.2 DATA USABILITY ASSESSMENT .....	4-2
4.3 VOC CONTAMINATION .....	4-5
4.4 BNAE CONTAMINATION .....	4-5
4.5 PESTICIDE/PCB CONTAMINATION .....	4-5
4.6 METALS AND CYANIDE CONTAMINATION .....	4-6
4.7 LEAD SHIELDING .....	4-9
4.8 HISTORICAL SOIL SAMPLING EXTERIOR TO BUILDING 3515 .....	4-10
4.9 SUMMARY .....	4-15
5. RADIOLOGICAL SAMPLING AND ANALYSIS .....	5-1
5.1 DATA PRESENTATION .....	5-1
5.2 DATA USABILITY ASSESSMENT .....	5-1
5.3 ASL RESULTS .....	5-5
5.3.1 Concrete Core 3 ft from South Outside Wall (73.SB001, Sample 04131) .....	5-5
5.3.2 Concrete Core 8 ft from South Outside Wall (73.SB002, Sample 04130) .....	5-5
5.3.3 Concrete Core 8 ft from South Outside Wall (73.SB002, Sample 04279) .....	5-5
5.3.4 Outside Soil Under the Concrete Pad (73.SB002, Sample 03932) .....	5-5
5.3.5 Paint Chip from South Cell Wall (72.SB004, Sample 04045) .....	5-6

5.4	HISTORICAL SOIL SAMPLING EXTERIOR TO BUILDING 3515	5-6
5.5	SUMMARY	5-8
6.	RADIOLOGICAL FIELD MEASUREMENTS	6-1
6.1	DATA PRESENTATION	6-1
6.2	DATA USABILITY ASSESSMENT	6-1
6.2.1	Precision	6-1
6.2.2	Accuracy	6-1
6.2.3	Representativeness	6-2
6.2.4	Completeness	6-2
6.2.5	Comparability	6-2
6.3	FIELD MEASUREMENTS	6-2
6.3.1	North Cell	6-3
6.3.2	South Cell	6-9
6.3.3	Concrete Core Slit Scanning	6-23
6.4	OTHER OBSERVATIONS	6-39
6.5	SUMMARY	6-39
7.	WASTE TYPES AND VOLUME ESTIMATES	7-1
7.1	WASTE DISPOSAL TYPES	7-1
7.1.1	Radioactive	7-1
7.1.2	Hazardous	7-2
7.1.3	Mixed	7-2
7.1.4	Sanitary	7-3
7.1.5	Summary and Uncertainties	7-3
7.2	WASTE DISPOSAL VOLUMES	7-3
7.3	TOTAL CURIE ESTIMATES	7-4
8.	SUMMARY AND CONCLUSIONS	8-1
8.1	ENGINEERING PLANNING	8-1
8.2	PERSONNEL PROTECTION PLANNING	8-2
8.3	WASTE MANAGEMENT PLANNING	8-2
8.4	CONCLUSIONS	8-4
9.	REFERENCES	9-1
Appendix A:	Listing of historical ORNL Drawings and Photographs of Building 3515	A-1
Appendix B:	Structural Condition Assessment for Decontamination and Decommissioning of Building 3515	B-1
Appendix C:	Field Investigation Measurement Equipment	C-1
Appendix D:	Contract-Required Detection Limits for TAL Inorganics and Contract- Required Quantitation Limits for TCL VOCs, SVOCs, and Pesticides/PCBs	D-1
Appendix E:	Detailed Field Measurement Results	E-1

## FIGURES

2.1a	Site Plan . . . . .	2-2
2.1b	Aerial photograph of South Tank Farm area and Building 3515 . . . . .	2-3
2.2	Plan and elevation views . . . . .	pocket
2.3a	North wall exterior . . . . .	2-7
2.3b	East wall exterior . . . . .	2-7
2.3c	West wall exterior . . . . .	2-7
2.3d	South wall exterior . . . . .	2-7
2.4	Copy of historical ORNL drawing A-RD-2108: Building 3515 alterations . . . . .	2-8
2.5a	Historical photograph: product sample and removal station exterior . . . . .	2-9
2.5b	Historical photograph: top view of the product sample and removal station interior . . . . .	2-9
2.5c	Present-day photograph: entombed product sample and removal station . . . . .	2-9
2.6	West wall of gallery or control room on east side of north cell . . . . .	2-11
2.7	Electrical conduit lying at the base of the east wall . . . . .	2-12
2.8	Concrete pad by the south wall . . . . .	2-12
2.9	Concrete core (location 73.SB002) from the concrete pad south of Building 3515 . . . . .	2-14
2.10	Blocked-up entrance ways to cells on the west wall . . . . .	2-14
2.11	Two concrete cores from the north cell door . . . . .	2-15
2.12a	Single concrete core from the south cell door . . . . .	2-15
2.12b	Stacked block filling the south cell entrance way . . . . .	2-16
2.13	North cell interior: composite photograph of vessel S-5, manometer board, and equipment rack . . . . .	2-18
2.14	North cell interior: composite photograph showing overhead view of cell from cell doorway . . . . .	2-19
2.15	North cell interior: northwest corner . . . . .	2-20
2.16	North cell interior: southwest corner of cell behind vessel S-5 . . . . .	2-20
2.17	Historical photograph showing extension handles from north cell equipment rack penetrating east wall to control room . . . . .	2-22
2.18	Location of vessels on the north cell equipment rack . . . . .	2-23
2.19	Historic (1953) photographs of individual sections of the north cell equipment rack . . . . .	2-25 through 2-31
2.20	South cell . . . . .	2-33
2.21	South cell . . . . .	2-34
2.22	South cell: composite photograph from entrance way showing north and east portions of cell . . . . .	2-36
2.23	South cell: composite photograph of cesium transfer tank and entrance way floor . . . . .	2-37
2.24	South cell: composite photograph of floor area behind (to the east of) cesium transfer tank . . . . .	2-38
2.25	South cell: composite photograph of southeast corner and south . . . . .	2-39
2.26	South cell: bottom portion of southwest corner . . . . .	2-40

3.1	Concrete core and soil sampling locations . . . . .	3-2
4.1	WAG 1 soil boring locations near Building 3515 . . . . .	4-11
6.1	Penetration distance of long-handled tools into cells from access holes . . . . .	6-4
6.2	Access to the south cell . . . . .	6-5
6.3	North cell teletector measurement results . . . . .	6-6
6.4	North cell HP-290 directional probe results . . . . .	6-7
6.5	North cell exposure profile from HP-290 and teletector probes . . . . .	6-8
6.6	North cell TLD results (deep dose) . . . . .	6-10
6.7	North cell TLD results (shallow dose) . . . . .	6-11
6.8	North cell TLD results (up) . . . . .	6-12
6.9	North cell TLD results (down) . . . . .	6-13
6.10	North cell TLD results (south) . . . . .	6-14
6.11	North cell TLD results (north) . . . . .	6-15
6.12	North cell exposure profile from TLDs and teletector probes . . . . .	6-16
6.13	Access to the north cell . . . . .	6-17
6.14	South cell teletector measurement results . . . . .	6-19
6.15	South cell directional HP-290 probe results . . . . .	6-20
6.16	South cell directional HP-220A results . . . . .	6-21
6.17	South cell exposure profile from HP-290 and teletector probes . . . . .	6-22
6.18	South cell TLD results (shallow dose) . . . . .	6-24
6.19	South cell TLD results (deep dose) . . . . .	6-25
6.20	South cell TLD results (up) . . . . .	6-26
6.21	South cell TLD results (down) . . . . .	6-27
6.22	South cell TLD results (south) . . . . .	6-28
6.23	South cell TLD results (north) . . . . .	6-29
6.24	South cell exposure profile from TLDs and teletector probe . . . . .	6-30
6.25	View from penetration, south cell . . . . .	6-32
6.26	Gamma spectroscopy (HPGe) slit scanning geometry/configuration . . . . .	6-34
6.27	Slit scanning results for concrete core 73.SB001 . . . . .	6-37
6.28	Slit scanning results for concrete core 73.SB002 . . . . .	6-38

## TABLES

2.1	Vessels on the north cell equipment rack . . . . .	2-24
3.1	Sampling summary . . . . .	3-3
4.1	Analytical detects for organic compounds . . . . .	4-4
4.2	Analytical results for metals and cyanide . . . . .	4-7
4.3	Chemical sampling summary for WAG 1 soil borings near Building 3515 . .	4-11
4.4	Analytical detects for organic compounds in WAG 1 soil borings . . . . .	4-12
4.5	Analytical results for metals and cyanide in WAG 1 soil borings . . . . .	4-13
5.1	Analytical methods . . . . .	5-2
5.2	Radiological analysis results for Building 3515 . . . . .	5-3
5.3	Radiological sampling summary for WAG 1 soil borings near Building 3515 .	5-6
5.4	Radionuclide concentrations in WAG 1 soil samples taken near Building 3515	5-7
6.1	South cell smear measurement results . . . . .	6-31
6.2	Slit scanning results for core 73.SB001 . . . . .	6-35
6.3	Slit scanning results for core 73.SB002 . . . . .	6-36
7.1	Disposal volume estimates (ft <sup>3</sup> ) . . . . .	7-5
7.2	Curie estimate for concrete in Building 3515 . . . . .	7-6
E.1	Teletector readings in the north cell as a function of distance . . . . .	E-2
E.2	HP-290 directional detector results for north cell as a function of distance . .	E-2
E.3	TLD string results for north cell, shallow dose (H <sub>s</sub> ) . . . . .	E-3
E.4	TLD string results for north cell, deep dose (H <sub>d</sub> ) . . . . .	E-3
E.5	Teletector readings for south cell as a function of distance . . . . .	E-4
E.6	HP-290 directional detector results for south cell as function of distance . . .	E-4
E.7	HP-220A directional detector results for south cell as a function of distance . .	E-5
E.8	TLD string results for south cell, shallow dose (H <sub>s</sub> ) . . . . .	E-5
E.9	TLD string results for south cell, deep dose (H <sub>d</sub> ) . . . . .	E-6

## ACRONYMS

ALARA	as low as reasonably achievable
ASL	analytical subcontract laboratory
BNAE	base/neutral/acid-extractable
BZA	breathing zone apparatus
CH	contact-handled
CLP	Contract Laboratory Program
CSL	Close Support Laboratory
D&D	decontamination and decommissioning
DOE	Department of Energy
EPA	Environmental Protection Agency
FWG	field work guide
GAAT OU	Gunite and Associated Tasks Operable Unit
GC-MS	gas chromatography/mass spectrometry
HPGe	high-purity germanium
LDR	land disposal restriction
LSA	low specific activity
MDL	minimum detection limit
ORNL	Oak Ridge National Laboratory
PCB	polychlorinated biphenyl
QC	quality control
RCRA	Resource Conservation and Recovery Act
RH	remote-handled
RI/FS	remedial investigation/feasibility study
ROI	region of interest
RPD	relative percent difference
SLLW	solid low-level waste
SWSA	solid waste storage area
TAL	Target Analyte List
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TIC	tentatively identified compound
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TRU	transuranic
TSCA	Toxic Substances Control Act
VOC	volatile organic compound
VLA	very low activity
WAG	waste area grouping

## EXECUTIVE SUMMARY

### BACKGROUND

Building 3515 at Oak Ridge National Laboratory (ORNL), also known as the Fission Product Pilot Plant, is a surplus facility in the main plant area to the east of the South Tank Farm slated for decontamination and decommissioning (D&D). The building consists of two concrete cells (north and south) on a concrete pad and was used to extract radioisotopes of ruthenium, strontium, cesium, cerium, rhenium and other elements from aqueous fission product waste.

Building 3515 is within the administrative boundary of the Gunite and Associated Tanks (GAAT) Operable Unit (OU). The contaminated soil surrounding Building 3515 is currently assigned to the GAAT OU remediation project. D&D of Building 3515 and remediation of the tanks and soils within the GAAT OU must be coordinated to avoid interference between these two projects.

Site characterization activities were performed to collect the information needed to plan the D&D of this building. The characterization followed the *Site Characterization Plan for Decontamination and Decommissioning of Buildings 3506 and 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, which presents a detailed discussion of data needs, uses, and collection methods.

### OBJECTIVES AND APPROACH

The objective of the site characterization was to provide information necessary for engineering evaluation and planning of D&D approaches, planning for personal protection of D&D workers, and estimating waste volumes from D&D activities. This site characterization report documents the investigation with a site description, a summary of characterization methods, chemical and radiological sample analysis results, field measurement results, and waste volume estimates.

Because the general area gamma radiation levels in the cells are high, characterization of the building interior was limited to remote general area measurements, gross smears, photographs, and a video. Openings in cell doorways were made just large enough to provide remote access for instruments deployed on long poles. This approach was based on ALARA (as low as reasonably achievable) principles and was in accordance with a tiered characterization scope outlined in the approved characterization plan.

Because of the limited remote characterization performed inside the building, planning for D&D implementation may require that additional information be obtained, either before or during phased implementation. Future characterization to address data needs could include core sampling from the cell walls and floors, smears from the core locations, detritus samples from the floor, and directional surveys of the equipment and specific floor areas to better define the source term.

## SUMMARY OF FINDINGS

No decontamination was performed on Building 3515 after it was abandoned in the late 1950s, and the interior, including the process piping and equipment, remains essentially unchanged. Alterations to the building were made circa 1964 to seal the doorways and add exterior shielding (e.g., increase wall thicknesses) and again in 1988 to repair cracks in the roof. The structural integrity of the building is adequate (i.e., the building will remain structurally intact) for safe decontamination or demolition. However, according to early ORNL drawings, a portion of the south wall and a portion of the roof of the south cell may consist of stacked (unmortared) concrete block. Stacked blocks also fill portions of the cell entrance ways. Road access and the sealed doorways are on the west side of the building.

The general area exposure rate in the north cell ranges from approximately 0.2 R/h at 1 ft from the access hole to 23 R/h at 8 ft. The general area exposure rate in the south cell ranges from approximately 25 mR/h at 3.5 ft from the penetration to 450 mR/h at 7.5 ft.

Directional measurements in the north cell show that the exposure rates due to the floor are higher than those due to walls. This is also the case in the south cell except at a distance of 5 to 7 ft from the penetration, where the south wall produces higher exposure rates, perhaps caused by some of the piping in that direction.

North cell thermoluminescent dosimeter (TLD) string results range from approximately 12 to 21,400 mrem/h for deep dose rate and 12 to 21,420 mrem/h for shallow dose rate. South cell TLD string results range from approximately 20 to 584 mrem/h for deep dose rate and 4 to 6952 mrem/h for shallow dose rate. The deep dose results indicate that the floor direction exhibits higher activity than the walls in both cells, but the shallow dose results in the south cell indicate that the south wall direction exhibits the highest dose rate. Comparison of deep versus shallow dose rates in the north cell showed no appreciable difference, indicating that most of the dose rate is caused by penetrating ionizing radiation fields, but the south cell results indicate the opposite.

Comparison of direct measurements and gross smears indicates that most of the contamination is fixed or inside the process equipment. Contamination of process piping and equipment was not investigated.

Alpha activity in the south cell smears is fairly low (<20 dpm/smear) for equipment, piping, and walls. The secondary smear obtained from the south cell floor indicates an alpha activity level of 30 pCi/smear; the smear from the north cell floor indicates approximately 40 pCi/smear. The low alpha activity in the cells is expected, given the process history.

Three cores were obtained from the concrete pad outside Building 3515. Slit scanning performed on the cores indicates that most of the measured activity is at the bottom where the pad contacts underlying soil. The activity distribution from the top of the core to near the bottom is relatively uniform and near measurement area background, but at the bottom, the activity suddenly increases. The higher activity at the bottom was expected, given the historical reports that the underground drain line leaked and contaminated liquid sometimes bubbled up through the soil. The contaminated soil is also a concern from the standpoint of safeguarding worker health during Building 3515 D&D. No Resource Conservation and

Recovery Act (RCRA) constituent metals or organics were found in the core samples. No core samples were taken from the building interior because of the prohibitively high radiation readings, and the radiological and chemical findings for the "outside" cores should not be considered representative of the concrete comprising the walls and floors of the cells.

Analyses for inorganics indicated two potential RCRA constituent metals (lead and mercury) for a soil sample from under the concrete pad and two (barium and lead) for a paint chip sample. A toxicity characteristic leaching procedure test can determine whether they are RCRA constituents.

Lead shielding, considered a mixed low-level radioactive waste, is indicated at several building locations in drawings and photographs. Most of the lead is in the form of bricks around the cesium crystallizer in the south cell and around the product sample and recovery station on the north face of the building. Drawings show a thick lead plate on the ground (under a gravel cover) adjacent to the east side of the building.

Concrete rubble will be by far the largest volume (over 6500 ft<sup>3</sup>) of waste generated. Classification of the concrete waste [remote-handled solid low-level waste (SLLW) for interior original walls, contact-handled SLLW for exterior pad and outside shield concrete, or very low activity] will depend on the D&D techniques used. Waste generated from demolition of building construction materials (e.g., concrete, soil, or sediment) and packaged in 55-gal drums or low-specific-activity boxes would not be considered fissile or transuranic waste.

# 1. INTRODUCTION

Building 3515 at Oak Ridge National Laboratory (ORNL), also known as the Fission Product Pilot Plant, is a surplus facility slated for decontamination and decommissioning (D&D). Site characterization activities were performed from December 1993 through February 1994 to collect the information needed to plan the D&D of this building. The characterization followed the *Site Characterization Plan for Decontamination and Decommissioning of Buildings 3506 and 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (Bechtel 1993a). This site characterization report presents the results of the investigation of Building 3515.

The objective of this field investigation and site characterization report is to provide information necessary for

- engineering evaluation and planning of D&D approaches,
- planning for personnel protection of D&D workers, and
- estimating waste volumes from D&D activities.

The characterization plan (Bechtel 1993a) presents an extensive discussion of the data needs, uses, and collection methods, and this information is not repeated here.

Site characterization consisted of three main activities: inspections, radiological measurements, and radiological and chemical sampling and analyses. The inspections recorded general facility conditions, as-built information, and specialized information such as a structural evaluation. The radiological measurements defined the quantity and distribution of radioactive contaminants. This information was used to calibrate a dose model of the facility and thus estimate the total activity, in curies, of each major radioactive isotope. Lastly, samples were taken and analyzed for radiological and chemical constituents. The radiological information was used to refine the radiological model of the facility, and the hazardous chemical information will be used for waste management planning.

During planning, it was acknowledged that radiation and contamination levels in Building 3515 were expected to be high. Therefore, using ALARA (as low as reasonably achievable) principles, the approved site characterization plan outlined a three-tiered approach for accessing the building during the field investigation. The general area gamma radiation level in the cells was one of the key decision criteria.

Tier	Approximate Criterion	Access and Scope of Characterization
1	< 100 mrem/h	Manned entry, full characterization
2	100–500 mrem/h	Manned entry, limited characterization
3	> 500 mrem/h	Limited remote characterization

Evaluation of teletector radiation readings (discussed in Sect. 6) taken through holes in the cell doorways indicated that the investigation should be Tier 3. Therefore, doorway openings

were only made large enough to provide remote access for instruments deployed on long poles, and the characterization scope for the building interior was limited to general area measurements and gross smears. Location-specific measurements, concrete core samples, subfloor soil samples, and other miscellaneous samples from the cell interior that could have provided useful data to meet site characterization objectives were prohibited under Tier 3 conditions.

This site characterization was done under the ORNL Remedial Investigation/Feasibility Study (RI/FS) Project and made extensive use of the existing programmatic structures. Permanent records of this investigation (including logbooks, photographs, laboratory analytical results, and engineering calculations) are maintained as RI/FS Project records.

The remainder of this report is organized into a site description (Sect. 2), a summary description of characterization methods (Sect. 3), chemical and radiological sample analysis results (Sects. 4 and 5), field measurement results (Sect. 6), and waste volume estimates (Sect. 7), and summary and conclusions (Sect. 8).

## 2. SITE DESCRIPTION

### 2.1 LOCATION

Building 3515 is in Bethel Valley in the ORNL main plant area, as shown in Fig. 2.1a. It is on the east side of the South Tank Farm, near the intersection of Central Avenue and Fourth Street. ORNL grid coordinates are approximately N21,940 and E31,030. Figure 2.1b is a 1986 aerial photograph of the South Tank Farm area and Building 3515.

Building 3515 is within the administrative boundary of the Gunitite and Associated Tanks (GAAT) Operable Unit (OU). The contaminated soil within the GAAT OU and surrounding Building 3515 is currently outside the scope of D&D activities. The Building 3515 D&D and the remediation of the tanks and soils within the GAAT OU must be coordinated to avoid interference between these two projects. The contaminated soil is also a concern from the standpoint of safeguarding worker health during Building 3515 D&D.

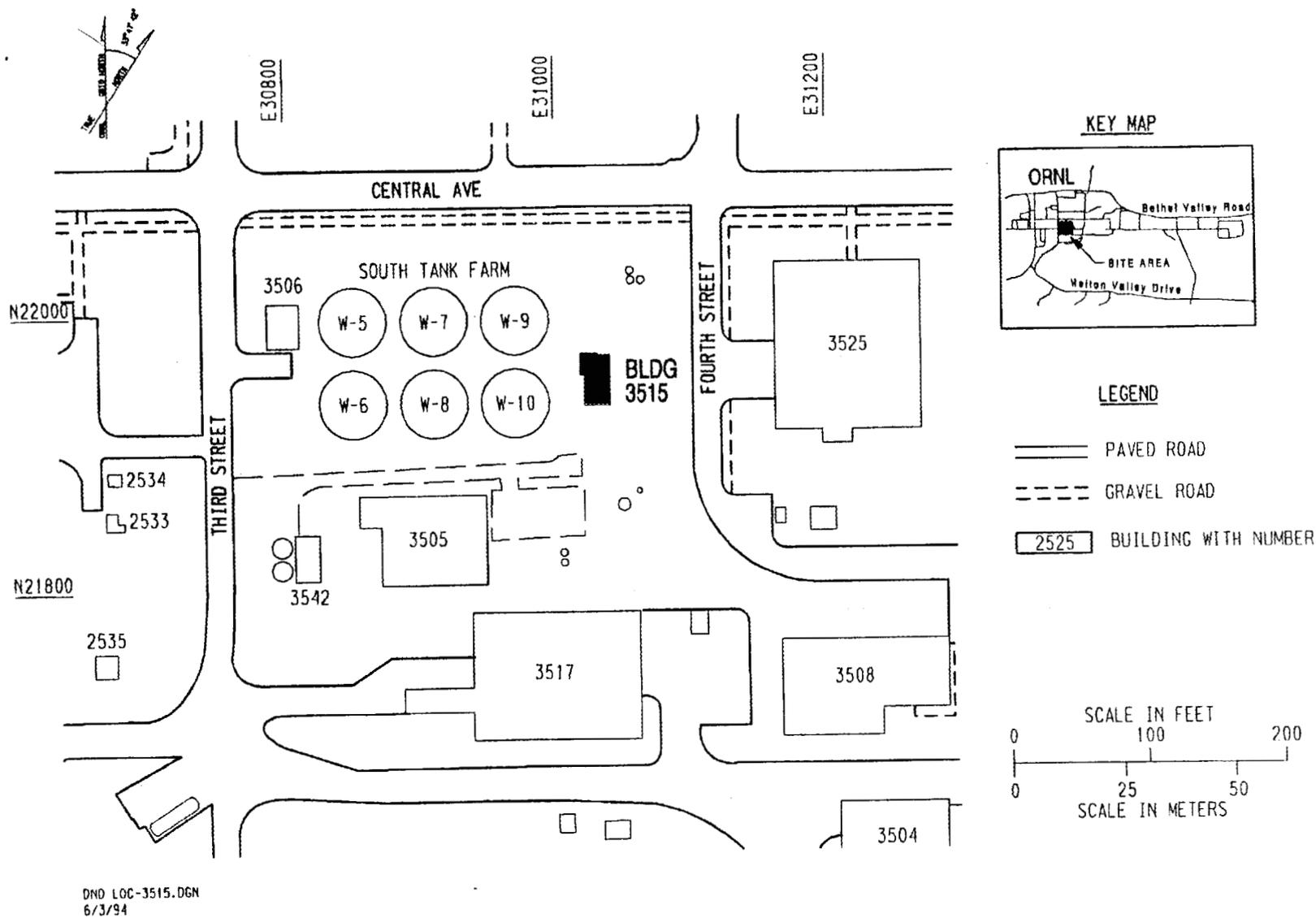
### 2.2 SOURCES OF INFORMATION

Appendix A lists historical drawings of Building 3515 obtained from ORNL. The principal drawings can be grouped as follows.

- Cell construction, piping, and equipment (multiple drawings dated May 1950).
- Building alterations and additions (multiple drawings dated November 1950 through June 1951).
- "EV process" flow and equipment (multiple drawings dated November 1950 through July 1951. (Note: the acronym "EV" was not defined in the drawings.)
- Location of holes through control room wall to north and south cells (single drawing dated November 1951).
- "Caesar process" flow, sampling stations, and equipment (multiple drawings dated December 1951 through September 1952).
- "FPP process" flow (single drawing dated September 1953).
- Building alterations/entombment (single drawing dated May 1964).

Historical photographs were also obtained from ORNL (see complete listing in Appendix A):

- Black and white photographs dated October 1952 that include the control room interior (one), the exterior north face of the building (one), the product and sample removal station



2-2

Fig. 2.1a. Site plan.



Fig.2.1b. Aerial photograph of South Tank Farm area and Building 3515. (ORNL photo 2077-86; 1986)

(one), and the north cell interior (multiple) that closely correspond to the "Caesar process" drawings dated January through July 1952.

- Multiple black and white photographs of the north cell interior dated September 1953; these photographs show much of the same equipment and piping as the October 1952 photographs, with a few equipment changes.
- Two black and white photographs of the south cell interior dated October 1952.
- One color photograph dated 1986 and three color photographs dated 1988 of the building exterior.

Many of these known drawings and photographs are obsolete because the equipment or piping has been changed and the building modified.

Inspections, radiological measurements, and radiological and chemical sampling planned for Building 3515 as 1993–94 site characterization tasks were severely curtailed for the building interior because of access limitations caused by high radiological contamination and dose rates. The characterization tasks were performed using long-handled tools inserted through small holes drilled in the blocked-up building doorways.

Photographs of the building interior were taken with a camera attached to the end of a long pole, which limited the number of different perspectives and the general quality of the photographs. Some of the figures shown in this report are composites of individual photographs and thus may have jagged borders, color discontinuities, or equipment/piping misalignments.

A 45-min video (VHS format) of the building interior was taken in January 1994 with a video camera attached to the end of a long pole. The videocassette has been placed in the RI/FS Program records.

## **2.3 BACKGROUND**

Building 3515 housed an operational pilot system for fission product recovery development from 1948 to 1958. For most of that period, the facility consisted essentially of a two-room hot cell with a control room or lean-to structure along the east and south sides of the building. After operations were moved to the Fission Product Development Laboratory (Building 3517), Building 3515 was abandoned and subsequently entombed in a concrete shell that remains today.

Prior analyses of the building with a portable gamma spectroscopy system (Simpson 1984) indicate that the principal source of gamma radiation is cesium-137. Records indicate that strontium-90 is also present inside the structure, although it would be undetectable on the outside (Simpson 1984). Ruthenium, rhenium, and cerium were also extracted within the facility; however, given that their half-lives are 1 year or less, they are not expected to be present in significant quantities.

The following history of the facility is taken from Horton (1984).

The Fission Product Pilot Plant facility, as now named, first existed in 1948 and was referred to as the  $^{106}\text{Ru}$  tank arrangement. At that time, the facility consisted of a concrete pad with tanks surrounded by stacks of concrete blocks three rows deep. A tent once surrounded the pad. Several modifications around 1950-51 resulted in construction of a hot cell with 18-in.-thick walls and a 2-ft-thick concrete roof. Lean-to buildings, which were added on the east and south sides, were later removed down to the concrete pad. The remaining hot cell portion of the building now has all doors sealed with concrete block and mortar. Additional concrete block shielding 2 to 3 ft thick was added bringing the total hot cell wall thickness in most areas up to around 3.5 to 4.5 ft.

The Fission Product Pilot Plant was used to extract radioisotopes of ruthenium, strontium, cesium, cerium, and other elements from liquid waste. The waste came from the ORNL operations and from the Canadian Chalk River cleanup operation.

The Fission Product Pilot Plant has not been used since the late 1950s. The concrete interior, particularly the concrete floor, was frequently soaked with contaminated waste and is very radioactive. When maintenance was required during facility operations, personnel entered the cells only after several weeks of decontamination by overflowing the piping and vessels with purge liquid followed by spraying down the equipment, walls, and floor for several weeks with ceiling-mounted sprays. Finally a few masonry blocks would be removed from the door to permit final spraying and decontamination using long-handled tools. A floor drain in the concrete floor exited under the lean-to room on the east side and turned southward to the waste tank. At times, the lean-to room had to be evacuated due to high radiation levels from the line. The line leaked outside the building and contaminated liquid sometimes bubbled up through the soil.

According to a former process design engineer who began work at ORNL in 1951 and was familiar with the fractional crystallization process, the feed solutions to Building 3515 were aqueous and contained mixed fission products. The feed solutions did not contain significant quantities of transuranics or organics. Flow between vessels was by gravity feed or steam jet; no pumps were used for fluid transport. Acids (e.g., nitric acid and sometimes sulfuric acid) as well as caustic solutions (e.g., sodium hydroxide and potassium hydroxide) were added to the process for unit operations (e.g., to change solution pH) and for decontamination of the equipment, pipelines, and other cell areas. Decontamination of the equipment and piping occurred with circulating solutions, but the former employee disagreed that the purge liquid was allowed to overflow the piping and vessels onto the floor as suggested by Horton (1984). However, spills and leakage around valve packing did occur (ORNL 1994) and the floor is highly contaminated.

In 1976, Building 3515 was transferred into the Surplus Facilities Management Program for routine surveillance and maintenance, and in 1988, cracks in the roof were repaired to prevent migration of contamination. The building is now in the D&D Program.

## 2.4 BUILDING EXTERIOR

Building 3515 currently consists of a north and a south cell with thick concrete walls on a concrete pad as shown in Fig. 2.2. (Note: this figure is oversized and is in the pocket at the back of this report.) The figure shows the exterior dimensions of the building as measured during the site investigation and the interior dimensions as estimated from available drawings.

The exterior of Building 3515 is painted and maintained by ORNL. Covering the ground on the north, east, and south sides of the building is a layer of plastic and pea gravel. Road access is on the west side of the building.

Figure 2.3 presents photographs of the north, south, east, and west elevation views of the building exterior as it appeared in June 1993. Additional details can be obtained from Fig. 2.4, an ORNL drawing entitled "Building 3515 Alterations" (drawing A-RD-2108, dated March 25, 1964). Although the sketch is not an as-built (i.e., the building footprint is not exact), it is assumed with no evidence to the contrary that the sketch indicates construction actually performed. Important exterior features noted from the 1993-94 photographs and the 1964 ORNL sketch are discussed below.

### 2.4.1 North Side

Attached to the north wall is the "product sample and removal station." The interior of the station was not accessed during site characterization; it is entombed with concrete blocks and, according to Fig. 2.4, the station interior has also been filled with concrete. Figure 2.5a shows an October 1952 photograph of the station exterior (and on the ground near the station, a lead-filled carrier for product transport), Fig. 2.5b shows a 1952 photograph of the station interior (see also the corresponding design drawings D-RD-645 and -646), and Fig. 2.5c shows the present-day entombment of the station.

The building exterior in Fig. 2.5a appears to match the alterations implemented from ORNL drawing D-RD-613 (January 1952). These alterations consisted of the following.

- Adding concrete fill plus 4 in. by 8 in. by 15 in. concrete blocks (for a total additional wall thickness of 1 ft) to the outside of the north and west walls of the north cell.
- Adding a new layer of 2 in. by 4 in. by 8 in. lead bricks on the three exposed sides of the product sample and removal station; available records do not indicate whether the lead bricks were removed before entombment.
- Constructing a new reinforced concrete pad (3 ft by 14 ft by 6 in. deep) just to the north of the product sample and removal station. This pad, though present in the historical photograph (Fig. 2.5a), does not appear in the present-day photograph (Fig. 2.3a).

Within 8 ft to the north of Building 3515 and near the product sample and removal station is a utility pole with active power lines. At the base of the utility pole and situated on a metal frame and concrete pad are electrical junction boxes.

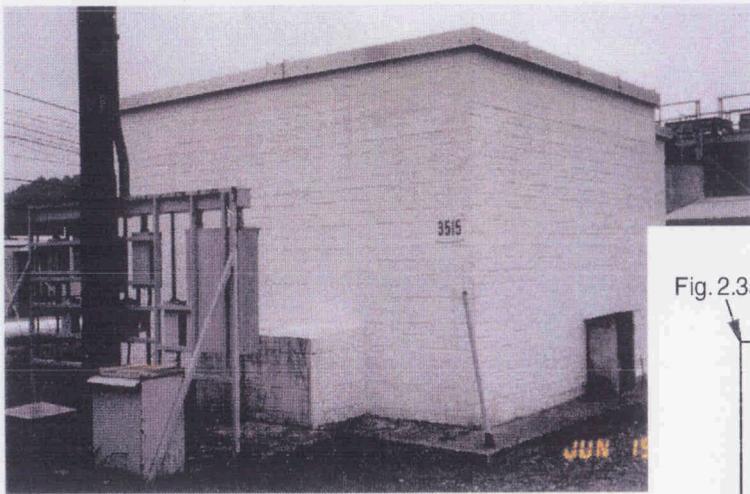


Fig. 2.3 a. North wall exterior.

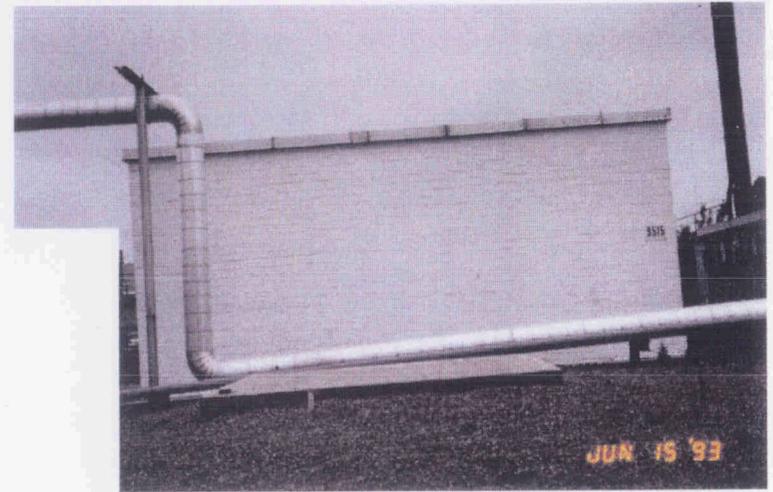


Fig. 2.3 b. East wall exterior.

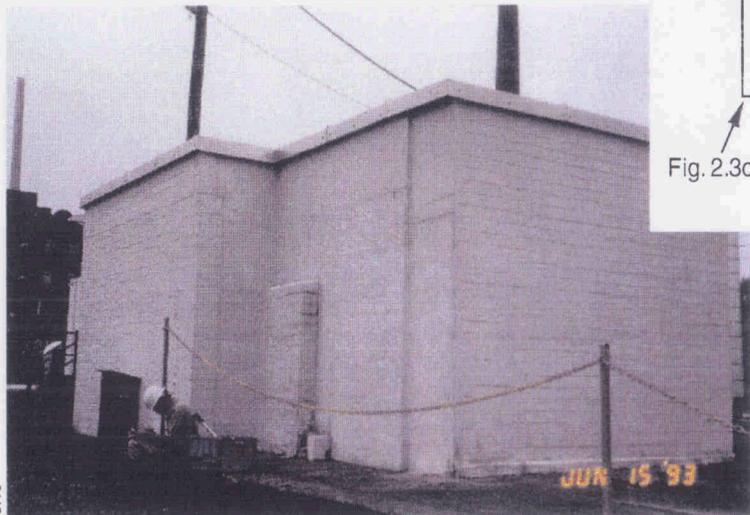
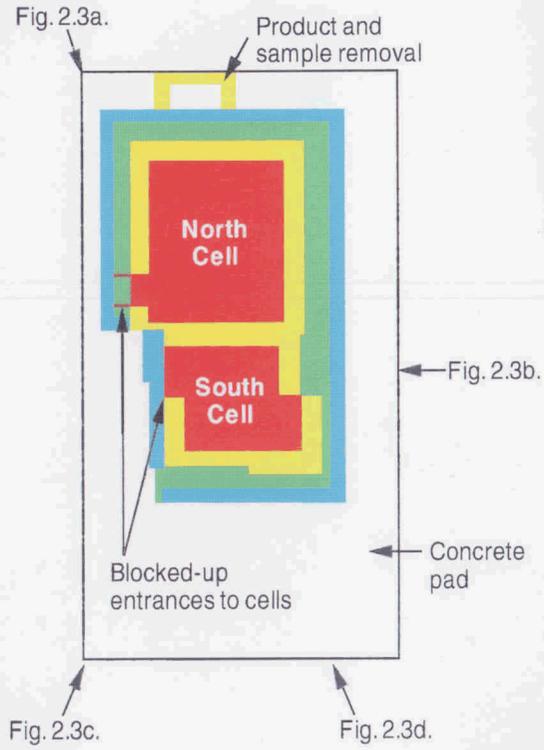


Fig. 2.3 c. West wall exterior.

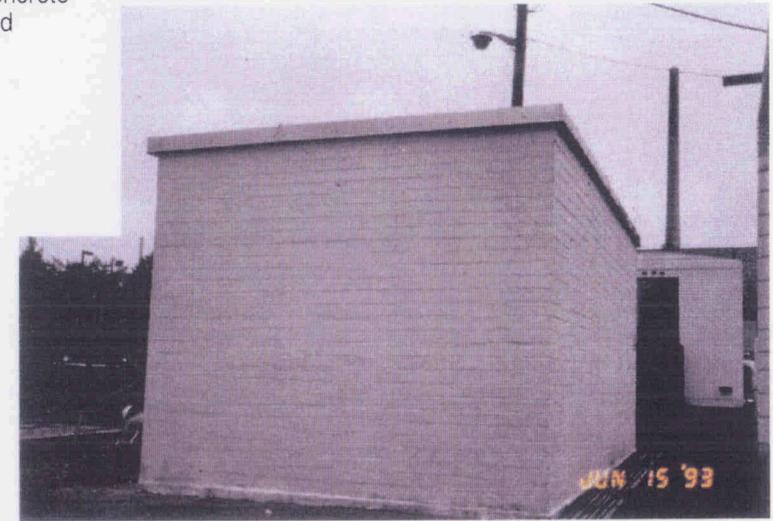
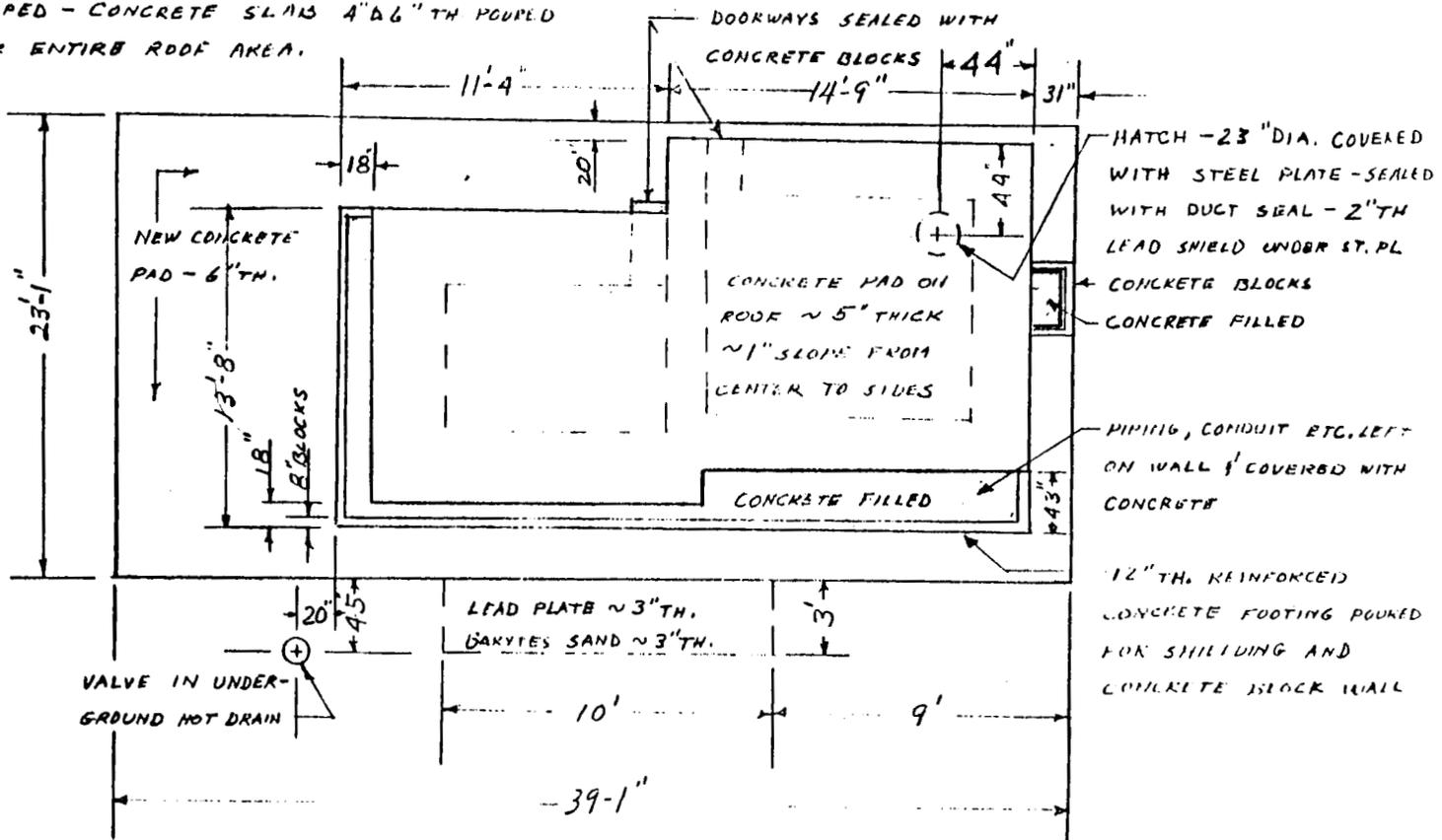
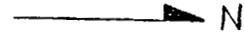


Fig. 2.3 d. South wall exterior.

Building 3515 plan.

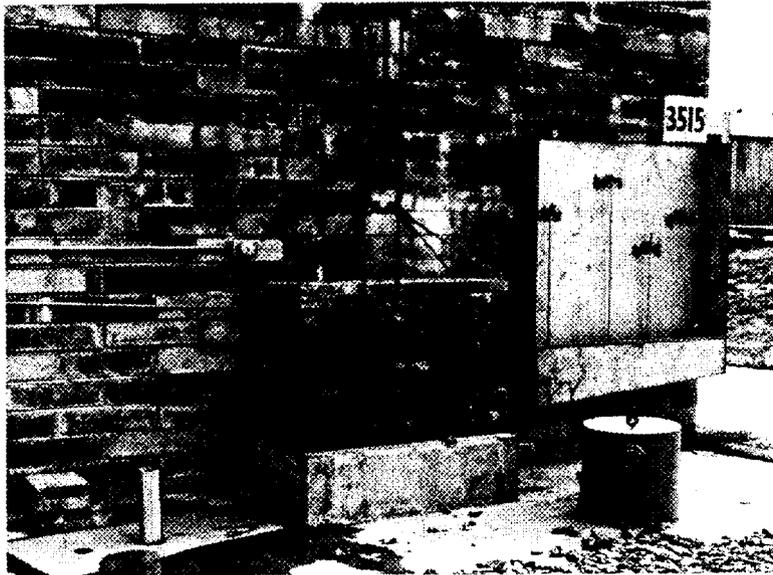
ALL PIPING, FUNNELS ETC FROM CELL ROOF TO  
 INSIDE OF CELLS CUT OFF ~3" ABOVE ROOF  
 & CAPPED - CONCRETE SLABS 4" & 6" TH POURED  
 OVER ENTIRE ROOF AREA.



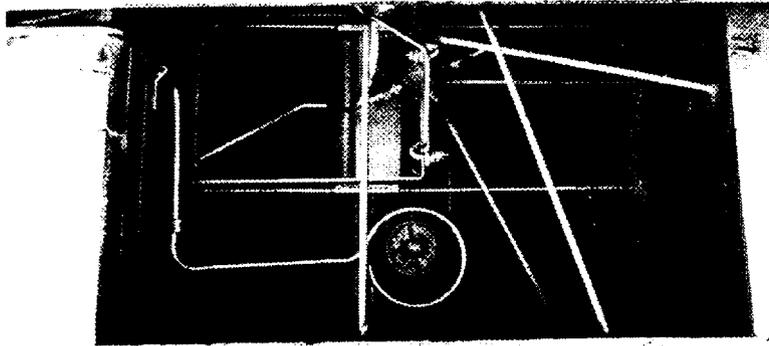
2-8

A-RD-2108  
 BLDG. 3515 ALTERATIONS  
 3/25/64 E.S. Pierce

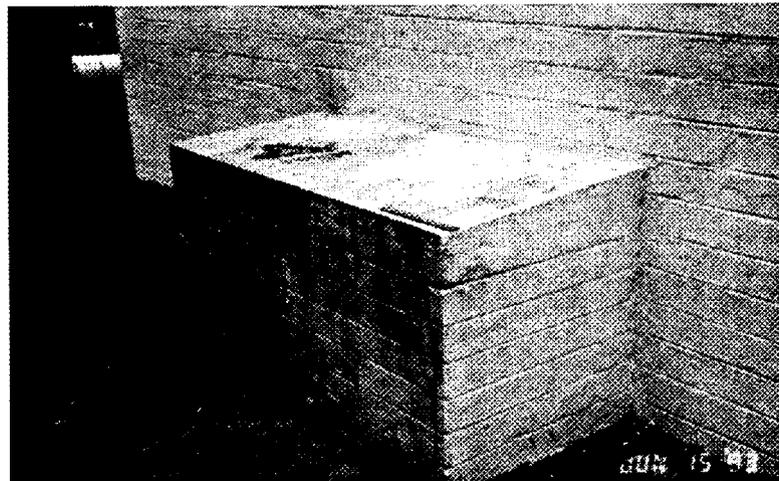
Fig. 2.4. Copy of historical ORNL drawing A-RD-2108: Building 3515 alterations.



**Fig. 2.5a. Historical photograph: product sample and removal station exterior.**  
(ORNL photo 10500; October 31, 1952)



**Fig. 2.5b. Historical photograph: top view of product sample and removal station interior.**  
(ORNL photo 10499; October 31, 1952)



**Fig. 2.5c. Present-day photograph: entombed product sample and removal station.**

### 2.4.2 East Side

The original control room for Building 3515 was attached to the east side of the building. Note: ORNL drawing D-9257 (June 1951) shows that the original control room was probably expanded to include the area south of the building (i.e., the expanded control room formed an L-shape). As shown in a 1952 photograph (Fig. 2.6; see also ORNL drawing D-RD-609), valve rods, piping, conduits, periscopes/sight glasses, and other items penetrated the wall between the control room and cells. Although the control room roof and walls were removed, Fig. 2.4 indicates that the piping, conduit, and other items were left on the wall and covered with concrete during the building alterations.

Figure 2.4 indicates that a 10 ft by 3 ft by 3-in.-thick lead plate covers contaminated soil directly adjacent to the concrete foundation. The presence of the lead plate was not verified during the site investigation because a plastic cover and gravel pad, installed to remediate soil contaminated by leaks from the drain line, now cover that entire area.

According to ORNL drawing D-337 (May 1950), a 6-in.-wide by 6-in.-deep concrete channel or culvert penetrated the middle of the east wall of the south cell at floor level and sloped to a drain immediately outside the original east wall. According to ORNL drawing C-RD-632 (January 1952), the culvert may have been modified to a 2-in. depth. The presence of the drain and culvert could not be verified because of the layers of concrete fill and concrete block added to the outside of the original walls during building alterations (see Fig. 2.4).

Figure 2.4 indicates that a valve off the southeast corner of the building connects to the underground hot drain. The valve was not visible on the surface and may be buried under the gravel cap.

Six electrical conduits lie at the base of the east wall, running parallel to the wall on the ground surface (Fig. 2.7).

One metal pipe and large cylindrical steam duct run parallel to the east wall at a distance of approximately 7 ft.

### 2.4.3 South Side and Building Slab

Prior to alterations circa 1964 (see Fig. 2.4), the original south wall of Building 3515 measured 3 ft 3 in. or 3 ft 9 in. thick, depending on the cross-section location. According to ORNL drawing D-338, an inner portion of this wall was stacked block (no mortar) approximately 1 ft 8 in. thick.

The concrete pad (foundation) extends 10 ft 8 in. from the south wall (Fig. 2.8). It was from this area of the pad that concrete cores were drilled from two locations for radiological and chemical analyses (see Sect. 3). Drilling at the location closest to the building progressed only 9½ in. before the drill encountered a steel plate, the extent and purpose of which are unknown. The other core penetrated the entire depth of the pad; this core (Fig.

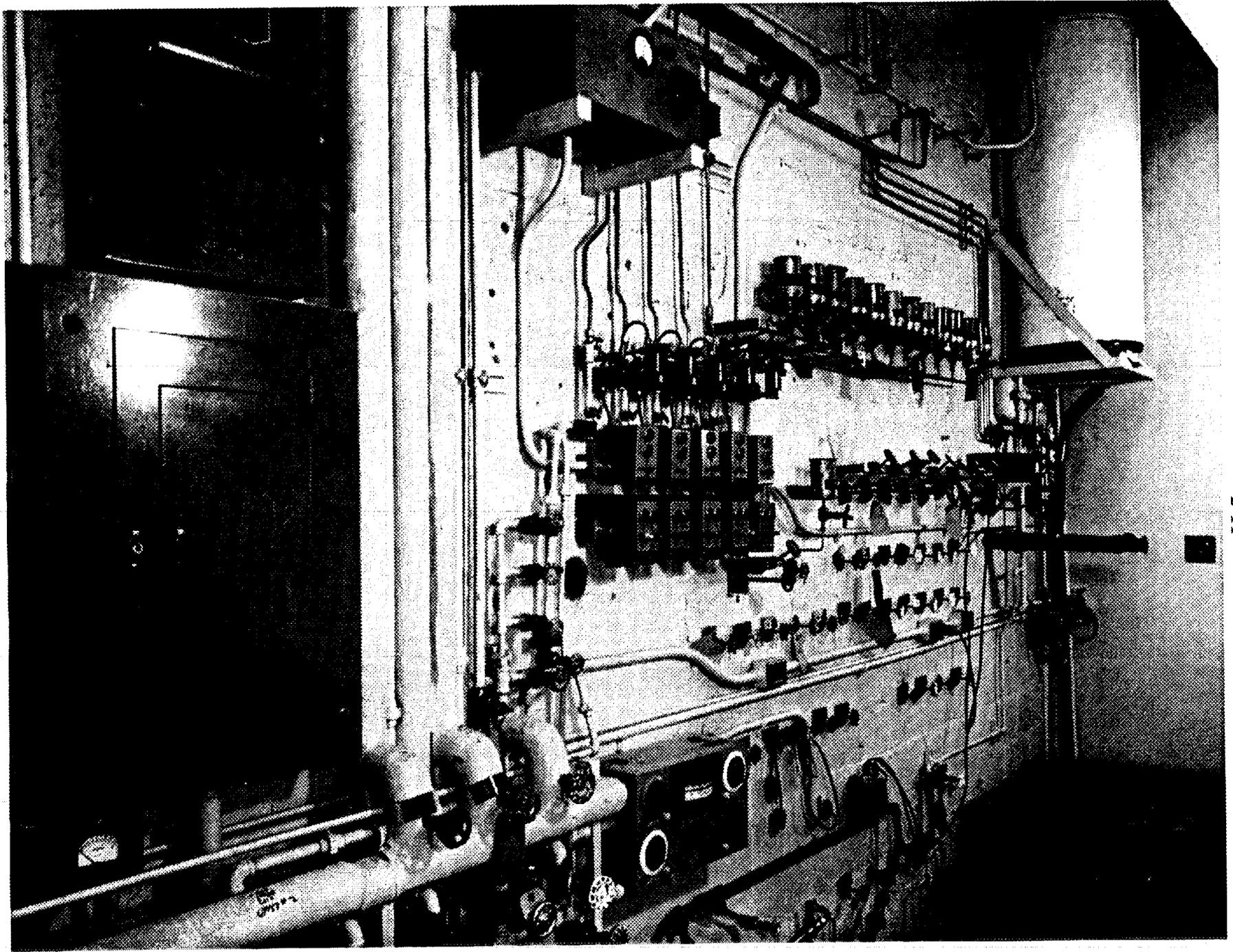


Fig. 2.6. West wall of gallery or control room on east side of north cell. (ORNL photo 10491; October 31, 1952)



Fig. 2.7. Electrical conduit lying at the base of the east wall.



Fig. 2.8. Concrete pad by the south wall.

2.9) indicates that the pad is 1.5 ft deep and consists of two separate pours; the first (bottom layer) is 0.7 ft thick and the second (top layer) is 0.8 ft thick. A 4.5-ft-deep soil composite sample was taken below the concrete pad; refusal (i.e., bedrock) had not been reached at this depth.

#### **2.4.4 West Side**

The west wall contains the blocked-up entrances to the north and south cells (Fig. 2.10).

Two 4-in.-diameter core holes were drilled in the north cell entrance way (see Sect. 6, Fig. 6.1); access to the north cell for the camera and instruments was through one of these holes. The north cell door cores (Fig. 2.11) were approximately 1.5 ft long and contained two concrete block sections "sandwiching" poured concrete fill. There is also a layer of stacked blocks in the entrance way; the core drill did not penetrate all the way through the stacked blocks, but pushed some of them into the north cell.

One 4-in.-diameter core hole was drilled in the south cell entrance way. This core (Fig. 2.12a) is approximately 11 in. long and contains two sections: one of 8-in.-thick block and one of 3-in.-thick poured concrete fill. Immediately behind the 11-in.-thick entrance way is a layer of stacked block. Access to the south cell was through a 5-in. by 10-in. opening obtained by (1) chipping out the remainder of the mortared block in the entrance way that contained the core hole, and (2) pushing into the cell (and letting fall to the floor) two of the stacked blocks behind the mortared block. Figure 2.12b is a photograph of the stacked block filling the entrance way; the photograph was taken inside the cell from a camera fixed at the end of a pole (shown in the photograph) inserted through the hole in the entrance way. The isometric drawing accompanying the figure shows the positions of the camera and the area being photographed (indicated in white).

#### **2.4.5 Roof**

According to Fig. 2.4, which shows building alterations circa 1964, all piping and funnels from the cell roof to the inside of the cells were cut off about 3 in. above the roof and capped, and then a 4- to 6-in.-thick concrete slab was poured over the existing 2-ft roof slab.

Figure 2.4 indicates that the hatch in the northwest corner of the roof was sealed with a 2-in.-thick lead shield and a steel plate cover. This was not verified during the site investigation, but some interior photographs of the north cell ceiling vaguely show a circular outline of what may be a closed access way.

In 1988, cracks in the roof were repaired and the roof was covered with stainless steel sheet.

### **2.5 NORTH CELL INTERIOR**

The north cell interior contains an equipment rack oriented north-south. Mounted on the rack are various sizes of process vessels (both glass and stainless steel), piping, and valves.



Fig. 2.9. Concrete core (location 73.SB002) from the concrete pad south of Building 3515.

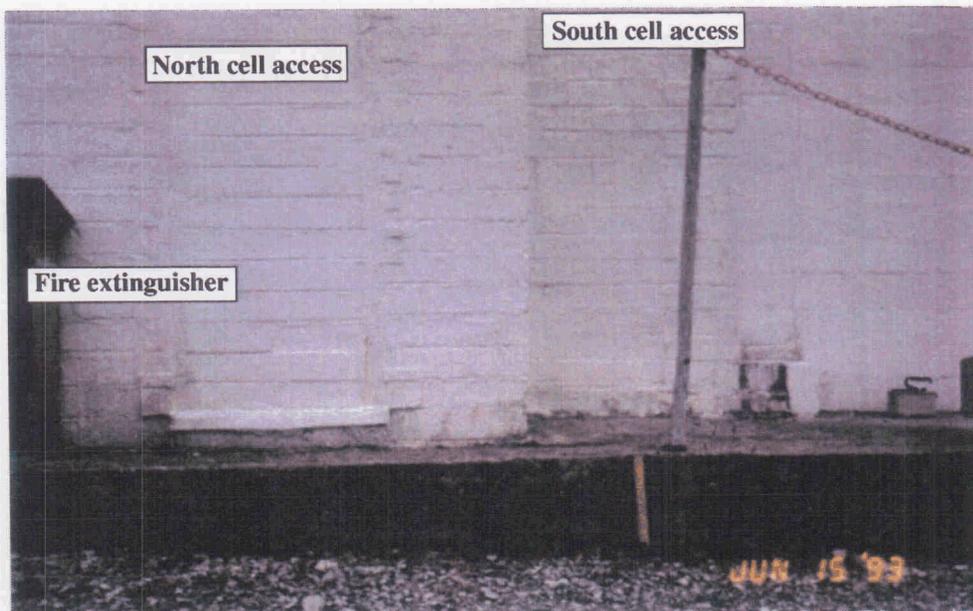


Fig. 2.10. Blocked-up entrance ways to cells on the west wall.



Fig. 2.11. Two concrete cores from the north cell door.

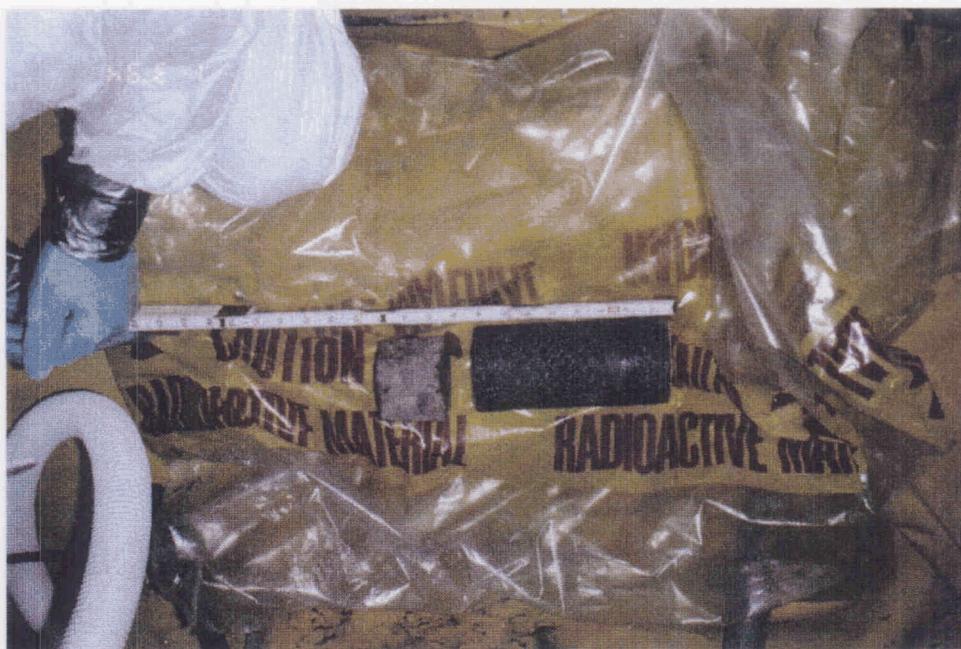


Fig. 2.12a. Single concrete core from the south cell door.

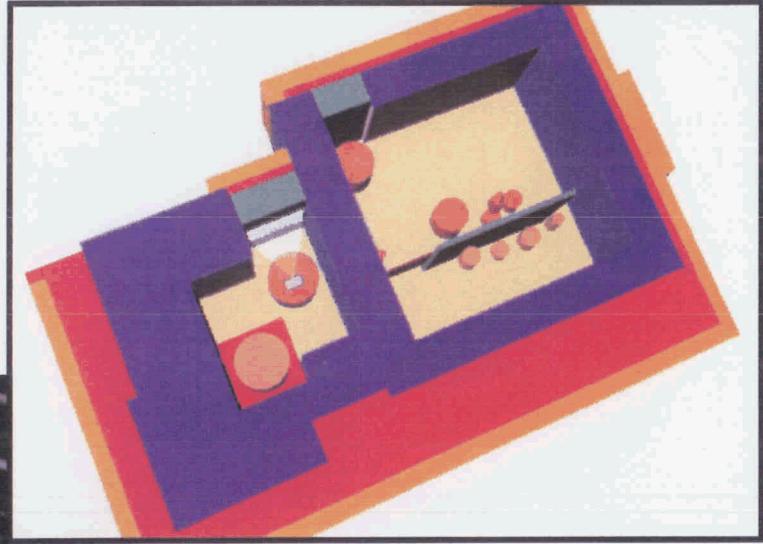
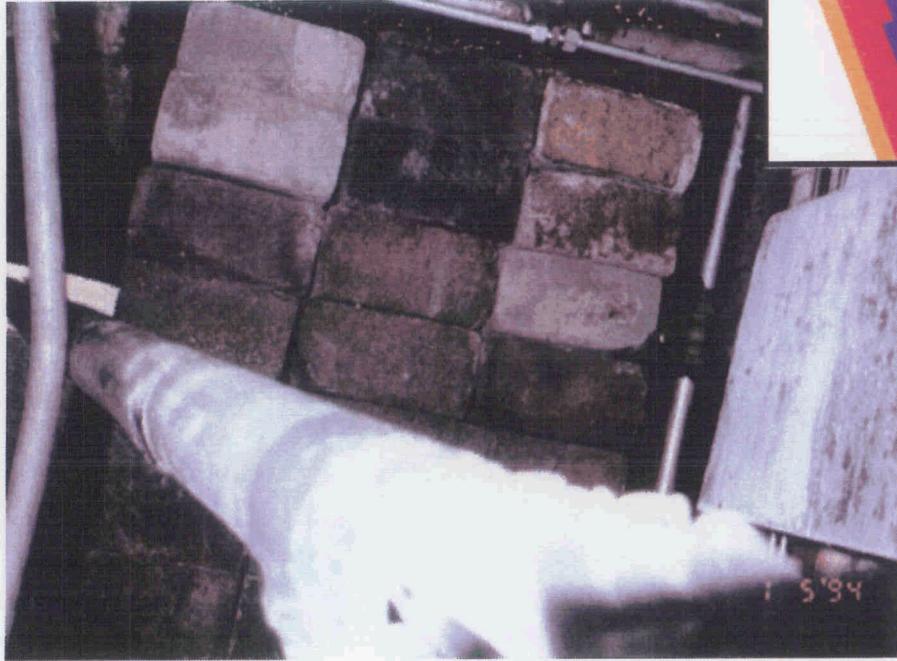


Fig. 2.12b. Stacked block filling the south cell entrance way.

A manometer board containing four manometers is mounted between the rack and the south wall; the manometer fluid (e.g., water, oil, or mercury) is unknown. Another steel vessel near the entrance is designated as "S-5" in ORNL process flow drawing D-RD-732; a review of historic drawings showed no other references to this vessel.

Figure 2.13, a 1993 composite photograph of the north cell interior, shows a portion of vessel S-5 and the manometer board and the equipment rack covered with piping and equipment. The figure also shows an array of lamps and/or lights on the north and west walls. Vessel S-5 has seven nozzles, three of which connect to tubes from the equipment rack.

Figure 2.14 is a 1993 overhead composite view of the cell taken near the entrance. Seen in this figure are the ceiling with valve extension handles passing overhead, the manometer board directly in front of the access way, and the upper portion of the south wall. A fully enclosed light fixture is attached to the ceiling. Localized discoloration and peeling paint are visible on the ceiling and upper reaches of the south wall.

Some piping penetrates the south wall between the manometer board and the doorway (the penetration is not shown in Fig. 2.14 but can be seen in the video). Discoloration and peeling paint are especially evident in the area around the pipe penetration.

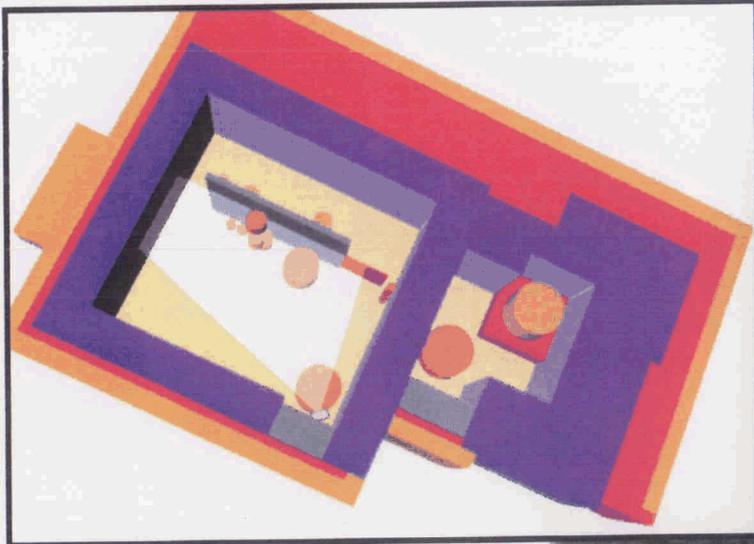
Figure 2.15, which shows the northwest corner of the cell, provides additional detail on the lamp/light fixtures on the west wall. The paint skin on the west wall has formed bubbles but is not flaking off; the floor in the northwest corner shows significant deterioration, discoloring, and patches of detritus. Near the top of the west wall (not shown in Fig. 2.15) is what appears to be a radiator or heat exchanger with cooling fins.

Figure 2.16 is a 1993 photograph of the southwest corner of the cell immediately behind the S-5 vessel showing valve extension handles passing to the south of the doorway and some of the stacked concrete blocks filling up the doorway.

According to ORNL drawing C-RD-371, the equipment rack is approximately 3 ft from the east wall and 2 ft 6 in. from the south wall. The frame rises from floor to ceiling (approximately 10 ft) and is 6 ft 4 in. wide. The outer frame of the rack is made of welded 3-in. stainless steel channel. The top of the rack is bolted to the ceiling, and the bottom rests on a 3-ft base, also made of 3-in. stainless steel channel. Twelve ½-in.-diameter stainless steel rods crisscross the steel frame at regular intervals.

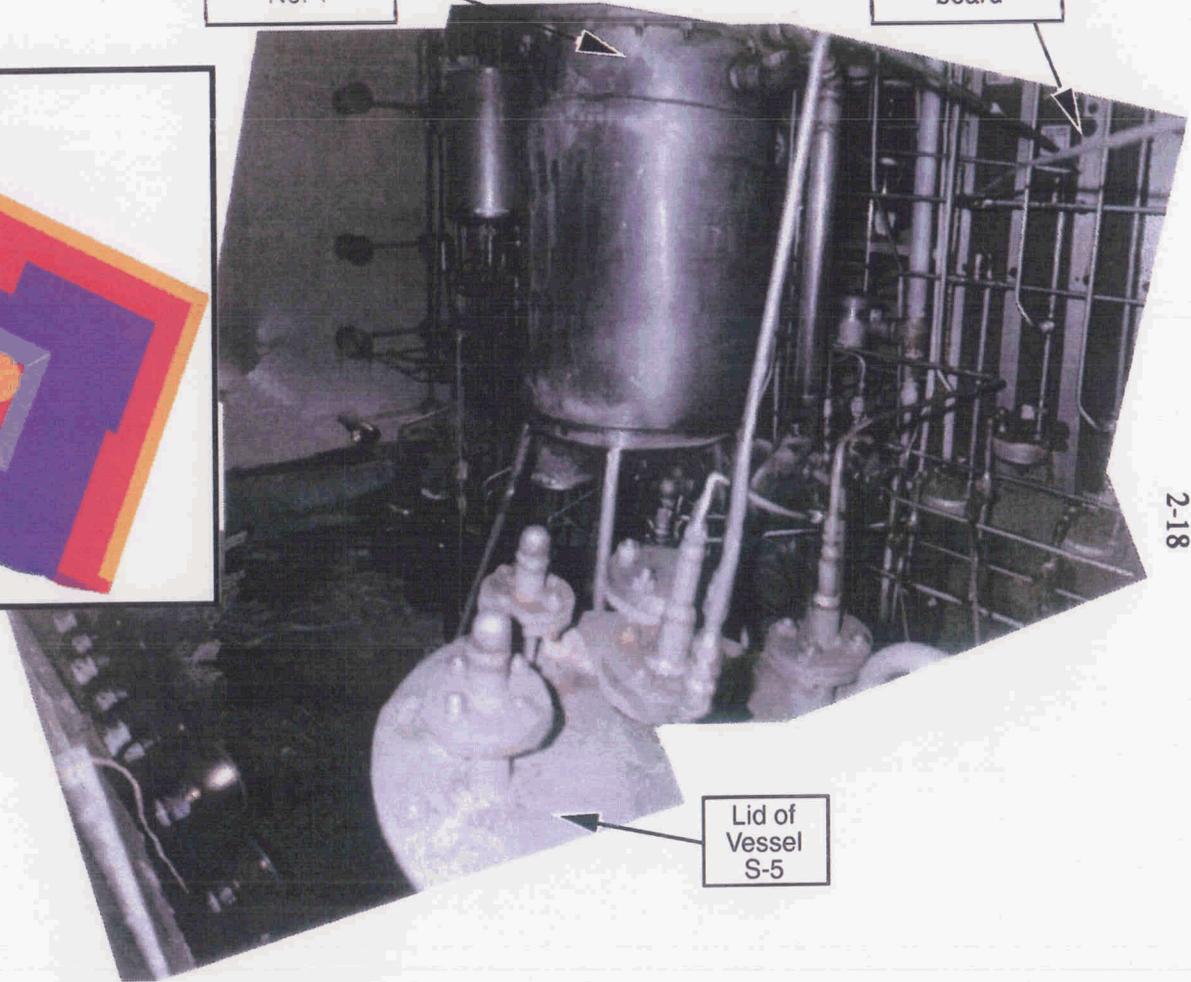
The process piping includes connections between vessels in a cell, connections between vessels in different cells, lines from the control room and roof for solution or solids addition, product discharge lines, and drainage lines. The hot drain header is at the bottom of the equipment rack. Some piping is for outside services that include 30- and 15-psi steam, air, water, demineralized water, hot off-gas, and vacuum. According to ORNL drawing D-RD-640, pipe diameters vary from ¼ in. to 1½ in. and much of the process piping is stainless steel tubing (¾-in. outside diameter, 18-gauge) with Swagelok tube fittings. Electrical power lines are also routed throughout the equipment rack.

88SYQ5.8 4669.3 iso



Precipitator  
No. 1

Manometer  
board

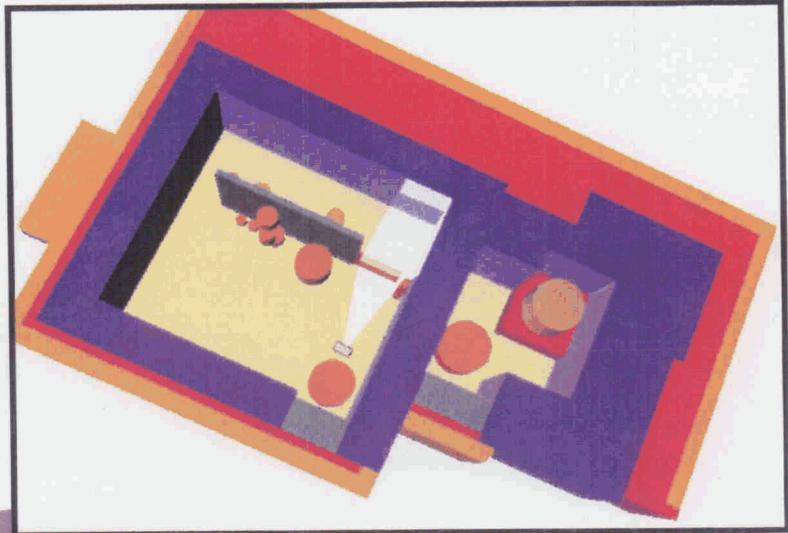


2-18

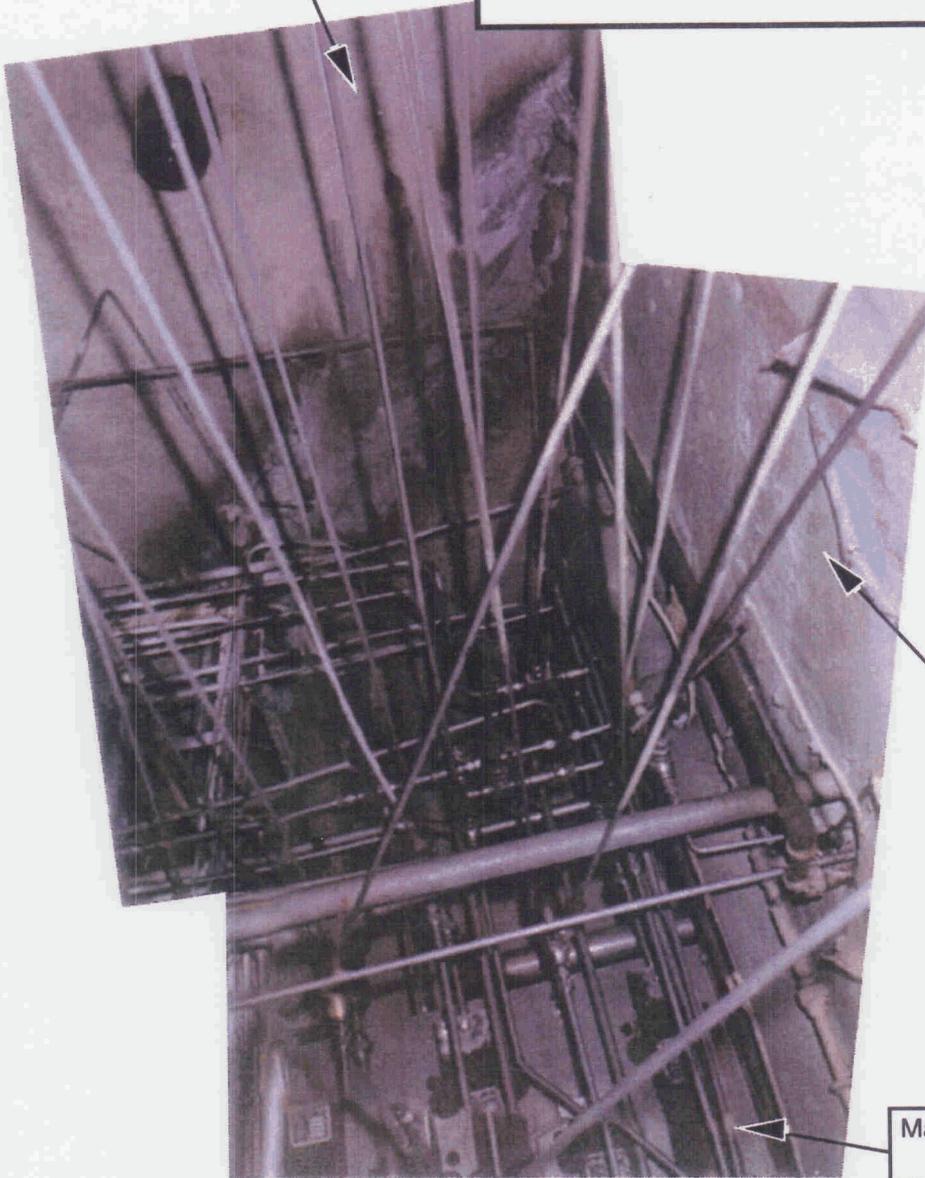
Lid of  
Vessel  
S-5

Fig. 2.13. North cell interior: composite photograph of vessel S-5, manometer board, and equipment rack.

2-19



Ceiling

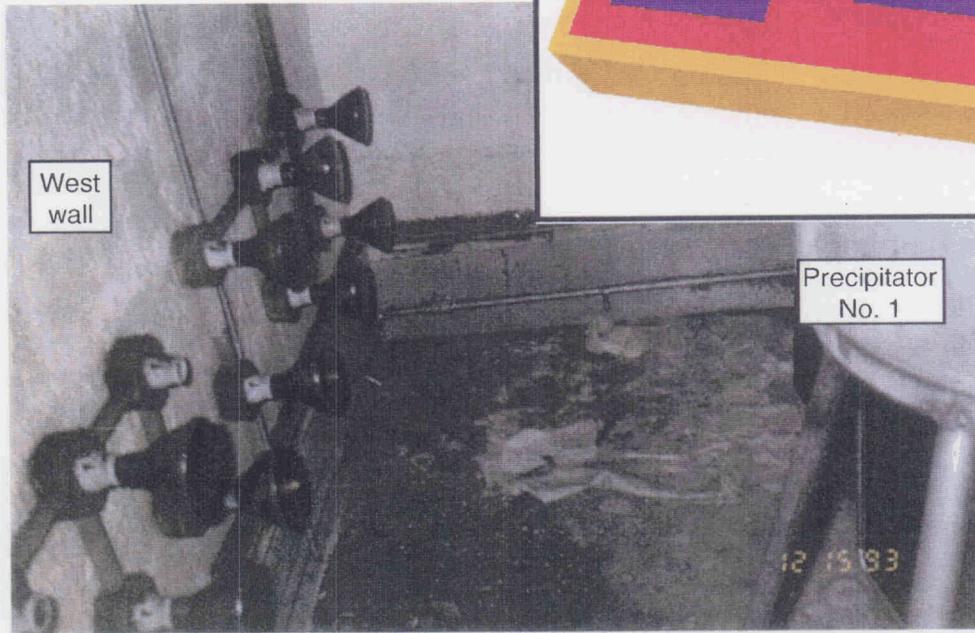


South wall

Manometer board

Fig. 2.14. North cell interior: composite photograph showing overhead view of cell from cell doorway.

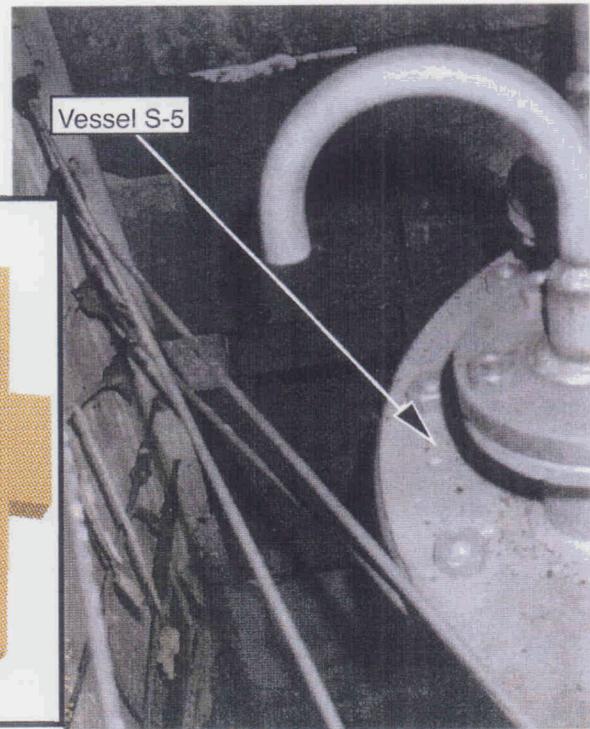
2-20



West wall

Precipitator No. 1

Fig. 2.15. North cell interior: northwest corner.



Vessel S-5

Fig. 2.16. North cell interior: southwest corner of cell behind vessel S-5.

Valves include two- and three-way solenoid valves, Alloyco and Powell ¼-in. semineedle valves, Powell ¼-in. check valves, a few Durco plug valves, and a few 1-in. gate valves. The process design specified that all valves, where possible, be on the west side of the equipment rack. Many valve extension handles were taken through the east wall of the cell into the control room (see Fig. 2.17), but extension handles also were taken through the west wall to meter flow for the product sample and removal station and through the walls around the doorway (Figs. 2.14 and 2.16) for the manometer board and the vacuum reducer on the south wall.

The 1993 photographs discussed earlier do not show all north cell equipment because of restrictions in access and lighting and other factors. However, 1993 and 1953 photographs show strong similarities for the major equipment and piping on the equipment rack. (Substantial resemblance with few exceptions can even be found between the 1993 photographs and those from 1952 dealing with the "Caesar process.") Because of the similarities in equipment which can be compared, it is assumed that the other equipment in the 1953 photographs may also be present in the north cell, even though the 1993 photographs cannot confirm their presence.

Figure 2.18 provides a plan and elevation view of the equipment rack based on 1953 photographs and 1952-53 drawings (e.g., D-RD-640, -641, -657, and -732), with approximate locations of 29 process vessels. Each vessel is labeled with a letter that corresponds to a vessel type (or name) shown in Table 2.1. Table 2.1 also lists (for each vessel) the principal fabrication material, the estimated length and diameter, and the associated ORNL fabrication drawing, if known and available. (Not included in Fig. 2.18 or Table 2.1 is vessel S-5, near the north cell entrance; vessel S-5 is not present in the 1953 photographs.) Figure 2.19 adds detail by using 1953 photographs to map out individual sections of the equipment rack.

ORNL drawing C-RD-632 (January 1952) indicates that drainage culverts and entrance way sills in both the north and south cells may have been modified at floor level. The drawing also indicates that a layer of concrete approximately 2 in. thick may have been added to the floors of both cells.

## 2.6 SOUTH CELL INTERIOR

Figure 2.2 shows the interior dimensions of the south cell. The 3-ft-long entrance hallway leads to a room measuring approximately 5 ft 8 in. in the north-south direction by 4 ft 6 in. in the east-west direction. In the southeast corner of the cell is a 1-ft-deep alcove.

According to ORNL drawing D-338, the ceiling in the entrance way is 7 ft high and is comprised of a ½-in.-thick steel plate (cap) supporting concrete blocks (with mortar). The ceiling in the main part of the cell is 9 ft high and is comprised of a ¼-in.-thick steel plate lying on four 4-in. steel I-beams running north-south. The steel plate and I-beams supported a 2-ft-high stack of unmortared blocks; available records do not indicate whether the blocks were left in place when a 2-ft-thick poured concrete roof slab was added in the early 1950s (an additional 4- to 6-in. roof slab was added circa 1964).

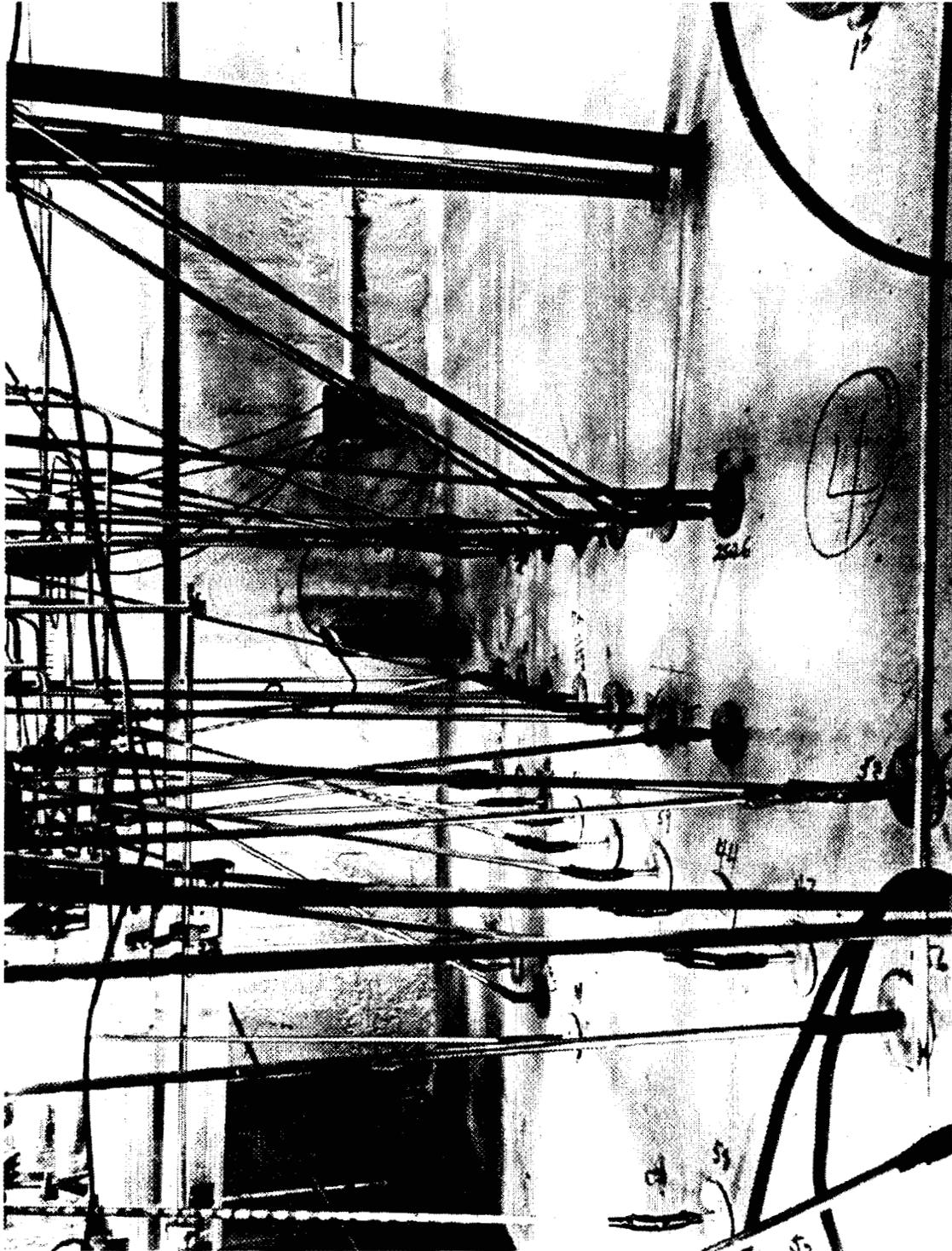
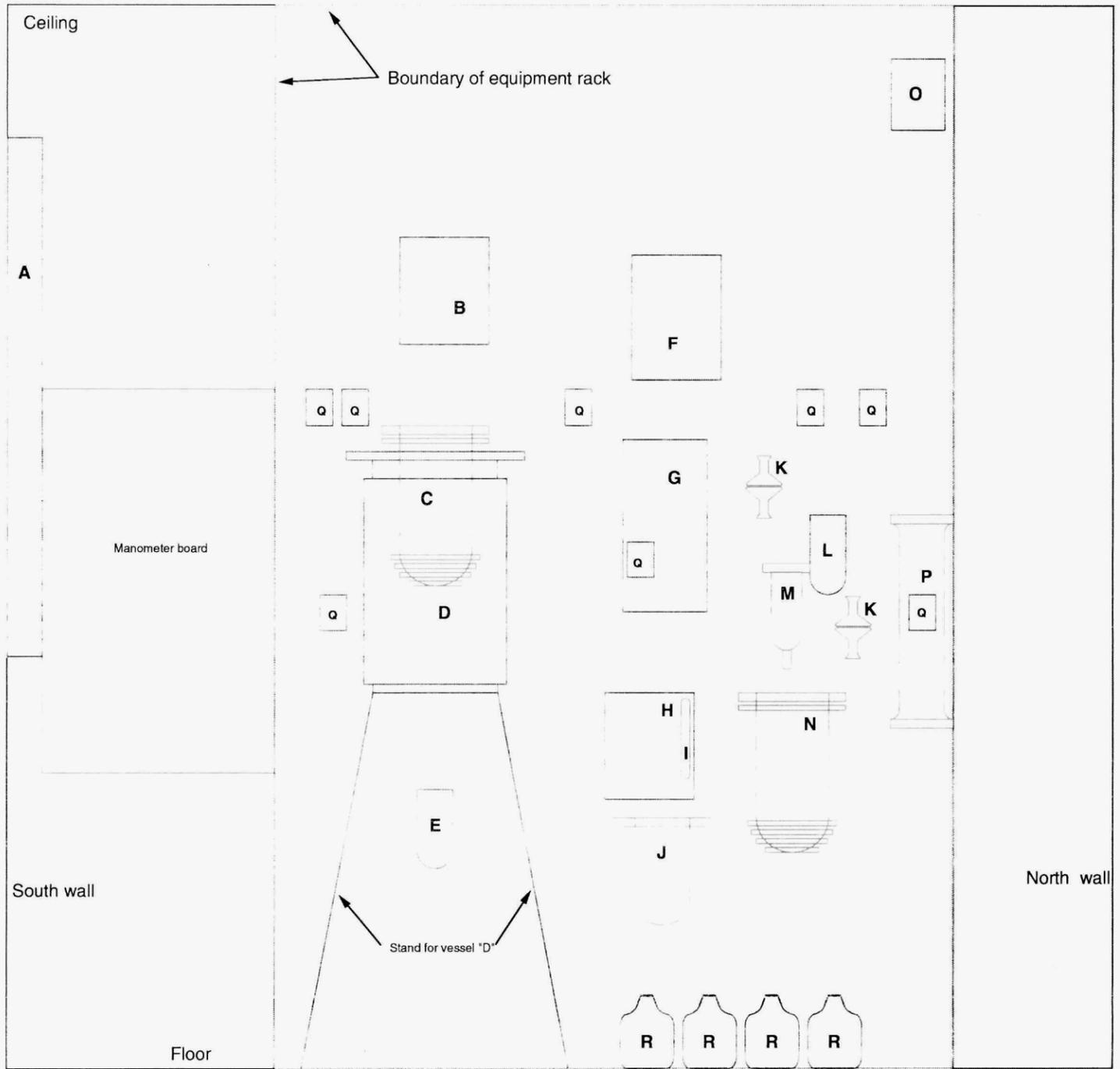
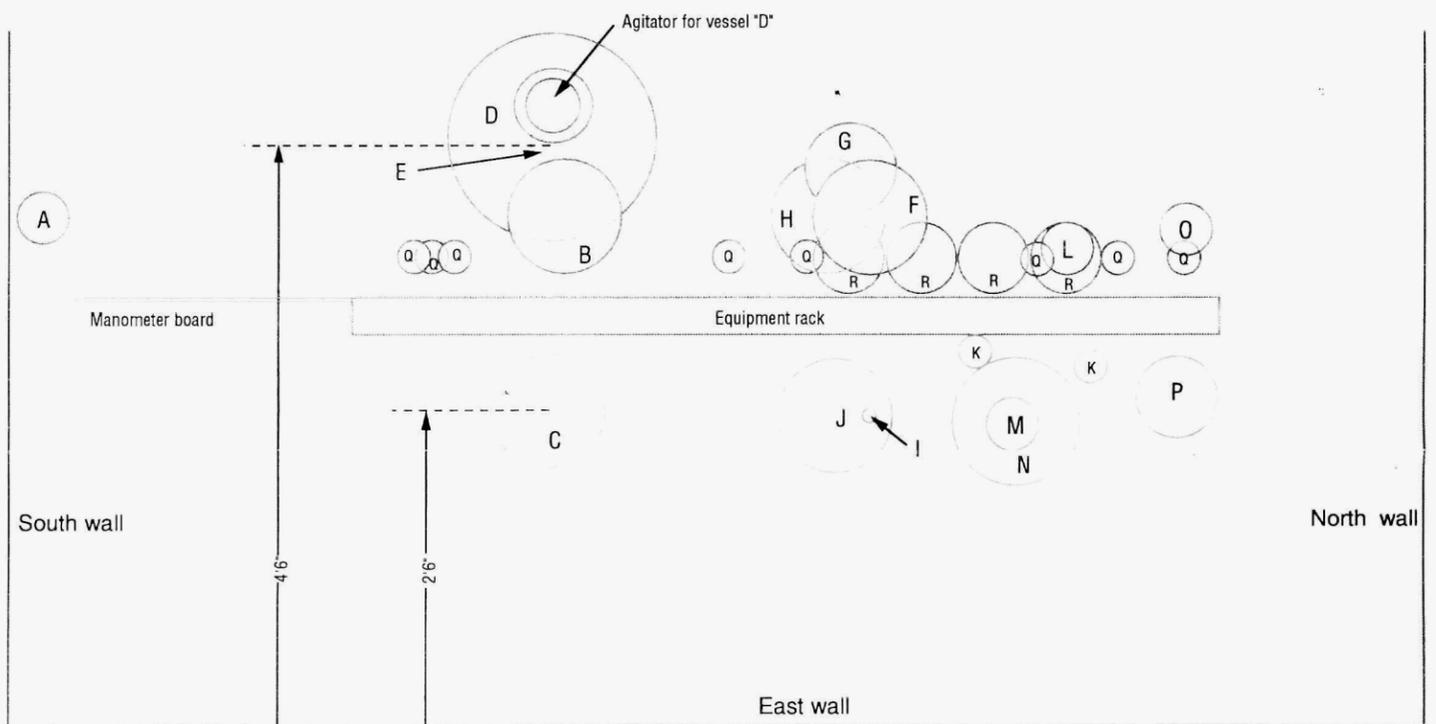


Fig. 2.17. Historical photograph showing extension handles from north cell equipment rack penetrating east wall to control room. (ORNL photo 10492; October 31, 1952)



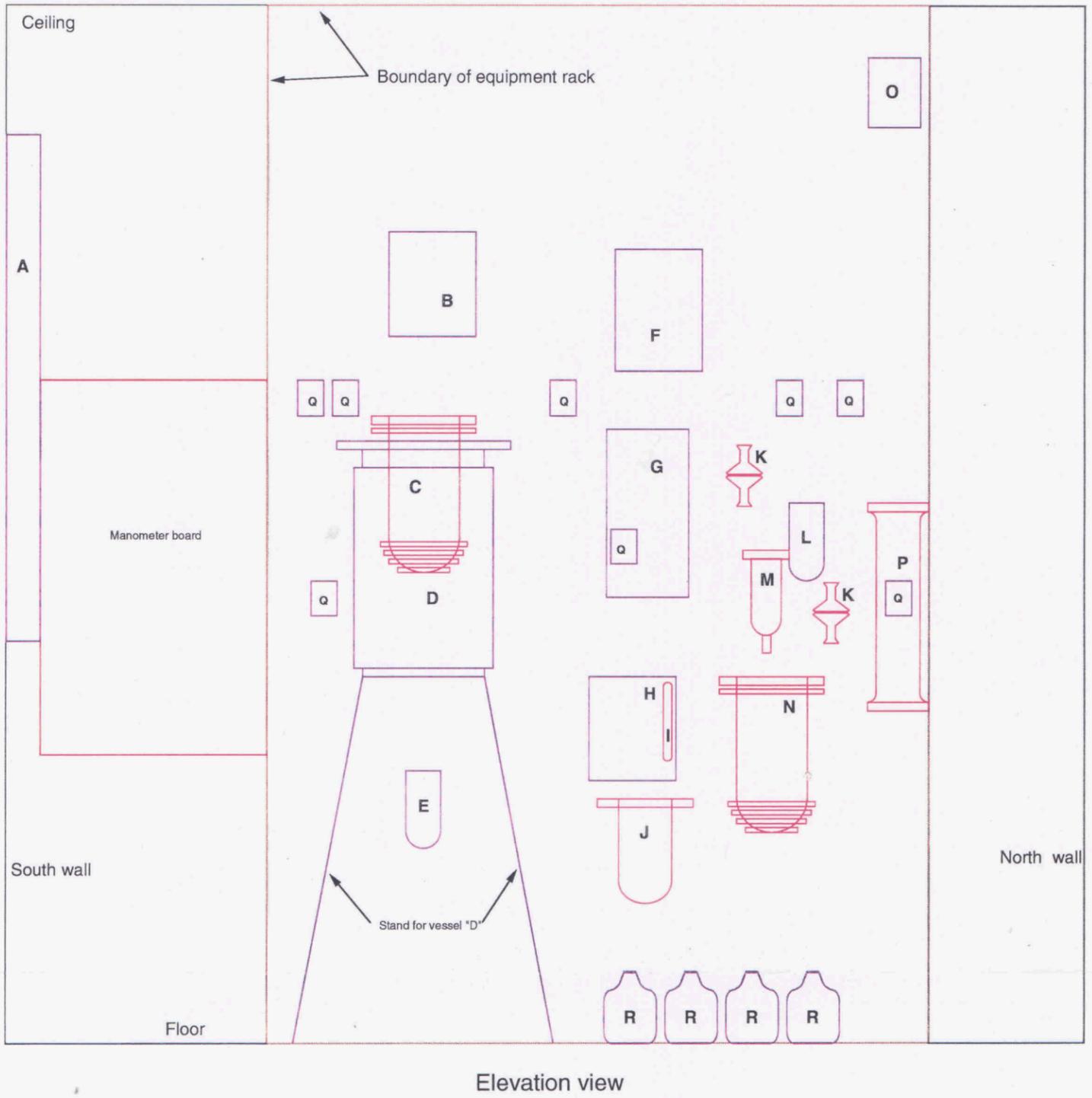
Elevation view



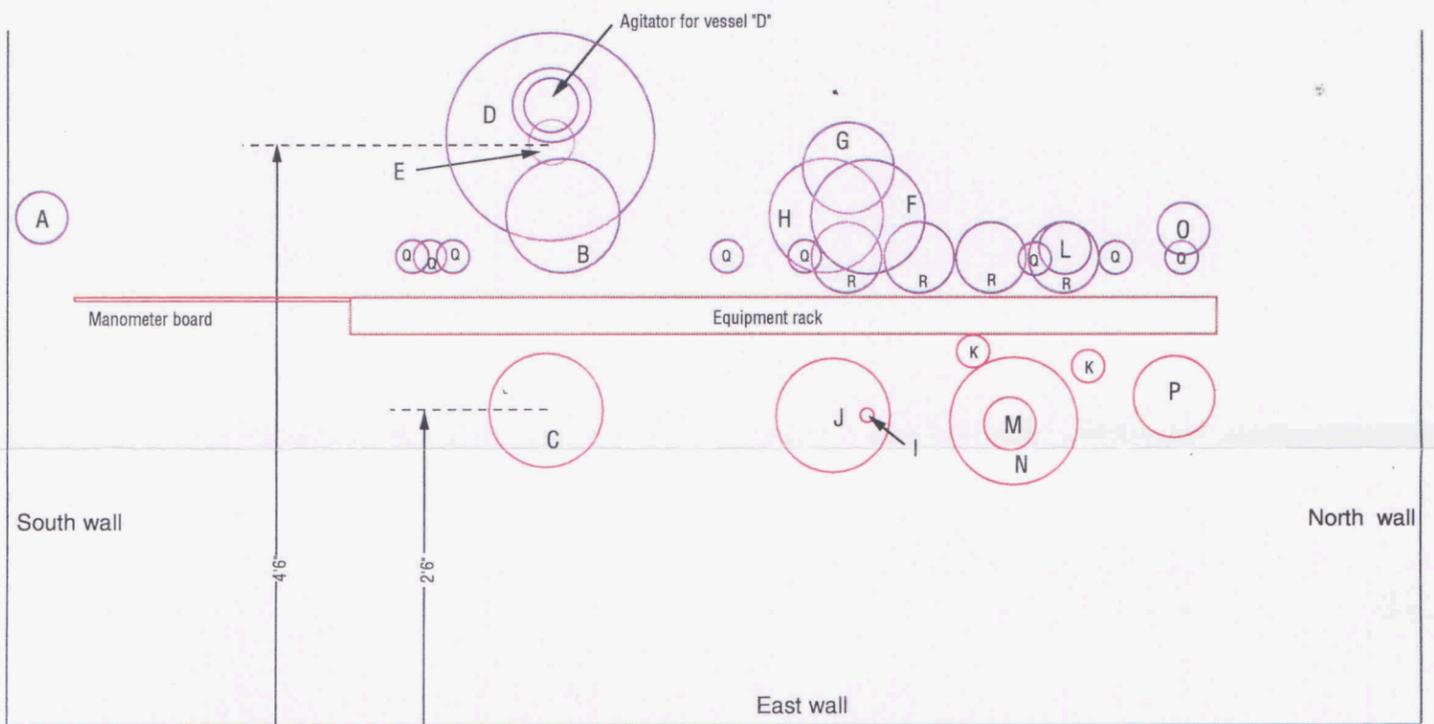
Plan view

**NOTES:**  
 Scale = 0.75 inch per foot  
 All positions and dimensions are approximate.  
 Pipes and connections are not shown.

Fig. 2.18. Location of vessels on the north cell equipment rack.



Elevation view



Plan view

**NOTES:**  
 Scale = 0.75 inch per foot  
 All positions and dimensions are approximate.  
 Pipes and connections are not shown.

Fig. 2.18. Location of vessels on the north cell equipment rack.

Table 2.1. Vessels on the north cell equipment rack

Vessel in Fig. 2.18	Potential Vessel Type	Description			ORNL Fabrication Drawing	Vessel ID in ORNL drawing D-RD-732 <sup>a</sup>
		Material	Length (in.)	Diameter (in.)		
A	Vacuum scrubber	Stainless steel	60-3/4	4-3/4	C-RD-633	None
B	Filtrate vessel No. 1 (15 L)	Stainless steel	12-3/4	10	C-RD-614	T-1
C	Crystallizer No. 2	Glass	18	8	C-RD-627 <sup>b</sup>	C-2
D	Precipitator No. 1 <sup>c</sup>	Stainless steel	27	15	A-RD-617 C-RD-618	P-1
E	Filter <sup>d</sup>	Glass	13	10-1/2	D-RD-655	F-1
F	Sampler transfer (15 L)	Stainless steel	12-3/4	10	C-RD-616	T-3
G	Unknown <sup>e</sup>	Stainless steel	16	8	NA	T-4
H	Filtrate vessel No. 2 (15 L)	Stainless steel	12-3/4	10	C-RD-615	T-2
I	Glass condenser	Glass	11-1/2	1-1/2	C-RD-643	None
J	Ru Scrubber	Glass	13	6	D-RD-628 <sup>b</sup>	SC-1
K	Product filter	Glass pipe	7-1/2	4	A-RD-703	F-2, F-4
L	Product transfer	Stainless steel	10-1/4	4-1/2	C-RD-629	PT-1
M	Selas filter assembly	Glass pipe	12-1/4	3	A-RD-702	F-3
N	Precipitator No. 2 (10 L)	Glass	17	8	D-RD-624 <sup>b</sup>	P-2
O	Vent overflow	Stainless steel	8	5	C-RD-636 <sup>b</sup>	None
P	Sample dilution (5 L)	Pyrex pipe	24	4	B-RD-630	PT-2
Q	Solution addition funnels (500 mL)	Stainless steel	5	3	C-RD-636	None
R	Storage bottles <sup>f</sup>	Glass (bottles)	16	9	NA	S-1 <sup>f</sup>

<sup>a</sup> ORNL drawing D-RD-732 is the FPP Process Flow Diagram (September 11, 1953). The ID letters may also be representative of vessel type; e.g., "T" is for transfer vessel, "C" is for crystallizer, "P" is for precipitator, "F" is for filter, "SC" is for scrubber, "PT" is for product transfer, and "S" is for storage.

<sup>b</sup> Drawing is not in possession of Bechtel team; dimensions are estimated from photographs or other drawings.

<sup>c</sup> Vessel measurements are deduced from drawings and do not include agitator and other equipment protruding above vessel lid.

<sup>d</sup> The filter vessel as shown in historical photographs does not match in detail that portrayed in the June 1952 drawing (D-RD-655) or in earlier drawings (A-RD-611 or A-RD-612), and may ultimately have been purchased rather than fabricated as indicated in D-RD-641.

<sup>e</sup> This vessel may also be the "Filter Tank W" in drawing D-RD-657. Dimensions were estimated from photographs.

<sup>f</sup> Identified in drawing D-RD-732 as "S-1 (Ru), S-2 (Re), S-3(Ce), and S-4 (Sr)"; dimensions estimated from photographs.

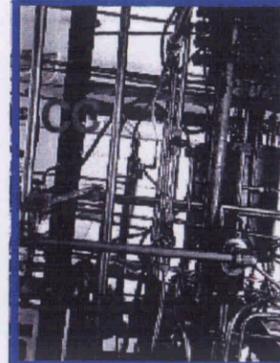


Fig. 2.19a

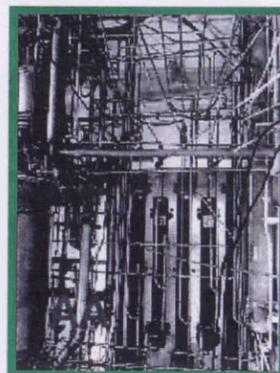


Fig. 2.19b

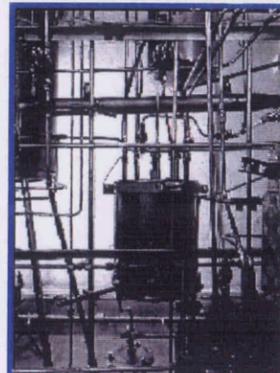


Fig. 2.19c

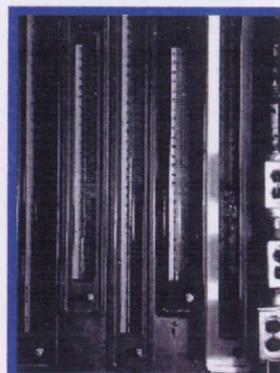


Fig. 2.19d

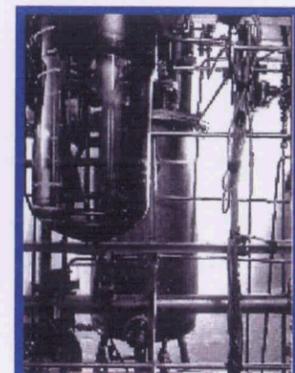


Fig. 2.19e

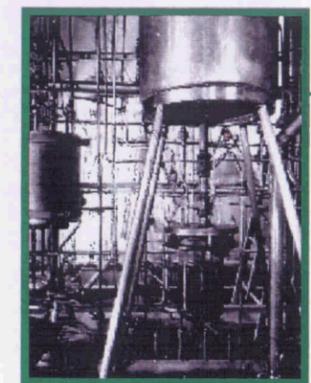
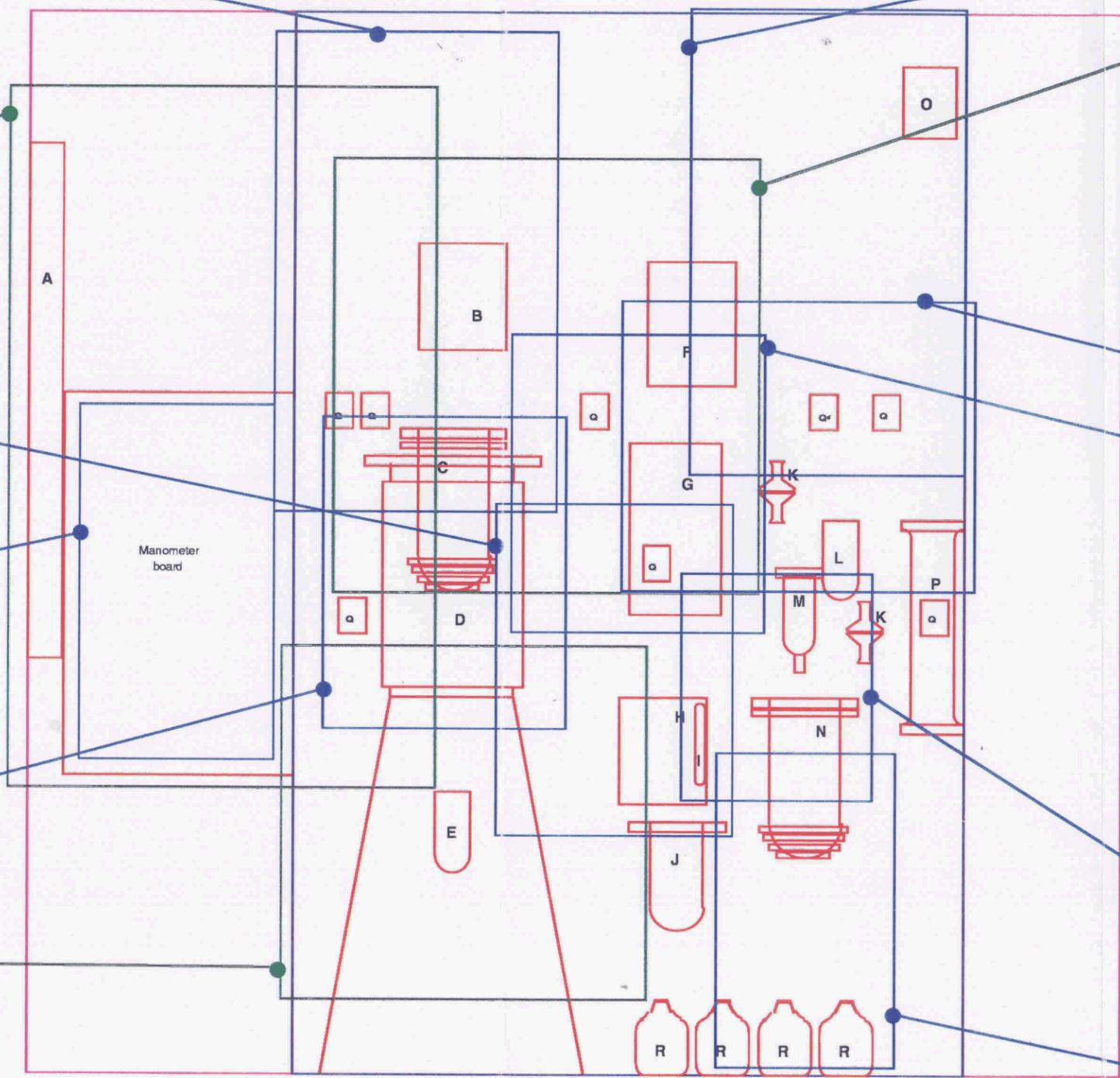


Fig. 2.19f



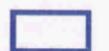
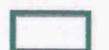
 Facing west  
 Facing east

Fig. 2.19g

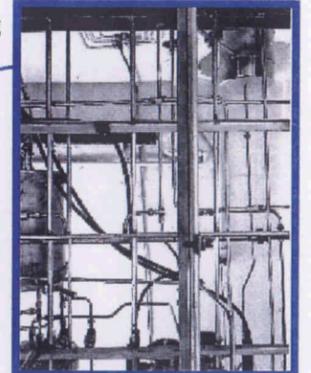


Fig. 2.19h

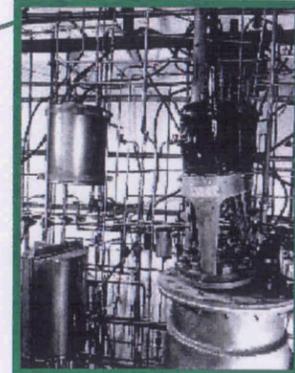


Fig. 2.19i

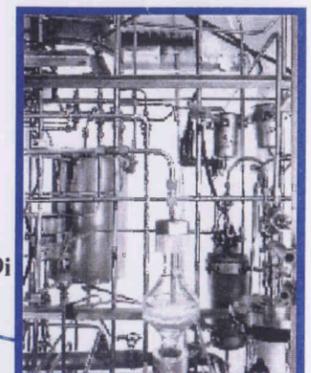


Fig. 2.19j

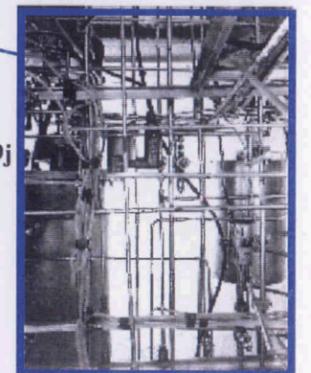


Fig. 2.19k

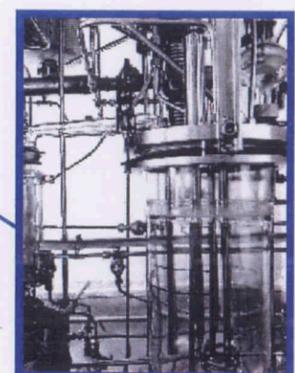


Fig. 2.19l

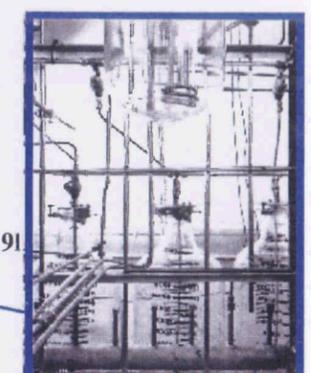
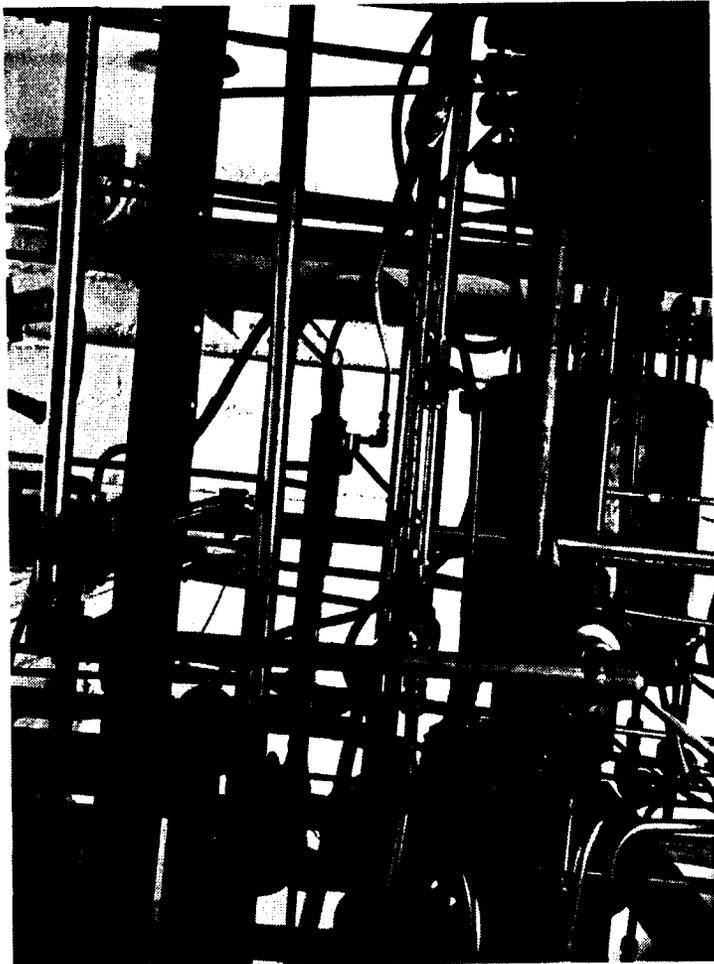
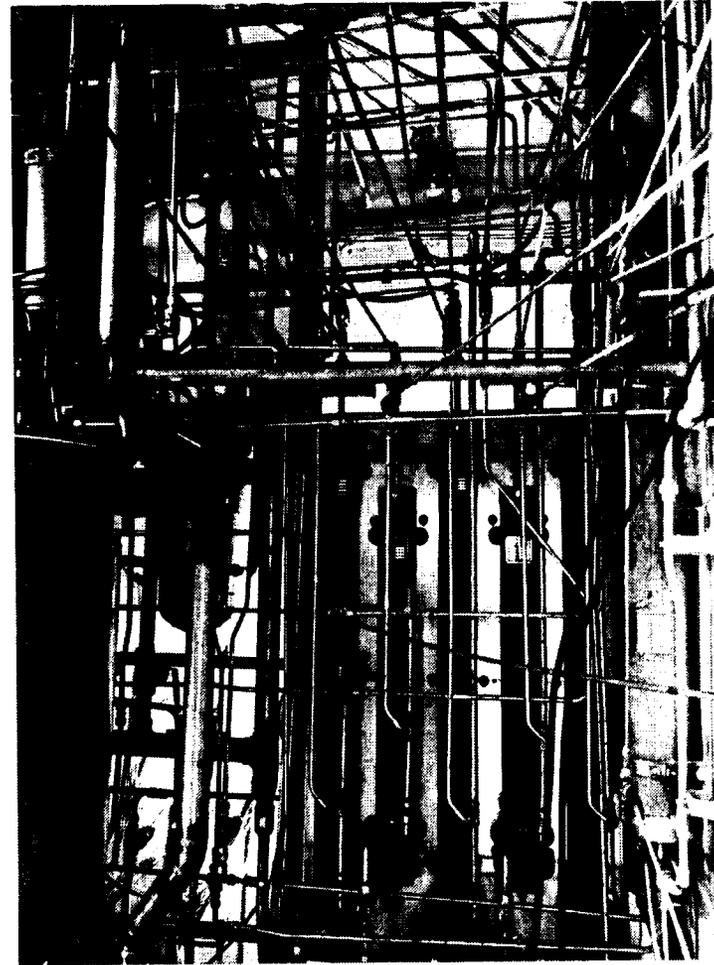


Fig. 2.19. Historic (1953) photographs of individual sections of the north cell equipment rack.



**Fig. 2.19a.**



**Fig. 2.19b.**

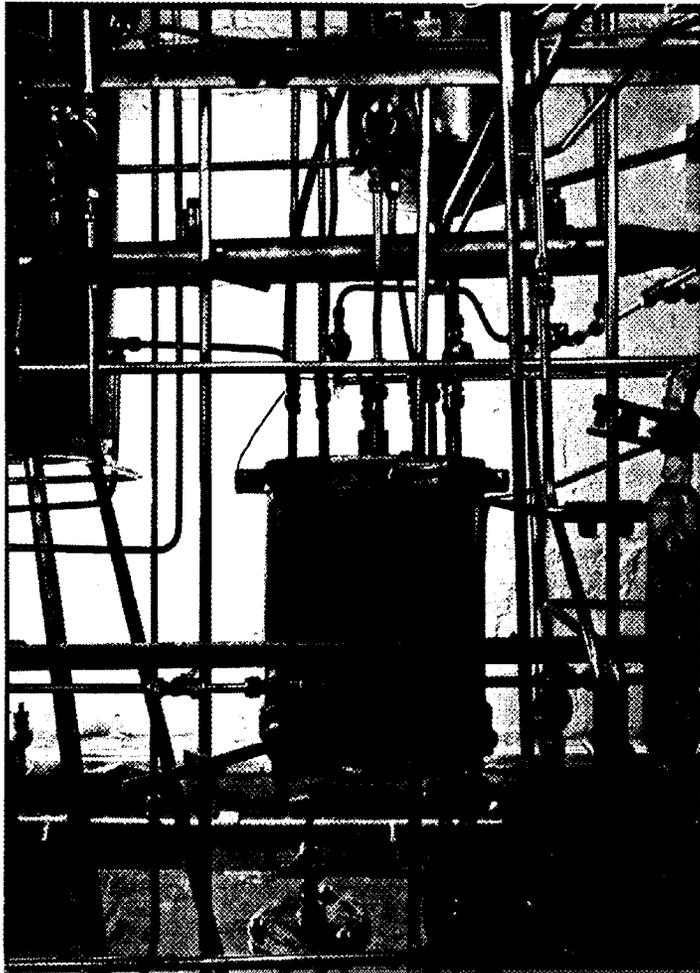


Fig. 2.19c.

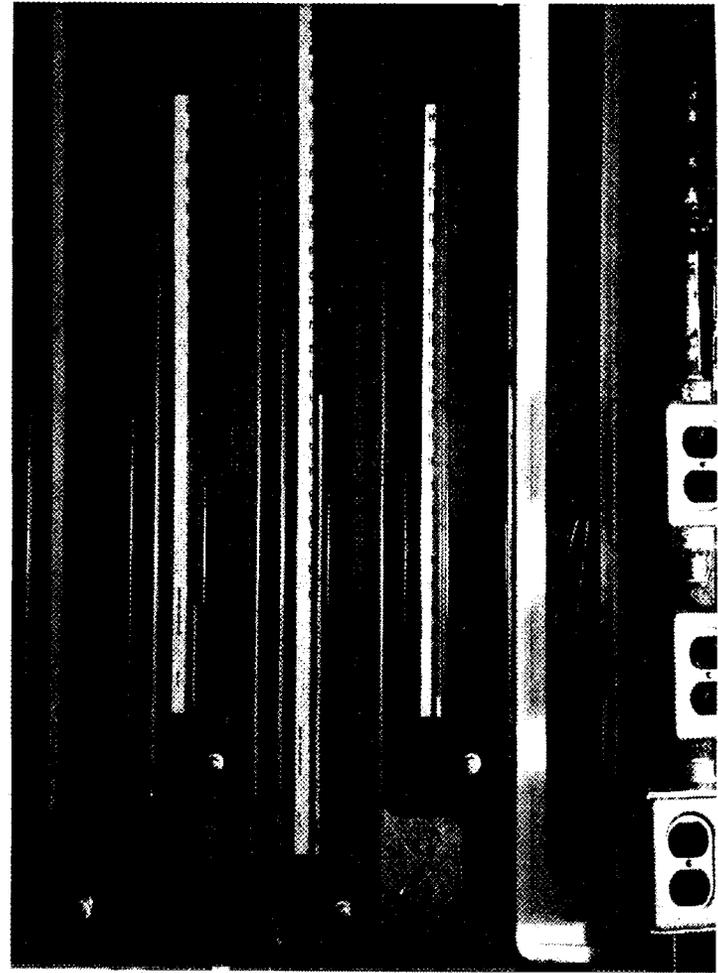


Fig. 2.19d.

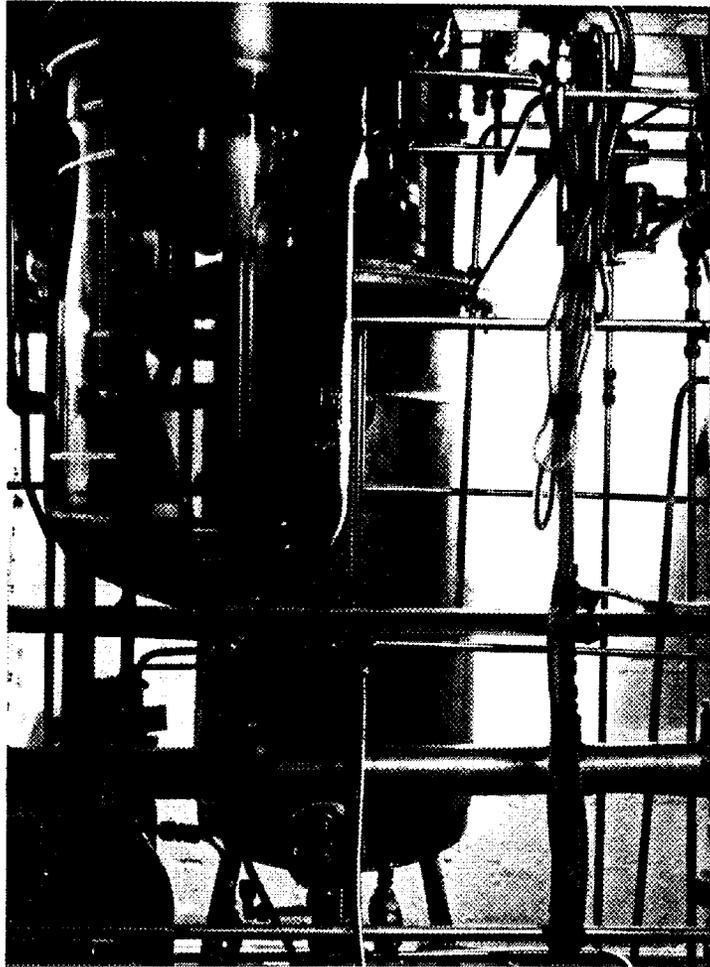


Fig. 2.19e.

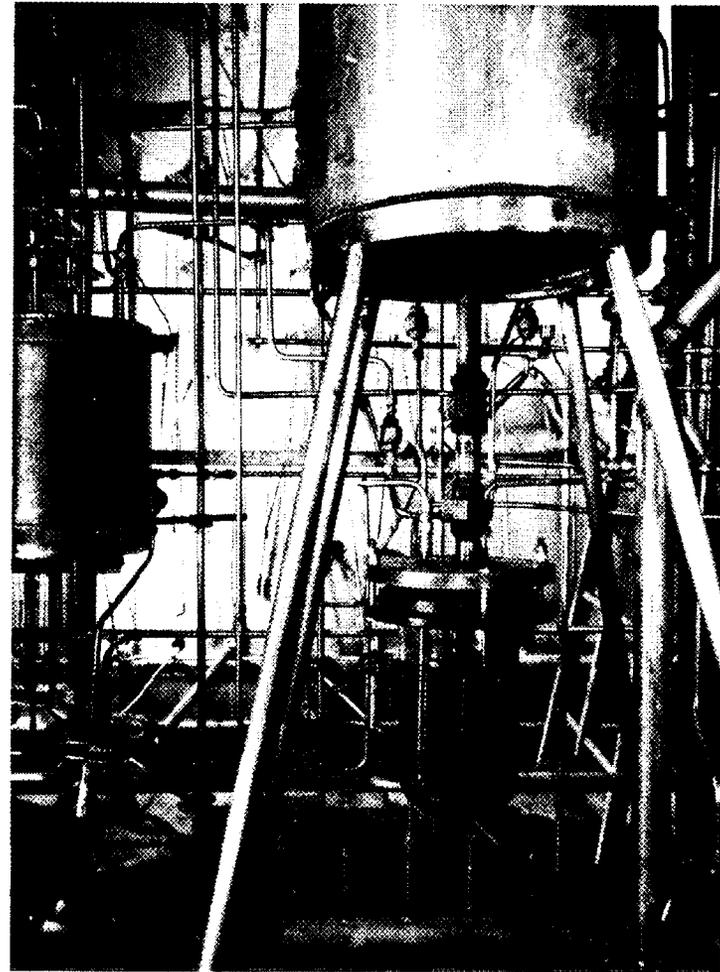


Fig. 2.19f.

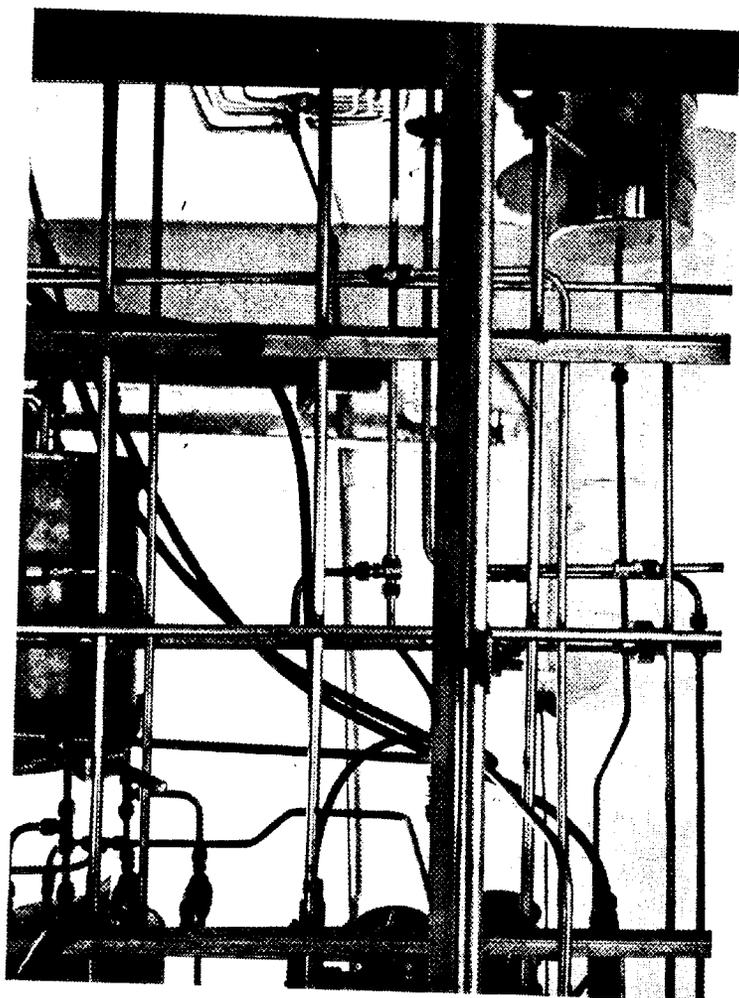


Fig. 2.19g.

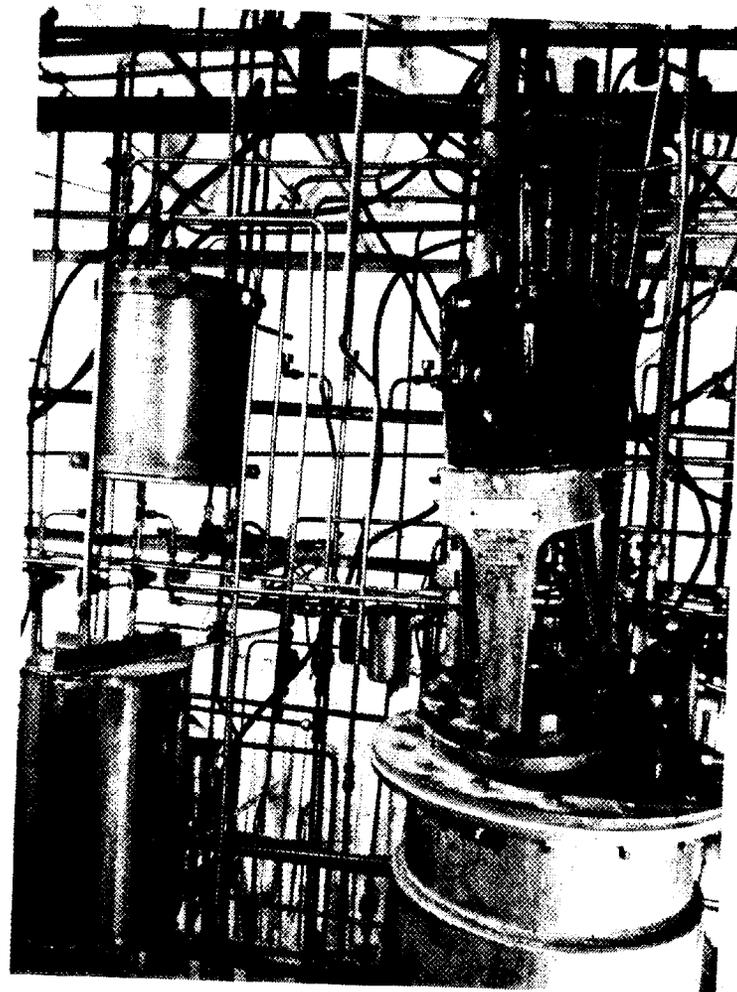


Fig. 2.19h.

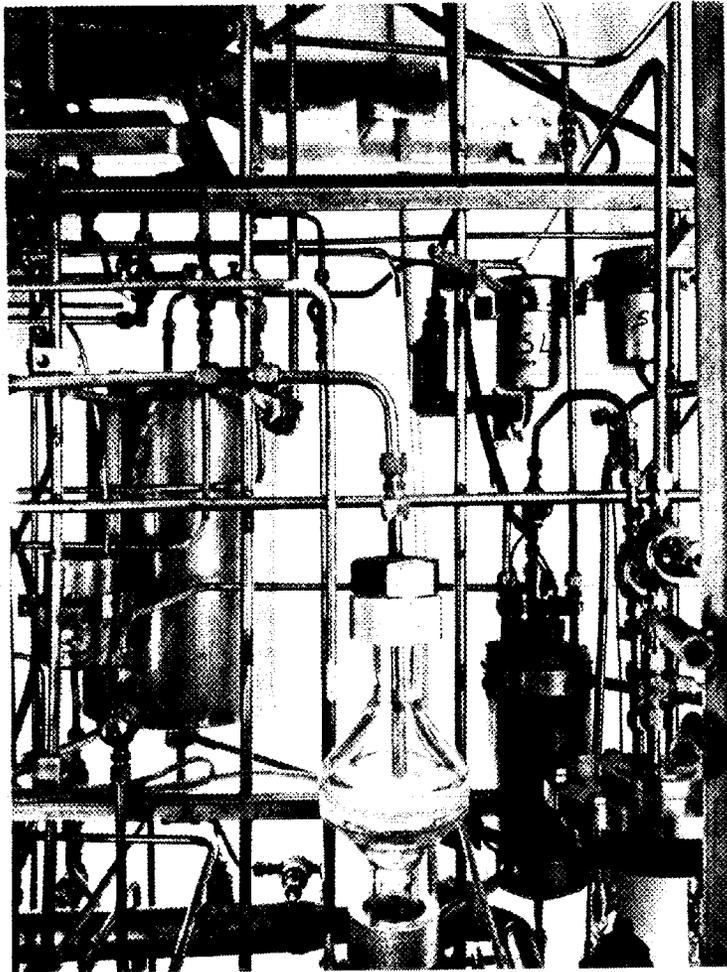


Fig. 2.19i.

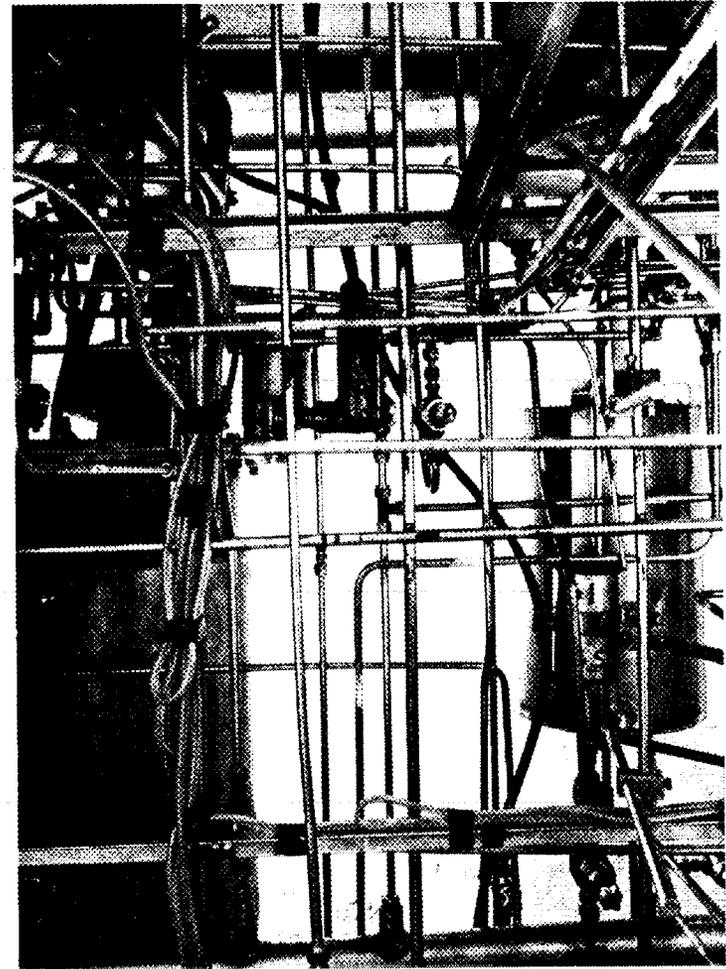


Fig. 2.19j.

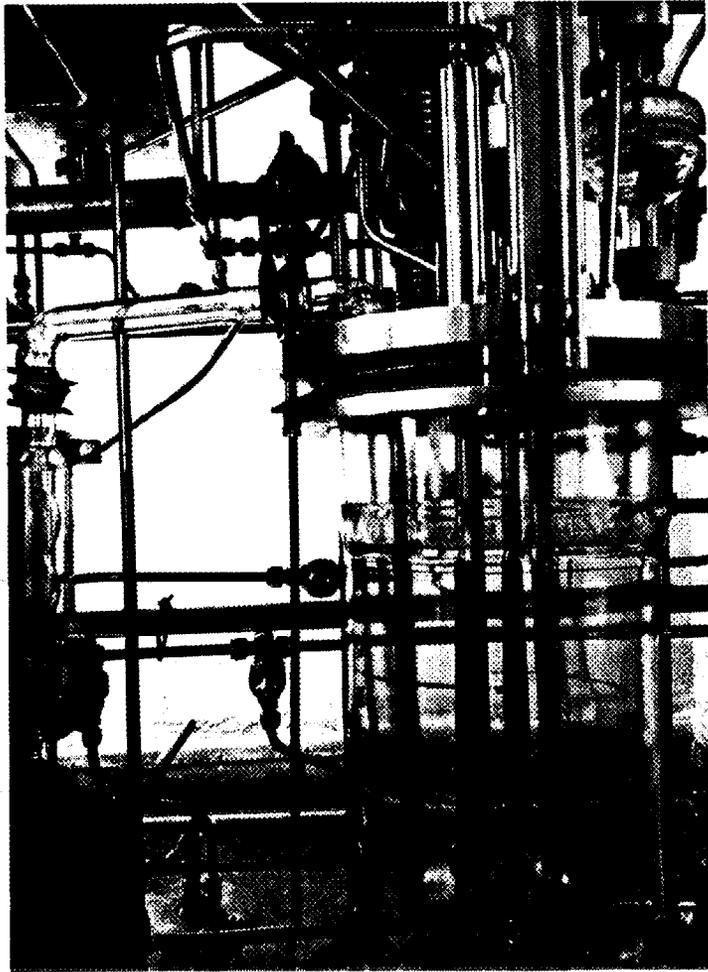


Fig. 2.19k.

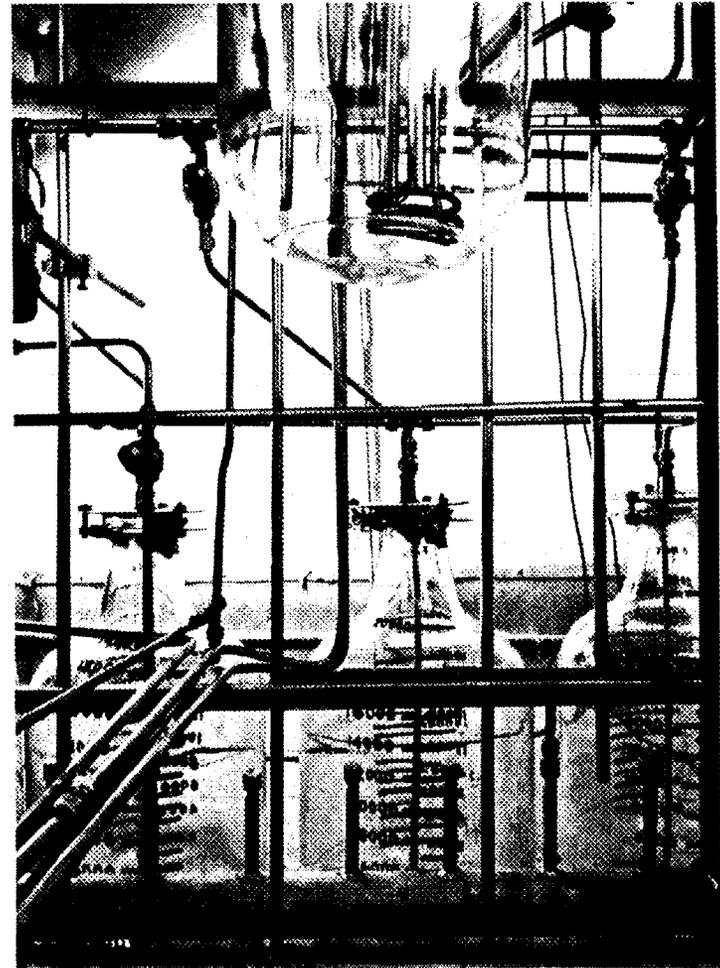


Fig. 2.19l.

Figures 2.20 and 2.21 are photographs of the south cell interior taken in October 1952 from the entrance way. A comparison with photographs taken during the 1993-94 site investigation (shown later in this subsection) indicates that the cell piping and equipment remain essentially unchanged.

Partly recessed within the southeast corner alcove and sitting on a pedestal is a vessel designated in the Caesar process diagrams (e.g., C-RD-648) as crystallizer No. 1. The pedestal is 2 ft 6 in. high, measures slightly over 3 ft on each side, and is covered by a ¼-in. steel plate. The steel crystallizer vessel measures approximately 40 in. in height and 22 in. in diameter; much of the vessel cannot be seen in the historical photographs because of the approximately 28-in.-high brick wall that shields the vessel on two sides. The wall composition (e.g., lead brick or masonry brick) is not indicated in the drawings; the smaller size of the brick and the fact that the bricks are stacked rather than mortared suggests that they are lead. Horton (1984) also indicates, based on remembrances of a former operator, that the brick is lead. The bricks appear to be covered by a thin fabric or coating. An agitator motor is mounted above the vessel, and a vertical pipe coming from the crystallizer lid penetrates the ceiling.

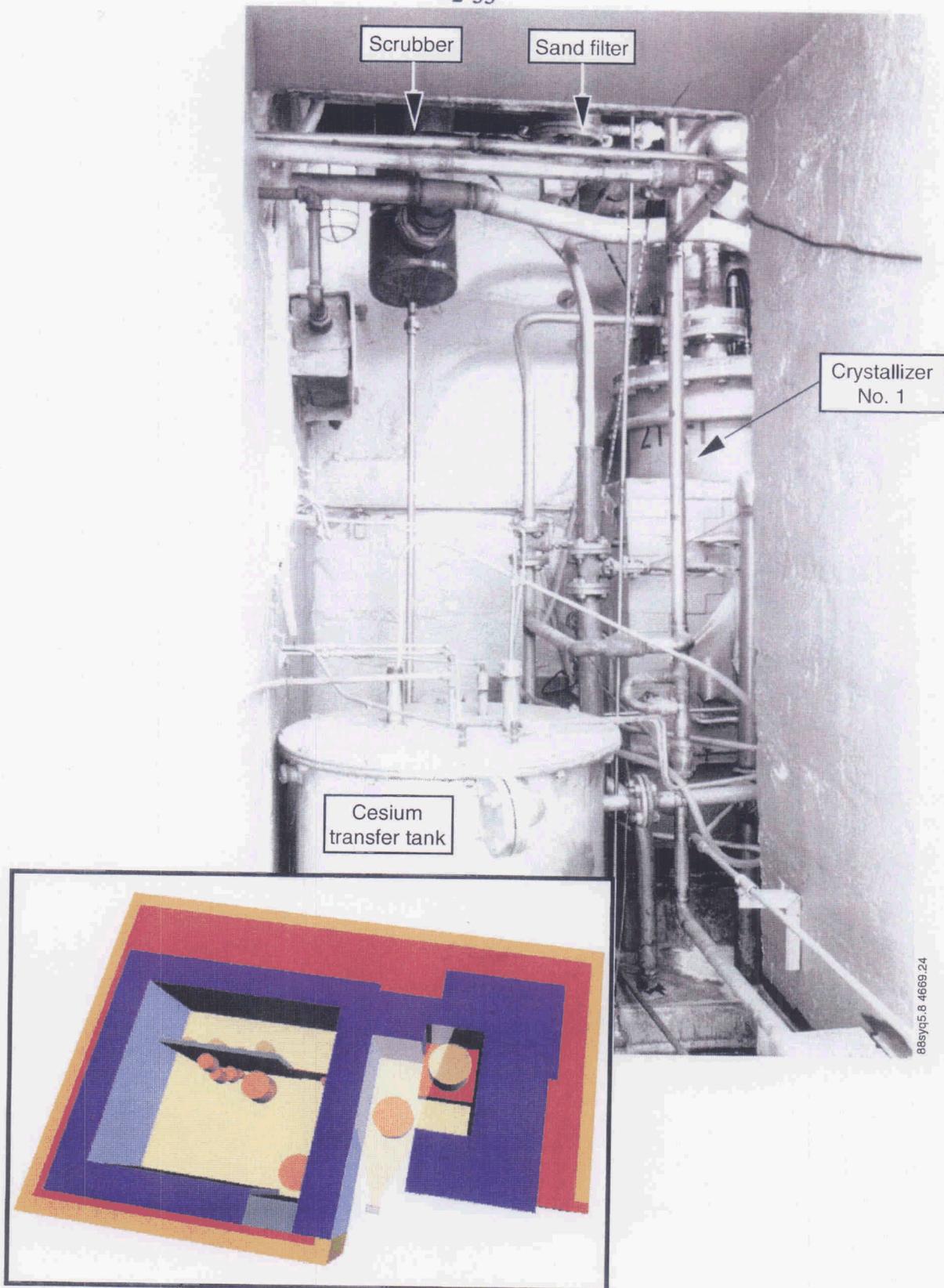
A second vessel that sits on the floor next to the north wall (and partway into the cell entrance) is designated as the cesium transfer tank. A 1950 ORNL fabrication drawing (D-341) of the stainless steel transfer vessel indicates a vessel height of 30 in. and a diameter of 24 in.

A cylindrical vessel designated as a hot off-gas scrubber in ORNL drawing D-340 is located in the northeast corner approximately 6 ft off the floor (shown in the upper left-hand corner of Fig. 2.21). The scrubber is approximately 1 ft 11 in. tall and 8 in. in diameter. On the north wall near the scrubber is what appears to be a radiator or heat exchanger with cooling fins. A brick and some metal sheeting (both probably made of lead) cover some of the cooling fins.

A sand filter canister is situated over the cesium transfer tank, approximately 2 to 3 ft southwest of the scrubber; the bottom portion of the canister is seen in Figs. 2.20 and 2.21. The design drawing for the sand filter (C-RD-622) indicates that the canister is slightly over 1 ft in height and 6 in. in diameter.

The process piping includes connections between vessels in a cell, connections between vessels in different cells, lines from the control room and roof for solids addition, liquid-level instrument lines, sample discharge lines, and drainage lines. Outside service piping includes 30- and 15-psi steam, air, water, demineralized water, and hot off-gas. Feed lines also entered the south cell to bring materials from tanks W-15, W-19, and W-20 (see process flow diagram D-RD-732). The feed line from tank W-15 entered the south cell through the floor; those from W-19 and W-20 entered through the entrance way (see C-RD-648). An early drawing (D-340) shows drainage lines to tanks W-3 and W-12 exiting the south cell through the floor and then under the east wall.

2-33



885yq5.8 4669.24

Fig. 2.20. South cell. (ORNL photo 10503; October 31, 1952)

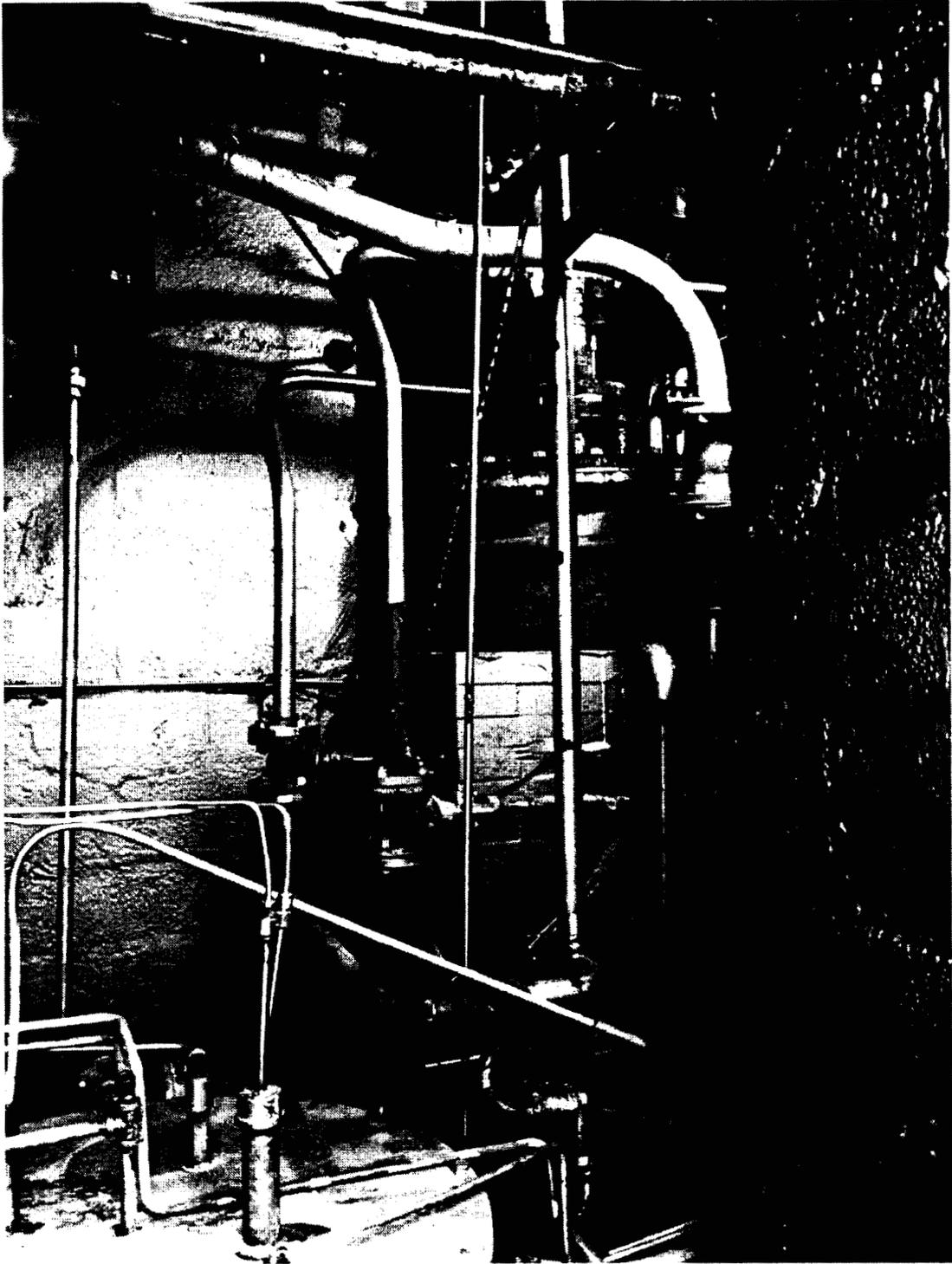


Fig. 2.21. South cell. (ORNL photo 10493; October 31, 1952)

According to ORNL piping layouts (e.g., D-340), piping in the south cell varies in outer diameter from ¼ in. to 2 in. Generally, the ¾-in. stainless steel tubing is connected with Swagelok fittings. Some piping with ¾-in. to ½-in. diameter passes through the north wall at two locations above the transfer tank, connecting the crystallizer and transfer tank in the south cell with the filtrate vessel and precipitator No. 1 in the north cell. A 1-in. pipe connecting the sand filter with precipitator No. 1 also traverses the north wall, and a 2-in. hot off-gas line penetrates the north wall at about 6 ft off the floor.

With the exception of two ½-in. gate valves and one ½-in. S&K water jet eductor, valve types and flow control types are not indicated in the piping diagrams obtained by the Bechtel team. Extension handles for the valves generally exit the south cell through the south and east walls.

Figure 2.22 is a 1994 composite photograph from the entrance way that primarily shows the north and east sides of the south cell. Seen in this figure are the crystallizer vessel, the scrubber, and assorted piping, including penetrations through the north wall for pipes at the top and end of the entrance way. The wall coloring in the photographs varies from yellow to brown to red, depending on camera lighting (flash) and photograph development. The exception is the wall coloring in the alcove, which is gray, indicating that the alcove walls may not have been painted and/or not exposed to the same chemicals as the other walls. Some of the paint covering the walls has deteriorated and is blistering or peeling.

Figures 2.23 and 2.24 are composite photographs of the cesium transfer tank, ancillary piping, valves, extension handles, and the area around the tank. Detritus is seen on the top of the tank as well as on the floor; only a small fraction of the piping shows rust. Shown in Fig. 2.23 are two concrete blocks that were pushed into the cell during the attempt to gain access through the stacked blocks in the entrance way. (One of the blocks was drilled halfway through before it fell out of the stack.)

Figure 2.25 is a composite photograph showing the crystallizer vessel, the shield wall, and the cell's south wall. Figure 2.26 shows the bottom portion of the south wall between the crystallizer shield wall and the west wall. Some flaking of the concrete wall and paint are evident where the valve extension handles and pipes penetrate the wall. The steel I-beams and steel plate forming the ceiling have rusted in the area above the crystallizer vessel.

2-36



88SY05.8.4669.17



88SY05.8.4669.17 iso

Fig. 2.22. South cell: composite photograph from entrance way showing north and east portions of cell.

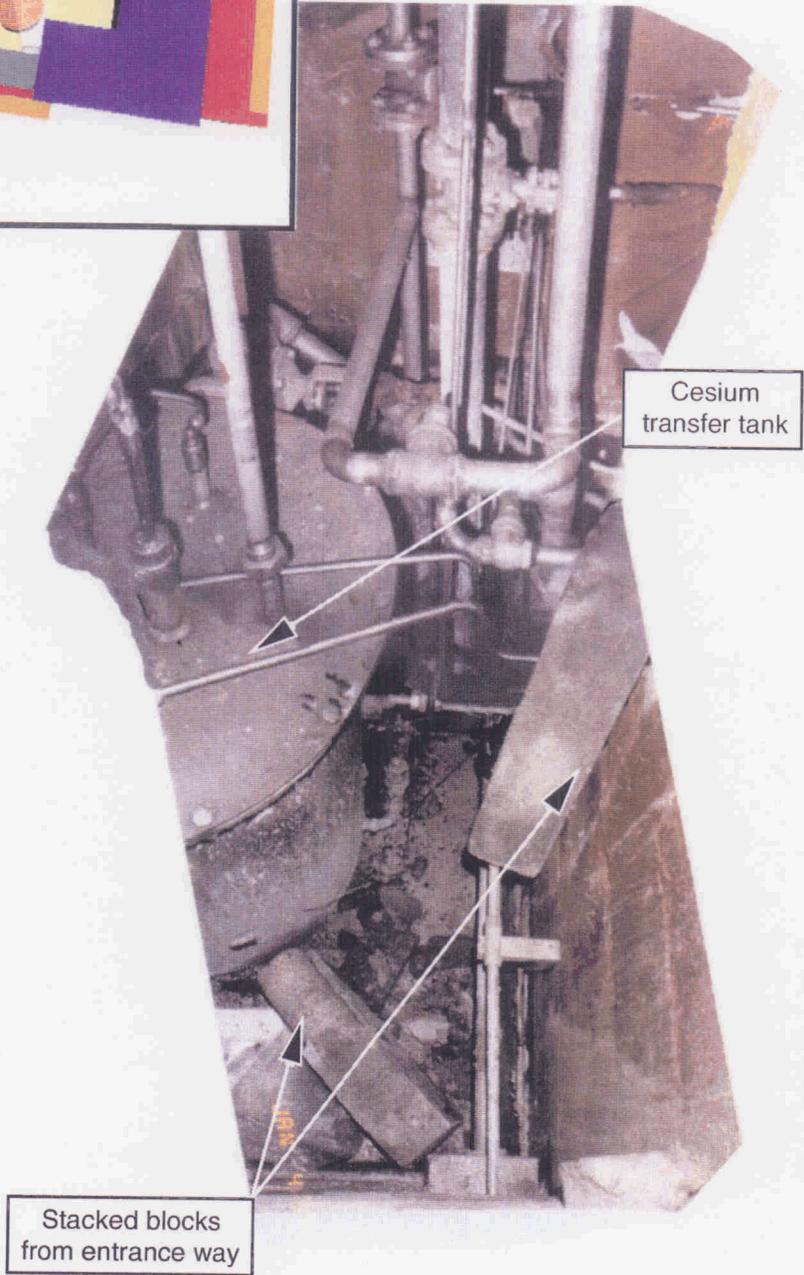
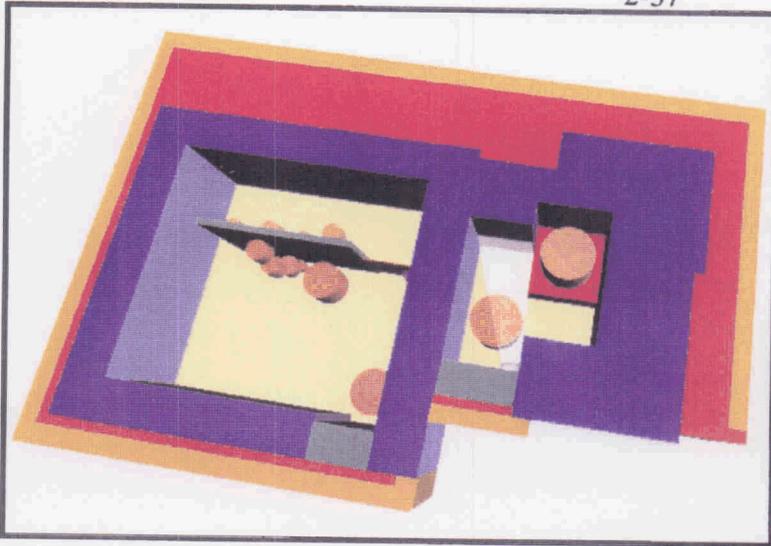


Fig. 2.23. South cell: composite photograph of cesium transfer tank and entrance way floor.

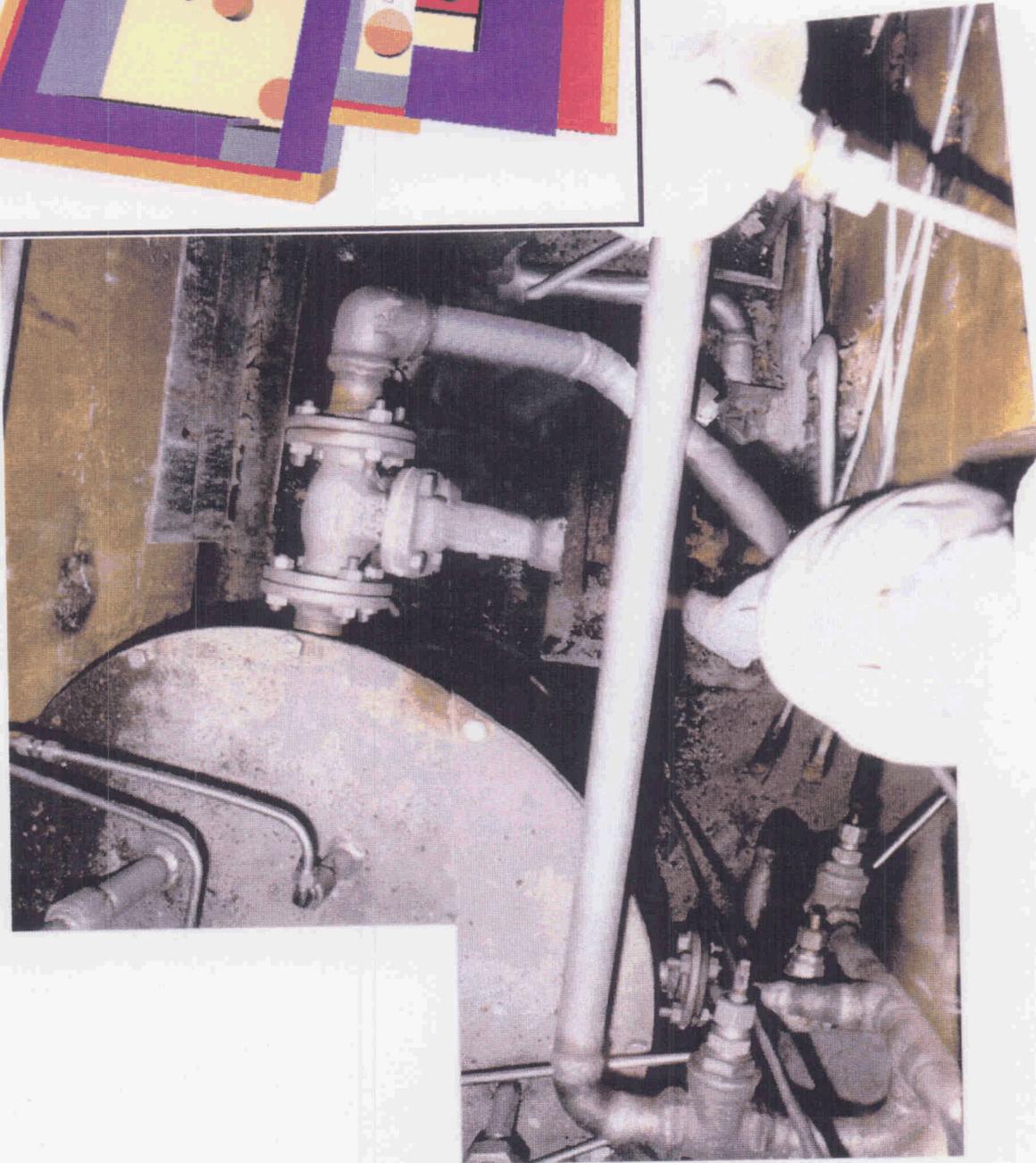
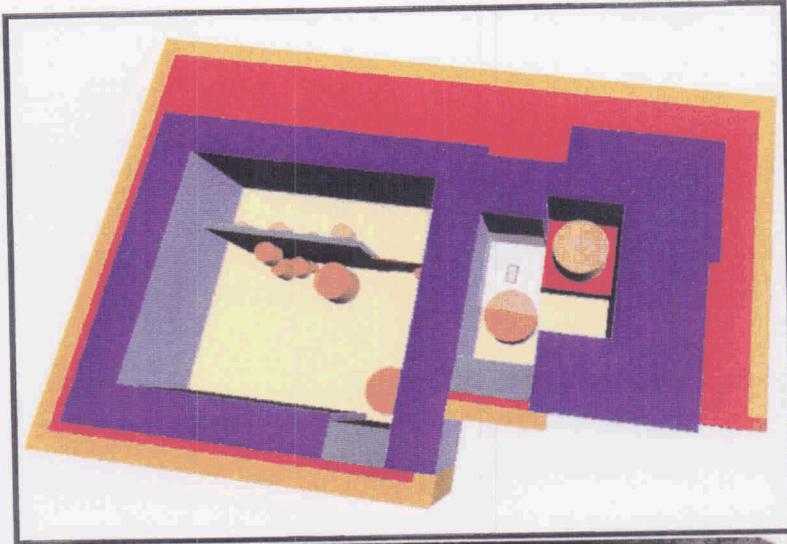


Fig. 2.24. South cell: composite photograph of floor area behind (to the east of) cesium transfer tank.

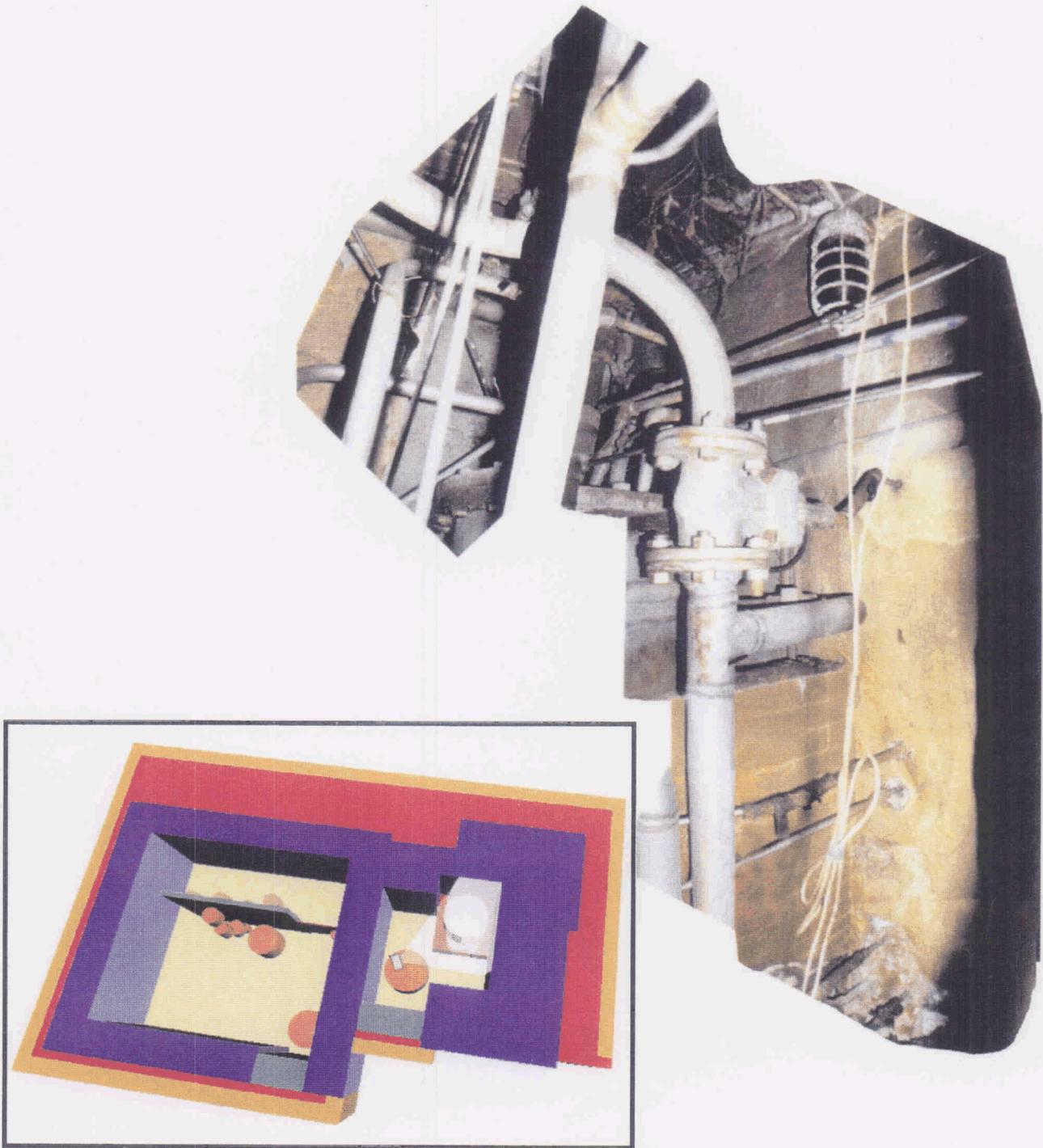


Fig. 2.25. South cell: composite photograph of southeast corner and south.

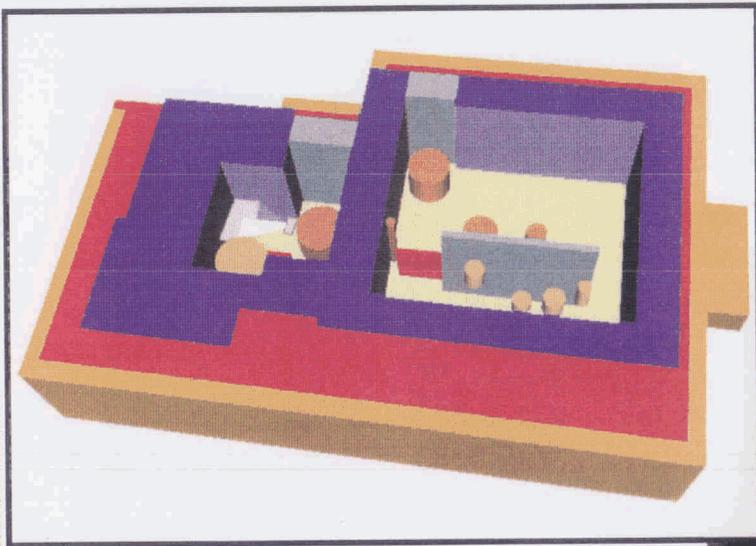


Fig. 2.26. South cell: bottom portion of southwest corner.

### 3. CHARACTERIZATION METHODS

The limited remote characterization of Building 3515 involved three techniques—inspections (Sect. 3.1), sampling and analysis (Sect. 3.2), and field radiological measurements (Sect. 3.3). Quality control (QC) for field work is addressed in Sect. 3.4.

#### 3.1 INSPECTIONS

Inspections were done to reconcile as-built dimensions against building design drawings and to provide records for future D&D planning. Historical ORNL drawings and photographs catalog some of the alterations and additions since the facility was built. No as-built information on Building 3515 was found during the review of drawings, photographs, and literature.

Photography, logbooks, and videotapes were the primary methods of documenting conditions in and around the building. Photographs provide a permanent record of the condition of the facility on the date of the inspection, and comparison of photographs with available drawings verifies as-built information and documents some of the modifications. All photographs were logged; time, date, photographer, and subject were minimum recorded information. A fully automatic 35mm camera was used so that the best possible images would be obtained regardless of the skill of the photographer. Negatives and complete albums of the photographs are maintained as permanent ORNL RI/FS Project records. ORNL personnel videotaped the interior and exterior of Building 3515 with assistance from the Bechtel team.

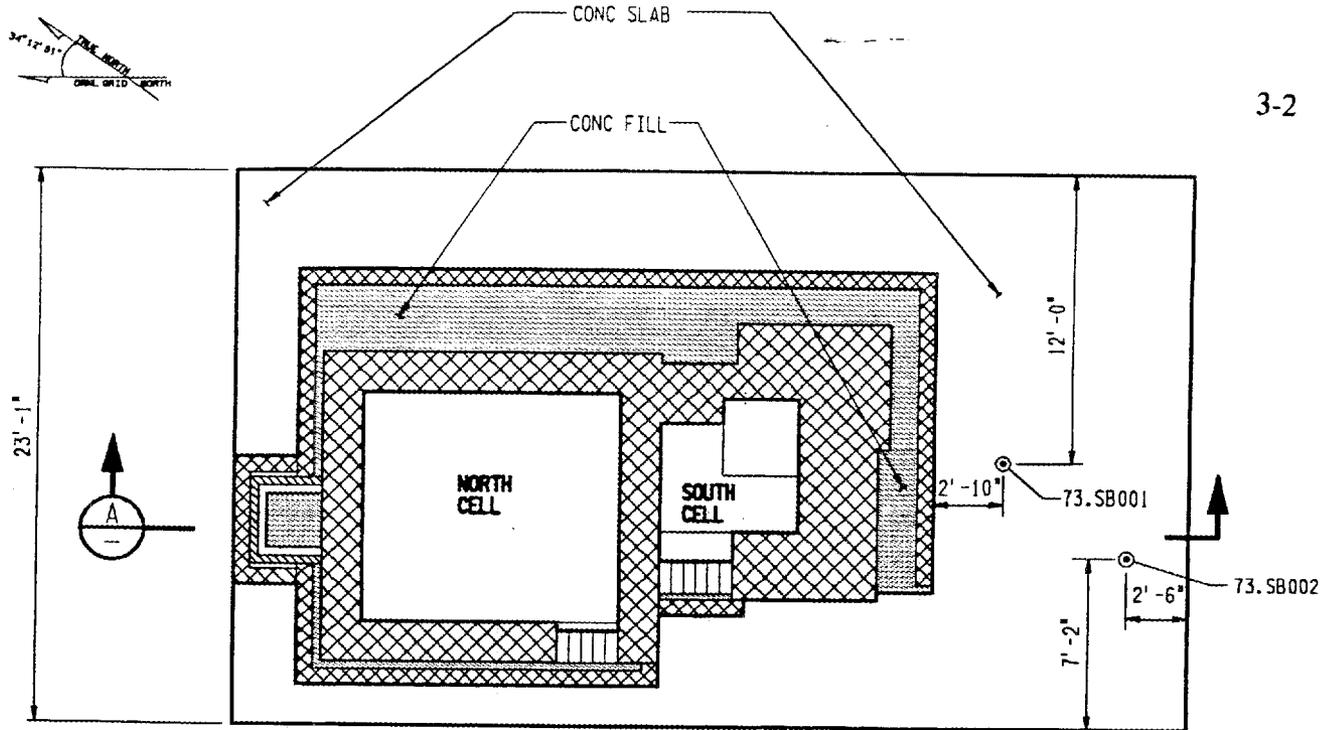
Exterior as-built dimensions were measured in the field with a steel tape to verify design drawings and recorded in field logbooks. Concrete cores taken from the west wall and the floor slab provided as-built thicknesses of those portions of the structure.

A structural engineer inspected Building 3515; the evaluation of the structure with respect to potential decommissioning is presented in Appendix B.

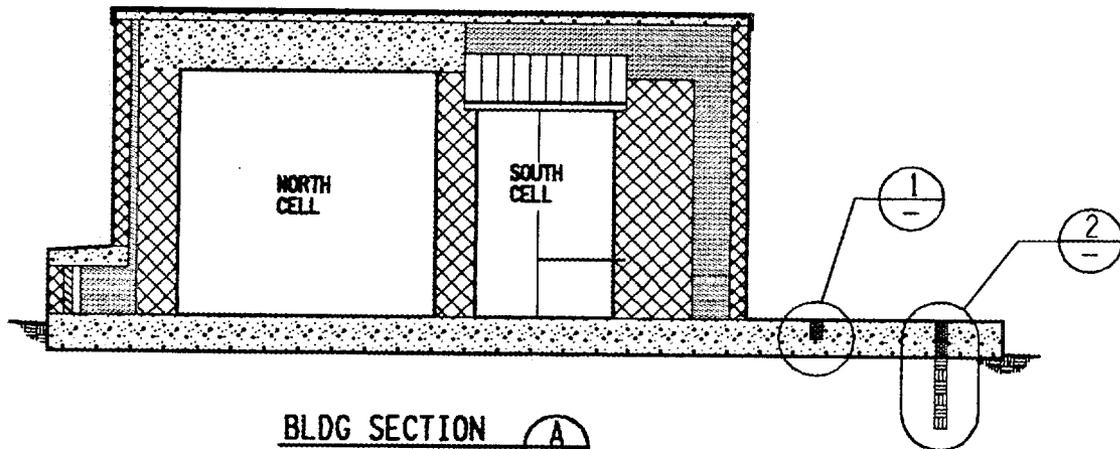
#### 3.2 SAMPLING AND ANALYSIS

The objectives of sampling were to identify radioisotopes present, including certain transuranic isotopes; determine depth of penetration of radionuclides into concrete surfaces; and screen for the presence of hazardous chemicals. Because the highly elevated general area radiation fields and high contamination levels prevented manned entry to the cells, sampling activities were limited to the building exterior. Samples consisted of three concrete cores from two coring locations in the building floor slab outside of the south wall of the structure, a subfoundation soil sample, and a paint chip sample from the south cell doorway.

Figure 3.1 shows the boring locations for the concrete cores and the soil sample. Table 3.1 provides location number, sample number, sample type and description, and types of analyses performed for each sample. Laboratory analyses included a full suite of hazardous chemicals and radionuclides; results are presented in Sects. 4 and 5.

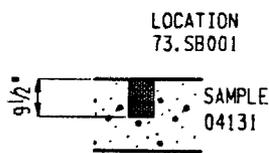


**BUILDING 3515, PLAN**

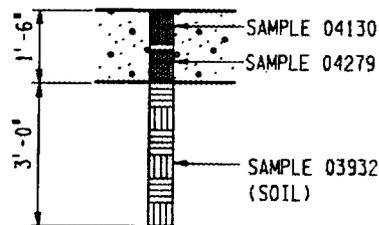


**BLDG SECTION A**

LOCATION  
73.SB002



**SECTION 1**



**SECTION 2**

**LEGEND**

- 73.SB002 LOCATION ID
- 04131 SAMPLE ID
- CONCRETE CORE SAMPLE
- ▨ SOIL SAMPLE

**Fig. 3.1. Concrete core and soil sampling locations.**

Table 3.1. Sampling summary

Location No. <sup>a</sup>	Sample No.	Sample Type	Sample Description	Chemical Analysis					Radiological Analysis
				TCL VOCs	TCL BNAEs	TCL Pest./PCBs	TAL Metals	TAL Cyanide	
73.SB001	04131	Concrete core	Core taken from the slab outside and to the south of Building 3515. The coring stopped when a steel plate was encountered; the plate made a hollow sound on contact. The core length is 0.8 ft.		X	X	X	X	X
73.SB002	04130	Concrete core	Core taken from the top half of the slab at a location approximately 10 ft south of Building 3515. The core length is 0.8 ft.		X	X	X	X	X
	04279	Concrete core	Core taken from the bottom half of the slab at the same location as sample 04130. The core length is 0.7 ft. The top surface of the core was painted grey. While most of the core was at background radiologically, the bottom surface was relatively "hot": 6 mR/h closed window and 100 mrad/h open window.		X	X	X	X	X
	03932	Soil	Hand-augered composite soil sample taken below the Building 3515 slab at depths of 1.5 to 4.5 ft. (Exception: the VOC sample was taken from a depth interval of 2.2 to 3.2 ft.) Refusal was not reached but drilling was stopped at 4.5 ft because of the relatively high radiation levels of the collected soil: gross gamma of 20 mR/h closed window and 100-plus mrad/h open window.	X	X	X	X	X	X
	04180	Trip blank/water	Submitted with sample 03932.	X					
Foyer wall in south cell	04243	Paint chips	Sample was submitted for TAL metals analyses without mercury analysis. Due to the limited volume of the sample, all of the sample volume was used to achieve the best detection limits; as a result, the analyses were performed without a matrix spike or duplicate.				X		X

3-3

<sup>a</sup>Locations are shown in Fig. 3.1.

Concrete core samples obtained using a 4-in.-diam diamond core drill were analyzed by slit-scanning with a high-purity germanium (HPGe) gamma spectroscopy system to determine radionuclide penetration. Slit-scanning involves shielding the detector so that only a ¼-in. slice of the core is measured at any one time. Each ¼-in. increment down the length of the core is measured to develop a contamination profile.

The soil sample was collected from under the floor slab by hand augering in a core hole.

### 3.3 RADIOLOGICAL MEASUREMENTS

Field measurements of the radiological conditions in Building 3515, which are of primary importance, were performed individually for the north and south cells. Because of high radiation fields, field measurements were performed remotely using long-handled tools. The field instruments were source- and background-checked at the beginning and end of each day's use.

The field measurements included gross gamma measurements using omnidirectional (teletector) and directional (shielded HP-290 and modified HP-220A) detectors mounted on a long pole, a thermoluminescent dosimeter (TLD) string, and gross smears. The general area gamma measurements meet the objective for ALARA (as low as reasonably achievable) needs and planning for D&D task sequencing. Directional gamma measurements and TLD strings provide radiation exposure rate profiles.

The smear samples were analyzed for gross beta/gamma, gross alpha, and gamma isotopes (spectroscopy); strontium-90 analysis was conducted if gross beta levels exceeded 500 cpm and could not be accounted for by gamma spectroscopy results.

The site characterization plan (Bechtel 1993a) includes detailed descriptions of the instruments and methods used for radiological measurements; Appendix C lists the instruments used in this investigation. Results of field radiological measurements are presented in Sect. 6.

### 3.4 FIELD QUALITY CONTROL

Field QC was ensured by adherence to approved plans, procedures, and field work guides (FWGs). These documents include requirements for training, record keeping, field QC checks, and personnel responsibilities. The FWGs detail proper measurement and sampling sequences.

Several QC oversight surveillances were conducted with checklists developed from approved ORNL RI/FS Project FWGs and other applicable procedures to ensure that activities were performed in accordance with appropriate requirements. These QC surveillances covered activities such as

- availability of work-controlling documents (project procedures and FWGs) for the work team at the site;
- deployment of required equipment and supplies;
- review of training records;
- use of appropriate personal protective equipment;
- access to the building in prescribed sequenced based on results of the initial health and safety monitoring;
- systematic survey of the area;
- selecting and marking of the measurement locations;
- methods of obtaining samples;
- radiological measurements;
- entry of radiological results into field logbooks;
- photography of the building, remaining equipment, access points, and selected sample locations;
- taking, marking, and handling of the concrete core and soil samples; and
- entry of information in the field logbooks.

These surveillances resulted in no adverse findings or corrective action requests.

## 4. CHEMICAL SAMPLING AND ANALYSIS

This section discusses the chemical findings from sampling in January and February 1994. In addition to the required QC samples, three concrete samples, one soil sample, and a paint chip sample were collected. Section 5 discusses the radiological findings for these same samples.

No known chemical characterization studies of Building 3515 had been performed before the 1994 field effort, and historical chemical findings for the building itself probably do not exist. However, there are historical chemical data for some of the soils surrounding the building; at the end of this section is a tabulation and summary of chemical findings for soil samples taken near Building 3515 during Phase I of the remedial investigation of Waste Area Grouping (WAG) 1.

### 4.1 DATA PRESENTATION

Chemical data for the solid samples (i.e., soil, concrete, or paint chip) are presented in units of milligrams of analyte per kilogram of solid (mg/kg) on a dry weight basis; one mg/kg is equivalent to one part per million (ppm).

For organic analytes, only those analytes detected (i.e., "hits") are reported in this section. For inorganic analytes (i.e., metals and cyanide), all data are reported. When an inorganic analyte concentration is reported as a "less than" (<) value (e.g., <20 mg/kg), this indicates that it was not detected at or above its detection limit (in this case, 20 mg/kg).

The analytical data presented here for the regular samples have been qualified by the project as part of the validation process. The qualifiers applicable to this report are defined as follows.

- J: The associated numerical value is an estimated quantity. For organic compounds, the qualifier also means the compound was detected at a value less than the quantitation limit.
- NJ: Presumptive evidence for the analyte exists (tentative identification) at an estimated quantity.
- R: Values are unusable (i.e., compound may or may not be present). Resampling and/or reanalysis is necessary for verification.

In the discussion that follows for the organic compounds, the notation "TIC" (tentatively identified compound) means that the compound has been identified solely by its mass spectrum in a machine search of spectra contained in a computer's library. The quantitation is based on the response factor of the nearest internal standard present in the chromatogram. Because of the nature of the quantitation procedure, all nonrejected values reported are, by definition, approximate concentrations and bear the NJ qualifier. Parentheses in the organic analytical data tables indicate the number of TICs.

Chemical analyses [Environmental Protection Agency (EPA)] analytical support level IV include both Target Compound List (TCL) and Target Analyte List (TAL) analyses. Appendix D lists the individual TCL organic and TAL inorganic analytes, as well as their respective contract-required detection/quantitation limits as referenced in EPA's Statements of Work (EPA 1991a,b). Organic TICs are not specifically on the TCL but were reported by the laboratory if detected during the organic analyses.

The concrete cores were slit-scanned soon after they were collected. After slit-scanning, each core was broken up into <2-in. fragments, placed in a capped stainless steel tube, and sent to an offsite analytical subcontract laboratory (ASL), where the concrete was crushed and homogenized and then distributed among containers for various designated analyses.

## 4.2 DATA USABILITY ASSESSMENT

Documentation provided by the laboratories for the chemical analyses met RI/FS QC level III requirements, as stated in the Technical Specification for Analytical Services (Bechtel 1993b). (Note: this QC level refers to reporting requirements for analytical laboratory services and is not to be confused with EPA analytical support levels.) QC level III mandates that QC data, including raw data (e.g., calibration and control data), be reported in a Contract Laboratory Program (CLP), or "CLP-like," data package.

Although the data packages from the laboratories met QC level III documentation requirements, validation of the packages met RI/FS Project QC level II requirements. Level II data validation means that the chemical data were reviewed in accordance with EPA CLP data validation procedures for organic data (EPA 1990) and inorganic data (EPA 1988), but the raw data were not checked by the validator to the same degree that they would have been checked in a QC level III protocol. QC level II validation was judged sufficient for this investigation.

The preparation and quantitative measurements of samples for organic compounds followed CLP methodology (EPA 1991a). Volatile organic compounds (VOCs) were determined using the CLP method for volatiles in water and solids by purge-and-trap gas chromatography-mass spectrometry (GC-MS). Analysis for base/neutral/acid-extractable constituents (BNAEs) consisted of extraction using methylene chloride, followed by GC-MS analysis. Pesticides/polychlorinated biphenyls (PCBs) were prepared using sonification extraction and then measured using a capillary column GC method with an electron capture detector.

The analytical method for inorganics requested by the Bechtel team and employed by the laboratories followed the CLP Statement of Work (EPA 1991b). In accordance with EPA's CLP protocol, arsenic, lead, selenium, and thallium were analyzed using atomic absorption (furnace technique); mercury was analyzed using the cold vapor technique (a flameless atomic absorption procedure); cyanide was analyzed using a semiautomated spectrophotometric technique; and the remaining metals were analyzed by inductively coupled plasma atomic emission spectroscopy.

Difficulties with the TCL organics analyses occurred because of severe matrix effects, particularly with the concrete core samples. Some of the BNAE and PCB analyses were qualified as estimated or rejected because the concrete matrix negatively affected surrogate recoveries, matrix spike recoveries, and internal standard area counts.

Uncertainties in the TAL inorganics data include the following.

- Blank analysis results are assessed to determine the existence and magnitude of contamination problems. Contaminants were found in some individual blanks; however, these appear to be isolated occurrences not affecting other data. Sample results greater than the detection limits but less than 5 times the amount in any blank were qualified as nondetects (U).
- The inductively coupled plasma interference check samples verify the laboratory's interelement and background correction factors. Interference check samples at the TMA laboratory had positive detects for sodium in two of the concrete cores (samples 04130 and 04279) and positive detects for antimony, potassium, and sodium in the third (sample 04131). Therefore, corresponding detects for these elements may be biased high.
- The matrix spike sample analysis provides information about the effect of each sample matrix on the digestion and measurement methodology. Analytes in samples most often found with percent recoveries less than the acceptable limits (of 80 to 120%) included antimony, arsenic, and selenium. Therefore, these spike recoveries indicate a negative bias and associated sample results were qualified [as estimated (J) or rejected (R)] as appropriate. A positive bias was indicated for copper in samples 04130 and 04279 since copper was found with a percent recovery greater than the acceptable limit. (As mentioned in Table 4.1, no matrix spike analysis was performed for the paint chip sample because of the limited sample volume.)

TCL organics analyses for the concrete core samples (04131, 04130, and 04279) were performed at the TMA laboratory in Monrovia, California; those for the soil sample (03932) were done at the IT laboratory in St. Louis, Missouri. TAL inorganics analyses for the concrete core samples were performed at the TMA/Skinner and Sherman laboratory in Waltham, Massachusetts; those for the other (soil and paint chip) samples were done at the IT laboratory in St. Louis.

The following subsections discuss the nonradiological chemicals detected, organized by contaminant groupings: VOCs, BNAEs, pesticides/PCBs, metals and cyanide, and lead shielding material. Only summary tables of chemical findings are presented; complete analytical data packages are available as part of the ORNL RI/FS Project permanent records.

Table 4.1. Analytical detects for organic compounds

Location ID	73.SB001	73.SB002		
Sample ID	04131	04130	04279	03932
Sample Type	Concrete Core	Concrete Core	Concrete Core	Soil
Units	mg/kg	mg/kg	mg/kg	mg/kg
<i>VOC TICs (No. of TICs)<sup>a</sup></i>				
Unknown	NA	NA	NA	0.007 NJ(1)
<i>BNAEs</i>				
Bis(2-ethylhexyl)phthalate			0.5 J	
<i>BNAE TICs (No. of TICs)<sup>a</sup></i>				
Aldol condensation				11. NJ(1)
Unknown				0.495 NJ(4)
Unknown alkane			2.77 NJ(6)	
Unknown hydrocarbon	1018.2 NJ(19)	1536.5 NJ(7)	1602.5 NJ(7)	
<i>Pesticides/PCBs</i>				
Aroclor-1254			1.1 J	
Aroclor-1260			0.46 J	
Heptachlor	0.0008 J			

<sup>a</sup> The result is the sum of the tentatively identified compounds (TICs). The number of TICs is shown in parentheses.

Notes: (1) No organic analysis was performed for sample 04243 (paint chip sample from south cell).

(2) "NA" indicates that analyses were not conducted; a blank space indicates that the analyte was not detected.

### 4.3 VOC CONTAMINATION

TCL VOC analyses were performed on the soil sample (sample 03932) taken below the slab. TCL VOC analyses were not performed on the concrete samples because of (1) the implausibility of significant quantities of VOCs remaining in concrete over years of non-use of the facility, or (2) the possibility of prematurely liberating the VOCs during drilling and core fragmentation (prior to shipment).

No VOCs were detected in the soil sample; however, Table 4.1 indicates that one unknown VOC TIC was detected at a concentration of 0.007NJ mg/kg. No VOCs or VOC TICs were detected in the trip blank (sample 04180) that accompanied the soil sample.

### 4.4 BNAE CONTAMINATION

No BNAEs were detected except in sample 04279, a concrete core taken from the slab at a depth of 0.8 to 1.5 ft (Table 4.1). The core sample was found to contain a minor quantity of common plasticizer [0.5J mg/kg of bis(2-ethylhexyl)phthalate]. The plasticizer, which is not listed as a Resource Conservation and Recovery Act (RCRA) toxicity characteristic contaminant (40 CFR 261.24), may have originated from the drilling fluid passing through the rubber/plastic hoses of the core drill, or as a laboratory contaminant.

Moderate quantities of TICs (primarily unknown hydrocarbons) were found in the concrete cores extracted from the slab. The number of TICs for each core ranged from 7 to 19, and the total (summed) concentration of TICs for each sample ranged from approximately 1018NJ to 1605NJ mg/kg. The BNAE TIC contamination characteristics (e.g., name and concentration of analytes) of the concrete cores are somewhat consistent between cores. Although the origin of the TICs is unknown, the similarities in BNAE TIC contamination among core-drilled samples lends credence to the hypothesis that some of the TICs possibly originated from core drill grease or lubricants liberated and transported during wet drilling operations.

The soil sample (03932) contains fewer TICs than the concrete cores (5 versus 7 to 19 TICs) at summed quantities two orders of magnitude less than those found in the concrete cores (11.5NJ mg/kg versus 1018NJ to 1605NJ mg/kg). The soil sample and its associated method blank each contain roughly the same quantity and number of BNAE TICs, indicating that the contamination may have been due to carryover from previous analyses.

### 4.5 PESTICIDE/PCB CONTAMINATION

Table 4.1 lists the concentrations of the single insecticide and two PCBs detected.

- A small amount of heptachlor (0.0008J mg/kg) was detected in core sample 04131 taken from the first boring location. No other pesticides or PCBs were detected at this location.

- Aroclors (PCBs) were found in sample 04279, a concrete core from the bottom half of the slab, at a summed concentration of 1.56J mg/kg (ppm). No aroclors were detected in samples from the top half of the slab.

The Toxic Substances Control Act (TSCA) regulations in 40 CFR 700 contain storage, disposal, and cleanup requirements for materials contaminated with PCBs (Etnier et al. 1993). These regulations require that debris with PCB concentrations greater than 50 ppm (40 CFR 761.60) be incinerated (40 CFR 761.70) or stored in a chemical waste landfill (40 CFR 761.75). Since the PCB concentration detected in the core sample is less than 50 ppm, the concrete should not be considered a TSCA waste (or a mixed waste if also radioactively contaminated). However, Energy Systems policy (ESS-EP-125, Rev. 1) states that waste soil, concrete, and other debris contaminated to levels under 50 ppm should be disposed of by incineration or burial in a chemical waste landfill, or through an approved alternative method of disposal. With appropriate approvals, on-site burial is allowed for debris, soil, or concrete with an average concentration of less than 25 ppm.

#### 4.6 METALS AND CYANIDE CONTAMINATION

Metals occur naturally in soil and are therefore an integral component of structural materials such as concrete that are comprised of soil-related minerals. Table 4.2 lists the TAL metal and cyanide concentrations detected and, for comparison, the RCRA toxicity characteristic equivalent limits for solids.

Under RCRA, solid waste is classified as hazardous if it exhibits any of the following characteristics: (1) ignitability, (2) reactivity, (3) corrosivity, or (4) toxicity. As described in 40 CFR 261.24, toxicity is generally determined by using an extraction procedure [i.e., the toxicity characteristic leaching procedure (TCLP)] with a 4.8–5.2 pH acetic acid solution to mimic sanitary landfill conditions. If the sample extract from the TCLP test contains toxic contaminants at concentrations greater than EPA's specified maximums for those contaminants, then the waste is considered hazardous. Eight metals are included in EPA's list of toxicity characteristic analytes to be evaluated in the TCLP test.

For the D&D characterization of Building 3515, TAL metals analyses, which give total metals content via a concentrated nitric acid digestion, were performed rather than the less aggressive TCLP tests. It was acknowledged during initial planning that the TCLP might not be required if it could be demonstrated that the total metals content did not exceed the TCLP equivalent limits shown in Table 4.2. [Because of a 20-fold dilution during the extraction procedure for solids, the TCLP equivalent limits for solids (in mg/kg) are defined as 20 times the EPA regulatory limits for the extract (in mg/L).] However, if the total concentration of a particular metal is greater than the TCLP equivalent limit in Table 4.2 (which is equivalent to assuming that metal will completely dissolve in the TCLP acetate buffer), that metal becomes suspect as a RCRA constituent exhibiting the toxicity characteristic. A TCLP test will need to be performed for that particular metal to determine whether it is a RCRA constituent.

Table 4.2. Analytical results for metals and cyanide

Location ID	73.SB001	73.SB002			South Cell	RCRA Toxicity Characteristic Equivalent Limits for Solids <sup>a</sup>
Sample ID	04131	04130	04279	03932	04243	
Sample Type	Concrete Core	Concrete Core	Concrete Core	Soil	Paint Chips	
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
<i>RCRA Metals</i>						
Arsenic	<3.	4.5 J	4. J	5.5	2.4	100
Barium	57.5 J	55.9	23.6	54.5	4,300	2,000
Cadmium	<0.21	<0.36	0.94	2.3	<0.26	20
Chromium	10.1	9.4	20.4	21.9	<5.3	100
Lead	79.8	8.2 J	15.9 J	213	158	100
Mercury	<0.05	<0.05	<0.05	12.4 J	NA	4
Selenium	<2	<0.82 R <sup>b</sup>	<4.2 R <sup>b</sup>	<0.17	<1.4	20
Silver	<0.84	<0.44	<0.44	1.5	<0.6	100
<i>Other TAL Metals</i>						
Aluminum	5,710	6,220	5,740	12,200	14,300	NA
Antimony	<2.8	<2.6	<2.6	12. J	<6.1	NA
Beryllium	0.42	0.34	0.34	1.2	<0.15	NA
Calcium	255,000	284,000	284,000	41,300. J	15,000	NA
Cobalt	3.6 J	4.1	2.3	15.1	18.9	NA
Copper	16.3	128. J	8.3 R	15.7	8.7 J	NA
Iron	5,980	6,780	6,270	34,600	2,680	NA

4-7

Table 4.2 (continued)

Location ID	73.SB001	73.SB002			South Cell	RCRA Toxicity Characteristic Equivalent Limits for Solids <sup>a</sup>
Sample ID	04131	04130	04279	03932	04243	
Sample Type	Concrete Core	Concrete Core	Concrete Core	Soil	Paint Chips	
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
<i>RCRA Metals</i>						
Magnesium	20,600	20,300	9,280	3,410	472	1NA
Manganese	273	284	216	731	34.6	NA
Nickel	5.8	6.5	6	19.1	4.8	NA
Potassium	1,280. J	1,250	731	<2,500	414	NA
Sodium	<322	224. J	202. J	189	106	NA
Thallium	<0.26	0.22 J	0.62 J	<0.32	<0.18	NA
Vanadium	9.4	8.8	7.1	33.1	<2.8	NA
Zinc	29.4 J	29.8	151	56.4 J	103	NA
<i>TAL Cyanide</i>						
Cyanide	<0.49	<0.53	<0.53	<0.03	NA	NA

<sup>a</sup> The RCRA equivalent limits are derived from values in 40 CFR 261.24; the maximum concentrations of contaminants for the toxicity characteristic, listed by EPA in 40 CFR 261.24 in units of mg/L, were multiplied by a factor of 20 to obtain equivalent limits for solids in units of mg/kg.

<sup>b</sup> Selenium nondetects were rejected because of zero percent recovery on the matrix spike analysis.

Note 1: Sample 04180 (trip blank) did not undergo metals and cyanide analyses. Sample 04243 (paint chip) did not undergo mercury or cyanide analyses.

Note 2: Shaded values indicate that the total metal content is greater than RCRA toxicity characteristic equivalent limits.

Two TAL metals (selenium and cyanide) were not detected in any sample collected during the characterization; three TAL metals (mercury, silver, and antimony) were detected in only one sample.

Three metals (i.e., barium, lead, and mercury) were detected in samples 03932 and 04243 at sufficiently elevated levels to exceed the suggested relevant toxicity characteristic equivalents.

- Barium was detected at 4300 mg/kg in the paint chip sample (04243). This barium concentration is a factor of 2 greater than the toxicity characteristic equivalent of 2000 mg/kg.
- Lead was detected at 213 mg/kg in the soil sample (03932) and at 158 mg/kg in the paint chip sample (04243). These lead concentrations exceed by a factor of 1.5 to 2 the RCRA equivalent limit of 100 mg/kg.
- Mercury was detected at 12.4J mg/kg in soil sample 03932; this concentration is a factor of 3 greater than the toxicity characteristic equivalent of 4 mg/kg.

A characterization of the paint removed during D&D will be necessary to determine whether any barium or lead residuals may be classified as RCRA characteristic waste. If any fail the TCLP, the RCRA land disposal restrictions (LDRs) of 40 CFR 268 may be triggered [40 CFR 262.11; TDEC 1200-1-11-.03(e)]. However, it is expected that the paint will be sufficiently immune to leaching that the extracted barium and lead concentrations will be below their respective RCRA limits.

Removal of any lead-based paint must comply with the Occupational Safety and Health Administration final rule on lead abatement or exposure (29 CFR 1926.62, issued May 1993). This rule sets a permissible exposure limit at 50  $\mu\text{g}/\text{m}^3$  of air computed as an 8-h time-weighted average. The rule requires that in any construction work (which includes demolition or salvage of structures) where there is any occupational exposure to lead, an exposure assessment must be conducted to determine whether exposure exceeds the action level of 30  $\mu\text{g}/\text{m}^3$  computed as an 8-h time-weighted average. In addition to the exposure assessment, interim protection must be provided for certain listed activities while the assessment is being conducted.

#### 4.7 LEAD SHIELDING

Photographs taken inside Building 3515 document the presence of bricks shielding the crystallizer No. 1 vessel in the south cell; these may be lead bricks, but no direct chemical analysis was performed. Though not visually verified, additional lead shielding may also be present on the east and north sides of the building. According to Fig. 2.4, there is a lead plate measuring approximately 10 ft by 3 ft by 3 in. thick below the ground surface adjacent to the eastern edge of the concrete pad. The same figure also indicates the presence of a lead shield measuring approximately 23 in. in diameter and 2 in. thick underneath a steel plate cover for a closed cylindrical access way on the north side of the building. ORNL drawing

C-RD-632 (Revisions to Cell Floor, Building 3515, January 25, 1952) indicates that (1) a lead cover was placed over the 6-in.-high floor sills in each of the cell entrance ways, (2) lead sheet was wrapped around some protruding pipes, and (3) lead pipe and poured lead were used to shield floor drainage culverts through the north and east walls of the south cell. Photographs indicate what appears to be lead sheet and a lead brick on the radiator/heat exchanger on the north wall of the south cell. As indicated in ORNL drawing D-RD-613, a layer of lead brick may also surround the product sample and removal station.

The lead would probably be considered a mixed low-level radioactive waste, and decontamination activities would be governed by the exposure limits of DOE Orders 5400.5 and 5820.2A as well as the RCRA LDRs. Lead shielding is classified in the LDRs under waste code D008, which includes radioactive lead solids (40 CFR 268.42, Table 3). The LDR for D008 is a technology-based standard: macroencapsulation with surface coating materials such as polymeric organics (e.g., resins and plastics) or with a jacket of inert organic materials to substantially reduce surface exposure to potential leaching media.

#### 4.8 HISTORICAL SOIL SAMPLING EXTERIOR TO BUILDING 3515

Two soil borings (01.SB182 and 01.SB183) were hand-augered near Building 3515 in July 1991, during Phase I of the WAG 1 RI (Bechtel 1992). These 4-in.-diameter borings yielded five soil samples. Figure 4.1 shows the location of the borings relative to Building 3515, and Table 4.3 presents the total drilling depth, number of soil samples collected, intervals sampled, and analyte groups investigated by the laboratories. The analyte groups included VOCs, BNAEs, metals and cyanide, sulfide, and total organic carbon (TOC); pesticides and PCBs were not targeted for analysis.

Table 4.4 presents the concentrations of the organic compounds detected. No VOCs were detected in any of the exterior samples; however, one unknown VOC TIC was found at a concentration of 0.061NJ mg/kg in boring 01.SB182 at a depth interval of 0 to 2 ft.

BNAEs and BNAE TICs were both detected in boring 01.SB183, approximately 12 ft east of Building 3515; no BNAE analysis was performed for samples from boring 01.SB182. The 0- to 2-ft interval (sample 2338) contained 10 BNAEs, including one phthalate, at minor concentrations ranging from 0.05J to 0.31J mg/kg. In the 2- to 4-ft interval (sample 2342), only one BNAE was detected: di-n-butylphthalate at 0.11J mg/kg. The upper soil interval (sample 2338) contained 18 BNAE TICs with a total (summed) concentration of 35.7NJ mg/kg, and the lower interval (sample 2342) contained 16 BNAE TICs with a total concentration of 19.25NJ mg/kg.

Table 4.5 lists results for the metals and cyanide analyses for the soil samples. The RCRA metals were all detected at concentrations less than their toxicity characteristic equivalent limits.

Sulfide and TOC analyses were performed for the 2- to 4-ft interval sample (02342) from boring 01.SB183. No sulfide was detected above the detection limit of 0.5 mg/kg, and the TOC level was 3000 mg/kg.

Table 4.3. Chemical sampling summary for WAG 1 soil borings near Building 3515

Location	Distance from Bldg. 3515 <sup>a</sup>	Total Depth (ft BGS <sup>b</sup> )	Interval (ft)	Sample	Chemical Analyses					
					VOCs	BNAEs	Metals	Cyanide	Sulfide	TOC
01.SB182	Approximately 14 ft (3 ft from SW corner of slab)	5.4	0-2	2206	X					
			2-4	2207 <sup>c</sup>						
			4-5.4	2251 <sup>c</sup>						
01.SB183	Approximately 12 ft (8 ft from SE corner of slab)	4.1	0-2	2338	X	X	X	X		
			2-4	2342	X	X	X	X	X	X

<sup>a</sup> For location 01.SB182, the ORNL grid coordinates are 21935 (northing) and 31021 (easting); for location 01.SB183, the coordinates are 21942 (northing) and 31048 (easting).  
<sup>b</sup> The acronym BGS is "below ground surface."  
<sup>c</sup> Samples sent to the CSL only.

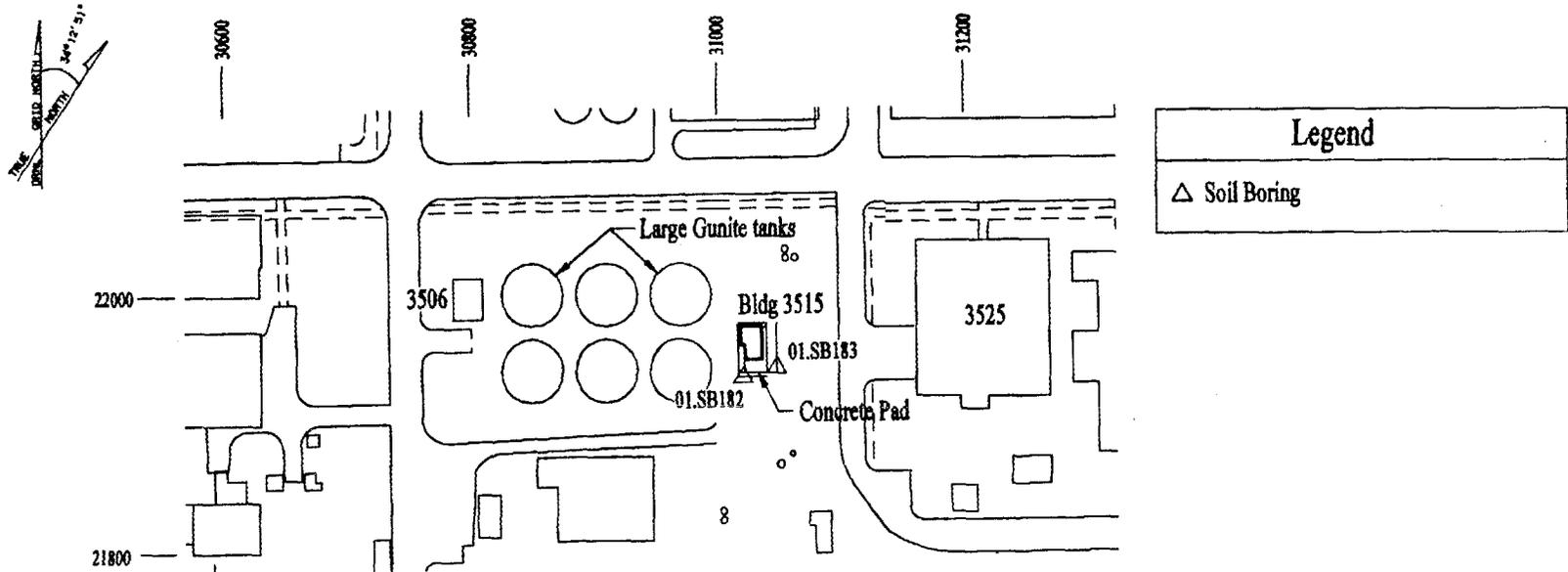


Fig. 4.1. WAG 1 soil boring locations near Building 3515.

Table 4.4. Analytical detects for organic compounds in WAG 1 soil borings

Location ID	01.SB182	01.SB183	
Sample ID	2206	2338	2242
Interval	0 to 2 ft	0 to 2 ft	2 to 4 ft
Units	mg/kg	mg/kg	mg/kg
<i>VOC TICs (No. of TICs)<sup>a</sup></i>			
Unknown	0.061 NJ(1)		
<i>BNAEs</i>			
Benzo(a)anthracene	NA	0.11 J	
Benzo(a)pyrene	NA	0.11 J	
Benzo(b)fluoranthene	NA	0.24 J	
Benzo(g,h,i)perylene	NA	0.05 J	
Chrysene	NA	0.19 J	
Di-n-butylphthalate	NA	0.098 J	0.11 J
Fluoranthene	NA	0.31 J	
Indeno(1,2,3-cd)pyrene	NA	0.063 J	
Phenanthrene	NA	0.066 J	
Pyrene	NA	0.3 J	
<i>BNAE TICs (No. of TICs)<sup>a</sup></i>			
Unknown alcohol	NA	0.4 NJ (1)	
Unknown alkane	NA	3.72 NJ(4)	2.09 NJ(2)
Unknown carboxylic acid ester	NA	0.4 NJ(1)	0.99 NJ(2)
Unknown hydrocarbon	NA	30.42 NJ(11)	15.38 NJ(10)
Unknown ketone	NA	0.76 NJ(1)	0.55 NJ(1)
Unknown phthalate	NA		0.24 NJ(1)

<sup>a</sup> The result is the sum of the tentatively identified compounds (TICs). The number of TICs is shown in parentheses.

Notes: (1) Samples from boring 01.SB182 did not undergo BNAE analysis.  
 (2) "NA" indicates that the analyses were not conducted; blanks indicate that the analyte was not detected.

Table 4.5. Analytical results for metals and cyanide in WAG 1 soil borings

Location ID	01.SB183		RCRA Toxicity Characteristic Equivalent Limits for Solids <sup>a</sup>
Sample ID	2338	2342	
Interval	0 to 2 ft	2 to 4 ft	
Units	mg/kg	mg/kg	mg/kg
<i>RCRA Metals</i>			
Arsenic	3.7 J	3.9 J	100
Barium	83.6	69.9	2,000
Cadmium	<0.52	<0.68	20
Chromium	9.7	27.7 J	100
Lead	19.5 R	25.7 J	100
Mercury	0.35	1	4
Selenium	0.79 J	<0.69 R	20
Silver	<0.35	<0.45	100
<i>Other TAL Metals</i>			
Aluminum	11,800	17,100	NA
Antimony	<2.3 R	<2.9 R	NA
Beryllium	0.8	0.63	NA
Calcium	36,900. J	46,700	NA
Cobalt	8.8 J	11. J	NA
Copper	10.2 J	13.1 J	NA
Iron	16,300	25,200. J	NA
Magnesium	8,330	6,250	NA
Manganese	648	650. J	NA
Nickel	12.6	20.7	NA
Potassium	1,580	2,660	NA
Sodium	<48.6	197. J	NA
Thallium	<2.8	<3.5 R	NA
Vanadium	16. J	23.5 J	NA
Zinc	48.6	45.1 J	NA
<i>TAL Cyanide</i>			
Cyanide	<0.35	<0.31	NA

Table 4.5 (continued)

---

<sup>a</sup> The RCRA equivalent limits are derived from values in 40 CFR 261.24; the maximum concentrations of contaminants for the toxicity characteristic, listed by EPA in 40 CFR 261.24 in units of mg/L, were multiplied by a factor of 20 to obtain equivalent limits for solids in units of mg/kg.

Note: Samples from boring 01.SB182 were not analyzed for metals and cyanide.

The above review of historical soil sampling data does not identify any chemical hazards that would be of particular concern in safeguarding worker health during D&D or indicate any chemical-related issues that would potentially interfere with coordination of Building 3515 D&D and the GAAT OU soil remediation.

#### 4.9 SUMMARY

Three concrete core samples from the slab were analyzed for TCL BNAEs, TCL pesticides/PCBs, and TAL inorganics. No BNAEs were detected except for 0.5J mg/kg bis(2-ethylhexyl)phthalate in core sample 04279. Moderate quantities of BNAE TICs (1018NJ to 1605NJ mg/kg) were detected in each core sample; a possible source of these TICs is core drill grease released during wet drilling operations. With regard to pesticides/PCBs, heptachlor at 0.0008 J mg/kg was found in one of the three core samples, and aroclors at 1.56J mg/kg (ppm) were found in another; this PCB concentration is below the TSCA limit of 50 ppm. No RCRA constituent metals were found. It should be noted that since the cores were all obtained outside Building 3515 but the chemical processing/activity was primarily inside the building, the chemical findings presented for the cores should *not* be considered representative of the concrete comprising the walls and floors of the cells.

One soil sample (03932) collected from under the building slab was analyzed for TCL organics and TAL inorganics. Although no VOCs, BNAEs, or pesticides/PCBs were detected, one unknown VOC TIC was detected at a concentration of 0.007NJ mg/kg, and 5 BNAE TICs were detected at a summed concentration of 11.5NJ mg/kg. Inorganic analyses indicated two potential RCRA constituent metals (lead and mercury); a TCLP test can determine whether or not they are RCRA constituents, and therefore whether the soil in its present form is a hazardous (or mixed) waste that may need to be segregated from D&D wastes.

One paint chip sample was submitted for TAL metals analyses (with the exception of mercury), and two potential RCRA constituent metals (barium and lead) were identified. A TCLP test should be performed before waste disposal to determine whether they are RCRA constituents; however, the paint is not expected to fail the TCLP test because of its relatively low leachability.

ORNL drawings indicate the presence of lead shielding, a potential mixed low-level radioactive waste, at various locations, and the wall around the crystallizer in the south cell may also be formed of lead bricks.

## 5. RADIOLOGICAL SAMPLING AND ANALYSIS

### 5.1 DATA PRESENTATION

Radiological data for solid samples (e.g., soil, concrete, or sediment) are presented in units of picocurie activity per gram of solids (pCi/g) on a dry weight basis. On occasion, the concentration of a radionuclide is reported as a "less than" (<) value (e.g., <2 pCi/g). This indicates that the radionuclide was not detected at or above its measurement method detection limit, referred to as minimum detection limit (MDL) (in this case, 2 pCi/g).

The radiological results presented for the regular samples were qualified as part of the validation process. The ASL prepared the blanks, spikes, and duplicates and qualified the blanks. The qualifiers (flags) for the regular samples were applied by RI/FS Project validators according to project procedures, taking the results of regular samples, blanks, spikes, and duplicates into consideration. The qualifiers present the following information.

- J:     The detected numerical value is an estimated quantity.
- U:     The radionuclide was not detected; MDL value is reported.
- UJ:    The MDL numerical value is an estimated quantity.
- R:     Indicates that the data are unusable (i.e., calibration data are wrong or resampling and/or reanalysis is necessary for verification.)
- (or blank):   No problems requiring the qualification of results.

ASL analyses included gross alpha; gross beta; gamma spectroscopy; total radioactive strontium; and plutonium, thorium, and uranium isotopes. Table 5.1 lists analytical methods; Table 3.1 provides location number, sample number, sample type and description, and types of analyses performed for each sample collected by the Bechtel Team; and Table 5.2 provides summary results of the radiological analyses for samples from Building 3515. Average radionuclide concentrations from WAG 1 reference soil sample results are listed in Table 5.2 for comparison. Figure 3.1 shows the location of core and soil samples collected from the concrete pad outside of the building.

### 5.2 DATA USABILITY ASSESSMENT

Radiological analyses were performed at the IT and TMA laboratories in Oak Ridge, Tennessee. The preparation and quantitative measurements of samples for radionuclide analysis followed the ASL's standard operating procedures, which are equivalent to the methods stipulated in Table 5.1.

Table 5.1. Analytical methods

Parameter	Analytical Technique	Method Number <sup>a</sup>	Detection Limit <sup>b</sup> (solids, liquids)
Gross alpha	Gas flow proportional counting	USEPA 900.0	1 pCi/g, 1 pCi/L
Gross beta	Gas flow proportional counting	USEPA 900.0	2 pCi/g, 4 pCi/L
Gamma spectroscopy	Gamma spectroscopy	USEPA 600/901.1	0.2 pCi/g Cs-137, 20 pCi/L Cs-137
Total radioactive strontium	Radiochemical separation followed by gas flow proportional counting	USEPA 600/905	0.5 pCi/g, 5 pCi/L
Plutonium isotopics ( <sup>238</sup> Pu, <sup>239/240</sup> Pu)	Radiochemical separation followed by alpha spectroscopy	EML Pu-02	0.6 pCi/g, 1 pCi/L
Thorium isotopics ( <sup>228</sup> Th, <sup>230</sup> Th, <sup>232</sup> Th)	Radiochemical separation followed by alpha spectroscopy	LANL ER200	0.6 pCi/g, 1 pCi/L
Uranium isotopics ( <sup>232</sup> U, <sup>233/234</sup> U, <sup>235</sup> U, <sup>238</sup> U)	Radiochemical separation followed by alpha spectroscopy	EML U-02	0.6 pCi/g, 1 pCi/L

Sources: Bechtel National, "Technical Specification for Analytical Laboratory Services," Specification 19118-99-SP-03, Rev. 4, 1993; EPA, *Index to EPA Test Methods*, EPA 901/3-88-001; EPA, *Contract Laboratory Program Statements of Work for Organics and Inorganics Analysis*, Documents OLM01.8 and ILM02.1, 1991; DOE, *EML Procedures Manual*, HASL-300, 1992; and LANL, *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance Manual*, LA-10300M/UC907, 1986.

<sup>a</sup> Abbreviations are: EML-Environmental Measurements Laboratory; LANL-Los Alamos National Laboratory; CLP-Contract Laboratory Program; and SOW-Statement of Work.

<sup>b</sup> Detection limits for radiological parameters are expressed as "detection limit goals."

Table 5.2. Radiological analysis results for Building 3515

Sample ID Location ID	04131 (Concrete)			04130 (Concrete, 0.8 ft)			04279 (Concrete, 0.8-1.5 ft)			03932 (Soil)			04243 (Paint Chip <sup>a</sup> )		
	Concentration (pCi/g)	Uncertainty (±)	Review qualifier /MDL	Concentration (pCi/g)	Uncertainty (±)	Review qualifier /MDL	Concentration (pCi/g)	Uncertainty (±)	Review qualifier /MDL	Concentration (pCi/g)	Uncertainty (±)	Review qualifier /MDL	Concentration (pCi/g)	Uncertainty (±)	Review qualifier /MDL
Gross Alpha	-1.40	9.50	U/9.72	7.60	4.50	--	10.70	4.20	--	7260.00	1460.00	--	78.00	17.00	
<sup>241</sup> Am										382.00	101.00	--			
<sup>239/240</sup> Pu	0.05	0.07	U/0.12	0.02	0.06	U/0.14	0.16	0.15	R	95.40	20.40	--			
<sup>238</sup> Pu	0.06	0.09	U/0.15	0.03	0.09	U/0.22	0.05	0.10	U/0.20	5.70	1.60	--			
<sup>228</sup> Th	0.44	0.23	--	0.34	0.23	J	0.68	0.37	--	5.51	1.97	--			
<sup>230</sup> Th	0.89	0.34	--	0.85	0.39	--	0.85	0.42	--	5.57	1.88	J			
<sup>232</sup> Th	0.36	0.19	--	0.55	0.30	--	0.28	0.22	--	1.09	0.76	J			
<sup>234</sup> U	0.76	0.32	--	1.30	0.53	J	0.82	0.41	--	1.81	0.95	--			
<sup>235</sup> U	0.00	0.00	U/0.06	0.03	0.06	UJ/0.08	0.03	0.07	U/0.09	0.04	0.22	U/0.59			
<sup>238</sup> U	0.68	0.30	--	1.40	0.56	--	1.37	0.59	--	2.40	1.01	--			
<sup>228</sup> Ac				0.29	0.19	--									
Gross Beta	39.90	7.10	--	18.80	6.30	--	10386.70	69.80	--	1390000.00	149000.00	--	110000.00	1200.00	
<sup>137</sup> Cs	27.74	0.28	--	9.20	0.31	--	2404.00	6.00	--	1300000.00	150000.00	--	431000.00	753.00	
<sup>40</sup> K	8.95	0.73	--	9.43	1.31	--	3.87	1.82	--						
<sup>226</sup> Ra	0.20	0.07	--												
<sup>90</sup> Sr	0.77	0.86	UJ/0.44	0.23	0.63	UJ/0.47	1370.00	16.10	--	254000.00	28100.00	--			
<sup>60</sup> Co				0.00	0.00	U/0.08	0.00	0.00	U/0.27						
<sup>14</sup> C													0.20		<0.198 /MDL
Tritium	-2.37	1.38	U/0.68	0.10	1.15	UJ/0.62	0.62	0.59	J	-0.05	0.25	U/0.45	0.18		<0.177 /MDL

### Table 5.2 (continued)

---

Source: Eisenbud, M. 1987. *Environmental Radioactivity from Natural, Industrial, and Military Sources*, Academic Press, Inc., 3rd edition.

<sup>a</sup> This sample was analyzed by the CSL only (rad screen).

Notes:

- (1) Blanks indicate that no data were reported by the laboratory.
- (2) Most of the concrete aggregate is composed of sandstones with the following natural background concentrations:
  - radium - 226, 0.71 pCi/g;
  - uranium - 228, 0.4 pCi/g;
  - thorium - 232, 0.65 pCi/g; and
  - potassium - 40, 8.8 pCi/g.
- (3) Concentrations are as reported from the laboratory and are background-subtracted. Review qualifiers of U indicate that the reported MDL value should be used for most purposes.

Deficiencies and uncertainties in the results include the following.

- One of the concrete core plutonium-239/240 results (location ID 73.SB002, sample 04279) was rejected because of a problem with spike recovery.

Documentation provided by the laboratories met RI/FS Project QC level III requirements as described in Sect. 4. Validation of the data packages met RI/FS Project QC level II requirements: analytical results were reviewed in accordance with RI/FS validation procedures for radiological data, but the raw data were not checked by the validator to the same degree that they would have been checked in a QC level III validation protocol.

### **5.3 ASL RESULTS**

Two concrete core samples collected from outside the building were crushed and sent to the ASL, where they were ground to a homogenized powder before radiological analysis. One of the concrete cores was collected in two pieces, which were analyzed separately (location 73.SB002, samples 04130 and 04279). The soil sample was also composited before radiological analysis. In addition, one paint chip sample was collected and analyzed at the Close Support Laboratory (CSL).

#### **5.3.1 Concrete Core 3 ft from South Outside Wall (73.SB001, Sample 04131)**

Gross alpha and beta activities were 0.0 (MDL) and 39.9 pCi/g. All of the alpha emitting radionuclides analyzed for were detected in concentrations <1 pCi/g. Plutonium-239/240/238 and uranium-235 levels were less than or equal to their MDLs, and cesium-137 and strontium-90 concentrations were approximately 27.7 and 0.44 (MDL) pCi/g.

#### **5.3.2 Concrete Core 8 ft from South Outside Wall (73.SB002, Sample 04130)**

Gross alpha and beta activities were 7.6 and 18.8 pCi/g. All of the alpha emitting radionuclides analyzed for were detected in concentrations <1 pCi/g. Plutonium-239/240/238, uranium-235, and strontium-90 results were less than or equal to their MDLs, and the cesium-137 concentration was 9.2 pCi/g.

#### **5.3.3 Concrete Core 8 ft from South Outside Wall (73.SB002, Sample 04279)**

Gross alpha and beta activities were 10.7 and 10386.7 pCi/g. All of the alpha emitting radionuclides analyzed for were detected in concentrations <1 pCi/g. The plutonium-239/240 result was rejected because of a problem with spike recovery. Plutonium-238 and uranium-235 results were less than or equal to their MDLs, and cesium-137 and strontium-90 concentrations were 2404.0 and 1370.0 pCi/g.

#### **5.3.4 Outside Soil Under the Concrete Pad (73.SB002, Sample 03932)**

Gross alpha and beta activities were 7260.0 and 1,390,000.0 pCi/g. Concentrations of most alpha emitters analyzed for were >1 pCi/g and <6 pCi/g, with the following exceptions: uranium-235 was <1 pCi/g (MDL of 0.59 pCi/g), americium-241 was 382.0

pCi/g, and plutonium-239/240 was 95.4 pCi/g. Cesium-137 and strontium-90 concentrations were 1,300,000.0 and 254,000.0 pCi/g.

### 5.3.5 Paint Chip from South Cell Wall (72.SB004, Sample 04045)

This sample was analyzed (rad screen) at the CSL for gross alpha and gross beta by gas-filled counters, cesium-137/barium-137m by gamma spectroscopy, and tritium and carbon-14 by liquid scintillation. Gross alpha and beta activities were 78.0 and 110,000.0 pCi/g. The cesium-137 concentration was 431,000.0 pCi/g, and both carbon-14 and tritium results were less than or equal to their MDLs (0.198 and 0.177 pCi/g, respectively).

## 5.4 HISTORICAL SOIL SAMPLING EXTERIOR TO BUILDING 3515

Soil borings 01.SB182 and 01.SB183 were hand-augered near Building 3515 in July 1991 during Phase I of the WAG 1 RI (Bechtel 1992). These 4-in.-diam borings yielded five soil samples, two of which were sent to the CSL only. Figure 4.1 shows the locations of the borings; Table 5.3 summarizes radiological sampling information for the three samples sent to the ASL.

**Table 5.3. Radiological sampling summary for WAG 1 soil borings near Building 3515**

Location	Distance from Bldg. 3515 <sup>a</sup>	Total Depth (ft BGS <sup>b</sup> )	Interval (ft)	Sample No.
01.SB182	Approximately 14 ft (3 ft from the southwest corner of the slab)	5.4	0-2	2206
01.SB183	Approximately 12 ft (8 ft from the southeast corner of the slab)	4.1	0-2	2338
			2-4	2342

<sup>a</sup> For location 01.SB182, the ORNL grid coordinates are 21935 (northing) and 31021 (easting); for location 01.SB183, the coordinates are 21942 (northing) and 31048 (easting).

<sup>b</sup> BGS, below ground surface.

Table 5.4 lists the concentrations of radionuclides detected in WAG 1 soil samples. Cesium concentrations (approximately 100 to 1400 pCi/g) in WAG 1 borings are lower than those in Building 3515 by approximately 3 to 4 orders of magnitude. Strontium concentrations (approximately 5.0 to 2200 pCi/g) are also lower in the WAG 1 borings than in the soil sample obtained from outside Building 3515 during D&D characterization (by 3 to 6 orders of magnitude). The higher concentrations of cesium and strontium in the soil

Table 5.4. Radionuclide concentrations in WAG 1 soil samples taken near Building 3515

Sample ID Location ID	2206			2338			2342		
	Concentration (pCi/g)	Uncertainty (±)	Review qualifier	Concentration (pCi/g)	Uncertainty (±)	Review qualifier	Concentration (pCi/g)	Uncertainty (±)	Review qualifier
Gross Alpha	216	55		47.2	16.7		180	46	
Gross Beta	17047	2558		1615	244		34381	5159	
Total Strontium	2180	240		5.2	0.8		169	30	
<sup>3</sup> H	0.10	0.02		0.16	0.02		0.15	0.02	
<sup>137</sup> Cs	429	25		103	6		1389	81	
<sup>40</sup> K	5.9	1.40		12.50	2.00		15.8	2.6	
<sup>212</sup> Pb				0.70	0.30				
<sup>228</sup> Ra	0.77	0.19	J	0.91	0.18	J	0.55	0.19	J
<sup>226</sup> Ra	0.32	0.22	J	0.81	0.20	J	0.29	0.2	J
<sup>238</sup> U	38.5	4.30	J	9.11	1.05	J	3.47	0.77	J
<sup>235</sup> U	0.76	0.32	J	0.16	0.06	J	0.10	0.12	UJ
<sup>234</sup> U	7.63	1.22	J	2.09	0.31	J	3.78	0.81	J
<sup>99</sup> Tc	1.5	3.5	UJ	0.5	0.4	J	8.0	4.2	J
<sup>232</sup> Th	0.7	0.18	J	.84	0.22	J	1.04	0.25	J
<sup>230</sup> Th	0.63	0.17	J	2.03	0.58	J	0.77	0.21	J
<sup>228</sup> Th	0.75	0.19	J			J	1.26	0.28	J
<sup>55</sup> Fe	66.70	50.70	J	6.40	10.10	UJ	1.1	5.0	UJ
<sup>147</sup> Pm	1762	185	J	95	11	J	2286	241	J
<sup>239-240</sup> Pu	10.86	1.84	J	2.28	0.7	J	8.01	0.93	J
<sup>238</sup> Pu	0.38	0.37	J	0.13	0.13	UJ	0.43	0.09	J
<sup>63</sup> Ni	11940	854	J				33010	2369	J
<sup>45</sup> Ca	28.3	2	J	17.8	1.7	J	87.3	6.8	J
<sup>154</sup> Eu	3.1	1.1					6.9	1.6	
<sup>155</sup> Eu	1.9	1.2					5.9	2.4	
<sup>241</sup> Am	3.7	1.5					8.4	2.5	
<sup>60</sup> Co							.41	.17	

under the building were expected because mixed fission product solutions were processed in the building and there was some leakage from the drainage lines (see Sect. 2.3). The concentrations of alpha emitters are not similar to those in Building 3515 and vary by isotope. The following differences were observed: (1) uranium concentrations are higher in the WAG 1 samples than in the sample obtained in the current study; (2) thorium, plutonium, and americium concentrations are higher in the Building 3515 sample than those collected during the WAG 1 RI.

## 5.5 SUMMARY

By far the highest radiological contaminant concentrations were found in soil (location 72.SB002, sample 03932), followed by the lower section of concrete core obtained from location 73.SB002 (sample 04279). Contaminant concentrations in the other samples seem to be similar.

Curium-242 was not detected in any sample. Americium-241 was detected only in soil sample 03932 at a relatively high concentration (approximately 382 pCi/g). Cobalt-60 was not detected in any sample and was <MDL. Actinium-228 was reported only for sample 04130 at a concentration of 0.29 pCi/g.

The concentrations of cesium and strontium in the soil sample are higher than those in concrete cores by approximately 3 to 5 orders of magnitude.

In general, the concentrations of radionuclides in the soil sample from Building 3515 are higher than those in WAG 1 soil samples, and it may be expected that levels of cesium and strontium activity in underlying soil increase with proximity to the building. Exceptions are uranium isotopes, present at lower concentrations in Building 3515 samples than in WAG 1 soil samples.

## 6. RADIOLOGICAL FIELD MEASUREMENTS

### 6.1 DATA PRESENTATION

As appropriate and depending on the instrument used, radiological data collected during field measurements are presented in counts per minute (cpm), disintegrations per minute (dpm), milliroentgen per hour (mR/h), or milliradiation absorbed dose per hour (mrad/h). TLD results are reported in millidose equivalent per hour (mrem/h). Smear sample results are reported in microcuries per one hundred square centimeters ( $\mu\text{Ci}/100 \text{ cm}^2$ ) or disintegrations per minute per one hundred square centimeters (dpm/100  $\text{cm}^2$ ). Modeling results are reported in nanocuries per cubic centimeter (nCi/ $\text{cm}^3$ ), microcuries ( $\mu\text{Ci}$ ), or millicuries (mCi) as appropriate.

### 6.2 DATA USABILITY ASSESSMENT

The measuring scheme for Building 3515 was "biased" (nonrandom) rather than "unbiased" (random or gridded). Unbiased measuring is sometimes used to predict overall site characteristics or to provide representative estimates, but a biased scheme increases the chance of obtaining measurements and samples from the most heavily contaminated areas; direct reading survey instruments identified "hotspots" that were used as measurement locations.

To ensure that the data collected are of known and acceptable quality, the data were evaluated for precision, accuracy, representativeness, completeness, and comparability.

#### 6.2.1 Precision

Precision is a measure of the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is evaluated through the use of duplicate or replicate measures and is determined using the concept of "relative percent difference" (RPD).

During the characterization, approximately 10% of the locations surveyed were randomly selected for remeasurement and the RPD was determined. If the RPD were to fall outside a control limit of 20%, the instrument would be removed from service and all data collected since the last acceptable RPD would be reviewed. No such situation was encountered during the D&D field activities. Precision analysis was not performed for smears because they were collected from each location only once.

#### 6.2.2 Accuracy

Accuracy is the degree of agreement between the observed (measurement) value and the true value. Each field survey instrument was calibrated, and changes in accuracy were monitored twice daily (when in use) via source checks for an instrument in a fixed geometry. RI/FS project procedures and appropriate field documents were followed to provide quality data for radiological analyses and counting at the CSL. During the characterization survey,

the field instruments were source-checked at the beginning and end of each day they were used. If the source check counts were within  $\pm 2\sigma$  of each other and within 10% of previous source checks, the instrument was approved for use.

### 6.2.3 Representativeness

Representativeness expresses the degree to which the data represent the contaminants present in the area of interest. Therefore, representativeness is dependent on appropriate measurement and sampling techniques for the matrix and contaminants under study and on measurement and sampling locations that are typical of the area being surveyed. Measurement and sampling techniques and the strategy for selecting locations are described in Sects. 4 through 6 of the site characterization plan (Bechtel 1993a). This investigation was conducted using biased sampling so that assumptions for D&D planning will be conservative.

### 6.2.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount specified by the sampling plan. For each data type, the data set was considered complete even if the actual number of measurements was less than the planned number due to access or ALARA limitations encountered in the field, per the tiered approach outlined in the characterization plan.

### 6.2.5 Comparability

Comparability expresses the confidence with which one data set may be compared to another. This includes two elements of the survey process: the measurement instruments and the technique by which measurements and samples were obtained.

Comparability of data collected with different measurement instruments was ensured through achievement of precision and accuracy. Comparability of survey technique was accomplished by adhering to FWGs and procedures and by documenting this adherence in field logbooks; environmental, safety, and health notebooks; and sample results.

Field measurements were performed in accordance with appropriate procedures and documents to ensure the quality and consistency of the data. The instruments were calibrated at the ORNL calibration facility and were source-checked before and after each use to ensure that they were responding properly. The source checks were performed three times in succession to ensure that the measurements were within  $\pm 2\sigma$  of each other. If an instrument failed the test, it was replaced by another calibrated instrument. In addition, field measurements were taken three times at each location to ensure representative and reliable results, and field and laboratory results were compared when data were available.

## 6.3 FIELD MEASUREMENTS

For field radiological measurements, Building 3515 was divided into north cell and south cell areas. Because of the high radiation fields encountered, measurements were obtained

remotely using long-handled tools and no location-specific measurements were taken. Figure 6.1 is a plan view of the north and south cells showing distances into the cell from the entrance way. This figure can be used to correlate the measurement results with the measurement locations, assuming that the long-handled tools were inserted perpendicular to the cell entrance way. All remote measurements were performed approximately 3 to 4 ft from the floor of the cell; measurements could not be made to determine this distance precisely.

Concrete core and soil samples collected outside the building were shipped to the ASL after a gamma spectroscopy slit scanning system evaluated the extent of contaminant penetration and isotopic distribution.

### **6.3.1 North Cell**

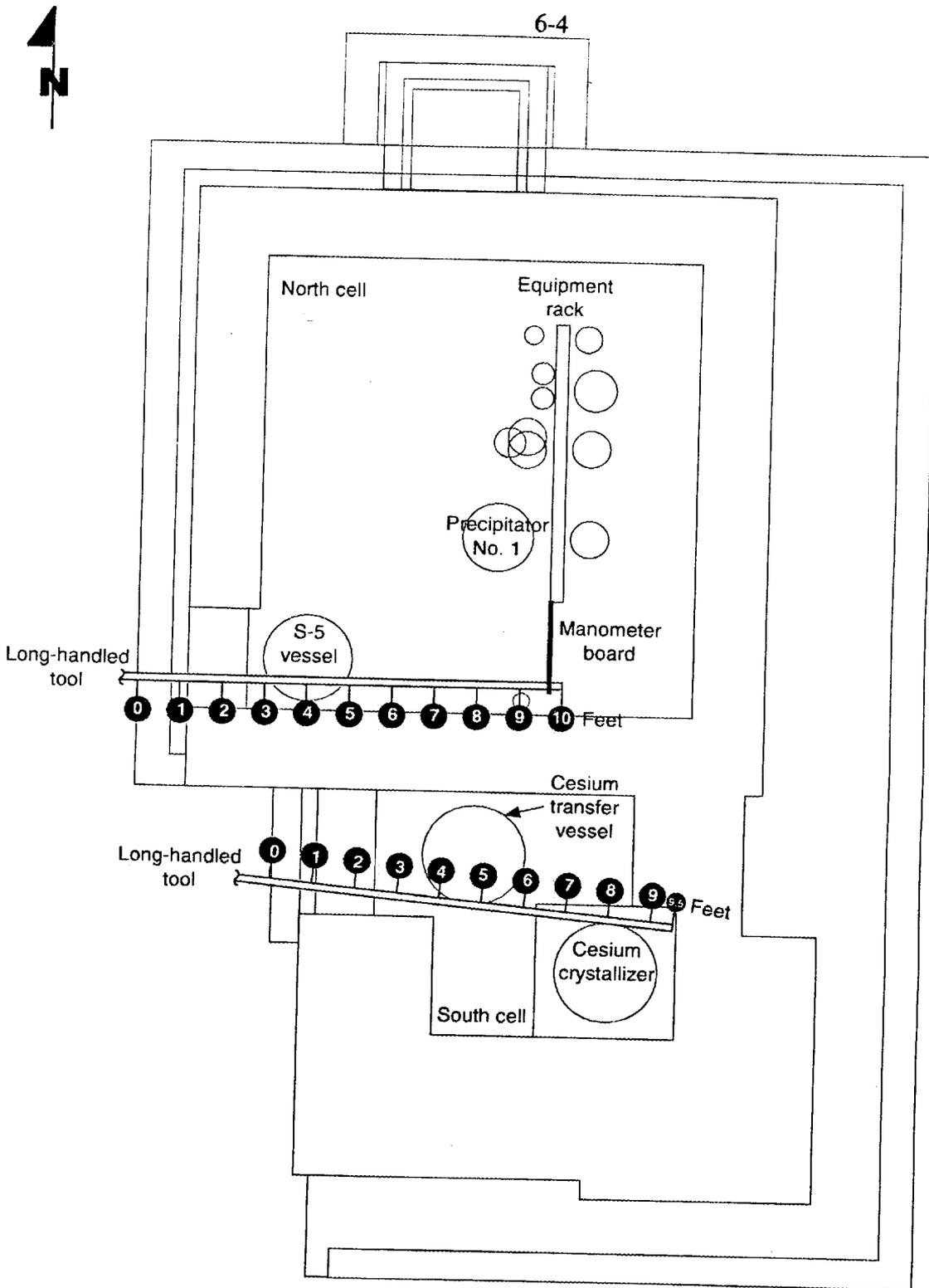
Gross gamma measurements were taken in the north cell using omnidirectional (teletector) and directional (shielded HP-290) detectors, TLD strings, and gross smears. To allow access into the north cell, a 4-in. hole was drilled on the west side (on the old covered entrance) approximately 52 in. above the exterior concrete pad (Fig. 6.2). The cell was observed to be under negative pressure.

#### **6.3.1.1 Teletector measurements**

A teletector (a telescopic radiation measurement instrument, Geiger-Mueller tube) took 11 horizontal measurements at 1-ft intervals between the access hole and the manometer board or equipment rack. Exposure rates, which increased with distance from the access hole, ranged from 11 mR/h at the access hole to 23 R/h at 8 ft. Results are plotted in Fig. 6.3, which presents radiation exposure rates as a function of distance. Detailed results are presented in Appendix E, Table E.1.

#### **6.3.1.2 Directional gamma measurements (HP-290)**

A directional HP-290 probe took horizontal measurements at 2, 4, 6, and 7 ft from the penetration. At each location, measurements were taken in the up, down, south, and north directions to determine which direction contributed the most to the exposure field in the cell. Three 30-s integrated counts were performed in each direction, and the average of the three counts was used with the calibration data to calculate exposure rate. The probe was shielded by ¼ in. of lead (used for gamma shielding to reduce the intensity by a factor of 2 for the cesium-137/barium-137m 662-keV gamma line) and encased in a ¼-in.-thick rectangular Plexiglas box to minimize the effects of beta fields. Figure 6.4 plots results as a function of distance, and Table E.2 presents detailed results. The radiation exposure rates increased with distance from the access hole (approximately 400 mR/h at 2 ft to approximately 5000 mR/h at 6 ft). Trends in radiation exposure rate were similar to those from teletector results. Figure 6.5 compares the teletector and HP-290 probe profiles. The down direction (toward the floor) is the major contributor to the exposure field, followed by the north direction (toward the equipment on the equipment rack). The other two directions are relatively minor contributors.



**Fig. 6.1. Penetration distance of long-handled tools into cells from access holes.**  
 (Note: locations and sizes of vessels are approximate; drawing not to scale.)

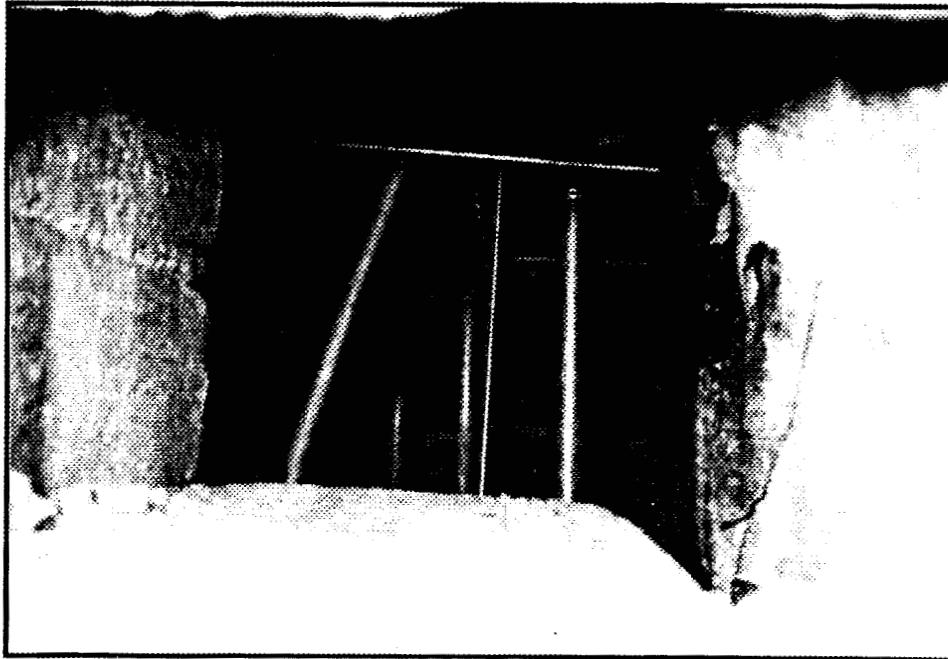


Fig. 6.2. Access to the south cell.

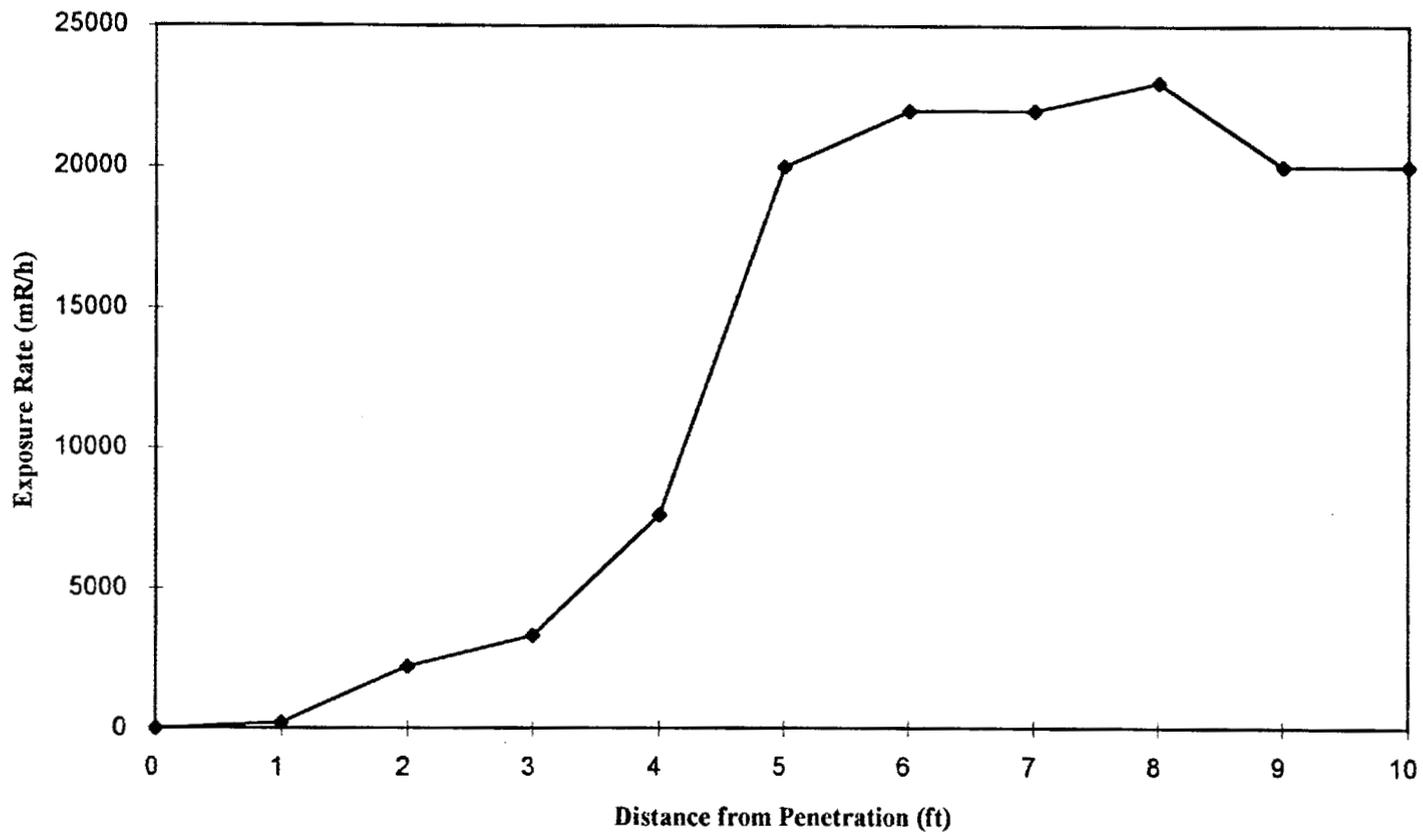
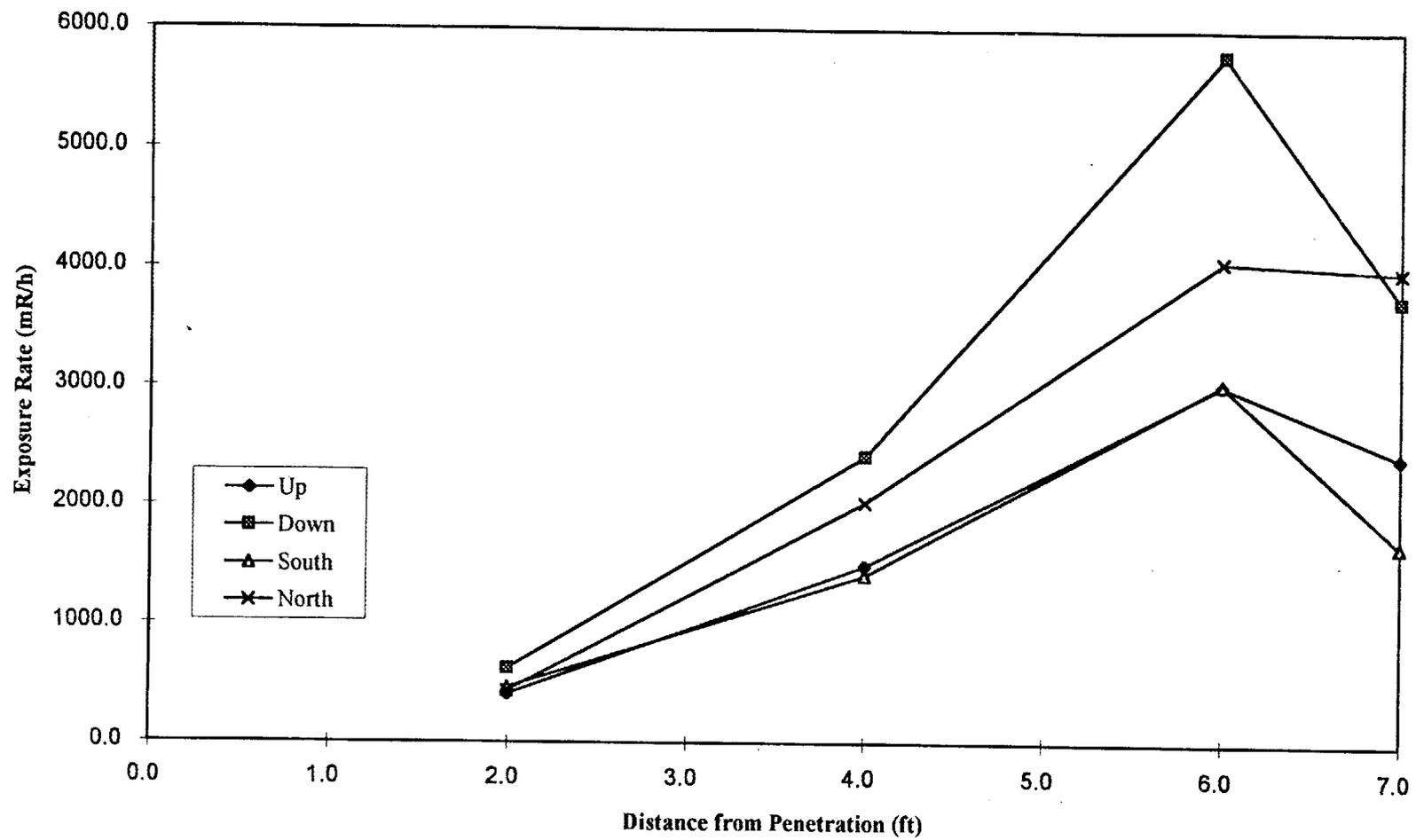


Fig. 6.3. North cell teletector measurement results.



6-7

Fig. 6.4. North cell HP-290 directional probe results.

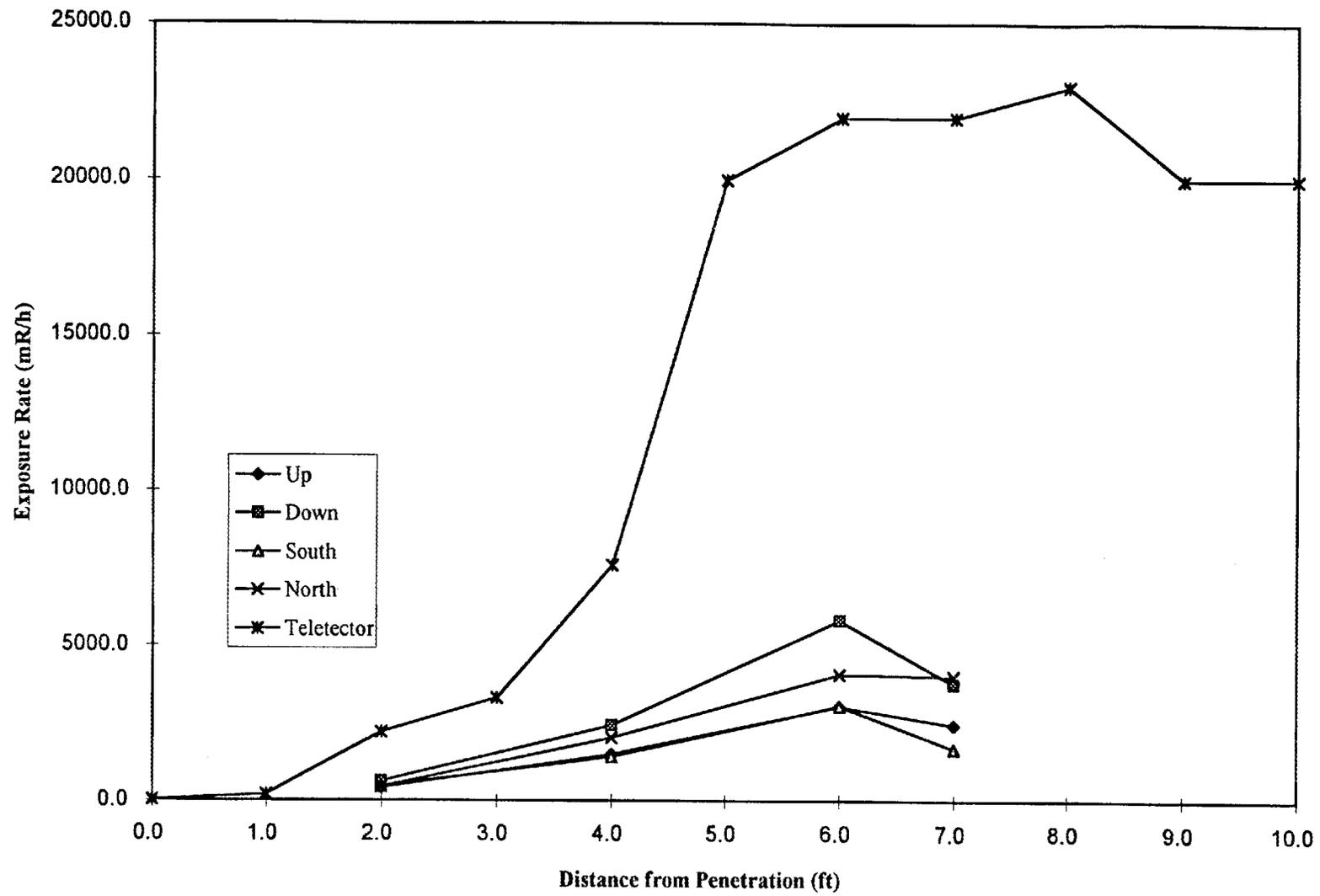


Fig. 6.5. North cell exposure profile from HP-290 and teletector probes.

### 6.3.1.3 TLD measurements

TLD strings deployed on four sides of a 2-in. pole to face up, down, south, and north were used to obtain the horizontal absorbed dose profile of the cell interior. TLDs in each string were approximately 1 ft apart and approximately 3 to 4 ft above the floor. This assembly was exposed to the cell radiation fields for 10 min. TLDs were analyzed by the Energy Systems External Dosimetry Department, and results ranged from approximately 10 to 23,500 mrem/h for deep dose rate ( $H_d$ ) and from 17 to 23,600 mrem/h for shallow dose rate ( $H_s$ ).  $H_d$  is reported for penetrating ionizing radiation such as gamma and X-rays, and  $H_s$  is reported for medium-range ionizing radiation such as beta particles.  $H_d$  and  $H_s$  are obtained from the response of TLD chips housed in the beta-shielded (approximately 1000 mg/cm<sup>2</sup>) and thin window cavities of a TLD, respectively. Tables E.3 and E.4 present detailed results of these measurements. Figures 6.6 and 6.7 are plots of shallow and deep dose rate profiles for all four strings; Figs. 6.8 through 6.11 are plots of shallow vs. deep dose rate profiles for individual directions. Trends in radiation exposure rate as a function of distance were similar to those from teletector and directional measurement results. Figure 6.12 compares teletector and TLD  $H_d$  profiles. Comparison of the deep and shallow dose rate results indicates that most of the exposure is caused by penetrating ionization radiation.

### 6.3.1.4 Smear analyses

The gross smears obtained from the cell floor were analyzed at the CSL for gross alpha, gross beta/gamma, and gamma spectroscopy:

- Gross alpha = 5.39E-05  $\mu$ Ci/smear (1.20E+02 dpm/smear).
- Gross beta/gamma = 7.76E-03  $\mu$ Ci/smear (1.72E+04 dpm/smear).
- Cesium-137/barium-137m = 6.53E-03  $\mu$ Ci/smear (1.45E+04 dpm/smear).

Each smear is believed to have covered approximately 100 cm<sup>2</sup>. These smears are not quantitative in nature, but qualitative. Gamma spectroscopy indicates that the primary gamma emitting isotope present is cesium-137/barium-137m, and most of the gross beta/gamma activity is due to cesium-137/barium-137m rather than beta emitters.

## 6.3.2 South Cell

Gross gamma measurements were taken in the south cell using omnidirectional (teletector) and directional (HP-290 and modified HP-220A with a 90° conical tungsten collimator) detectors, TLD strings, and gross smears. To allow access into the south cell, a hole approximately 5 in. by 10 in. hole was drilled on the west side (on the old covered entrance) approximately 44 in. above the exterior concrete pad (Fig. 6.13). The cell was observed to be under negative pressure.

### 6.3.2.1 Teletector measurements

A teletector took a series of eight horizontal omnidirectional measurements at approximately 1-ft intervals between 2.5 and 9.5 ft from the access hole. Exposure rates ranged from approximately 4 mR/h at 2.5 ft to 450 mR/h at 7.5 ft, but decreased to 400

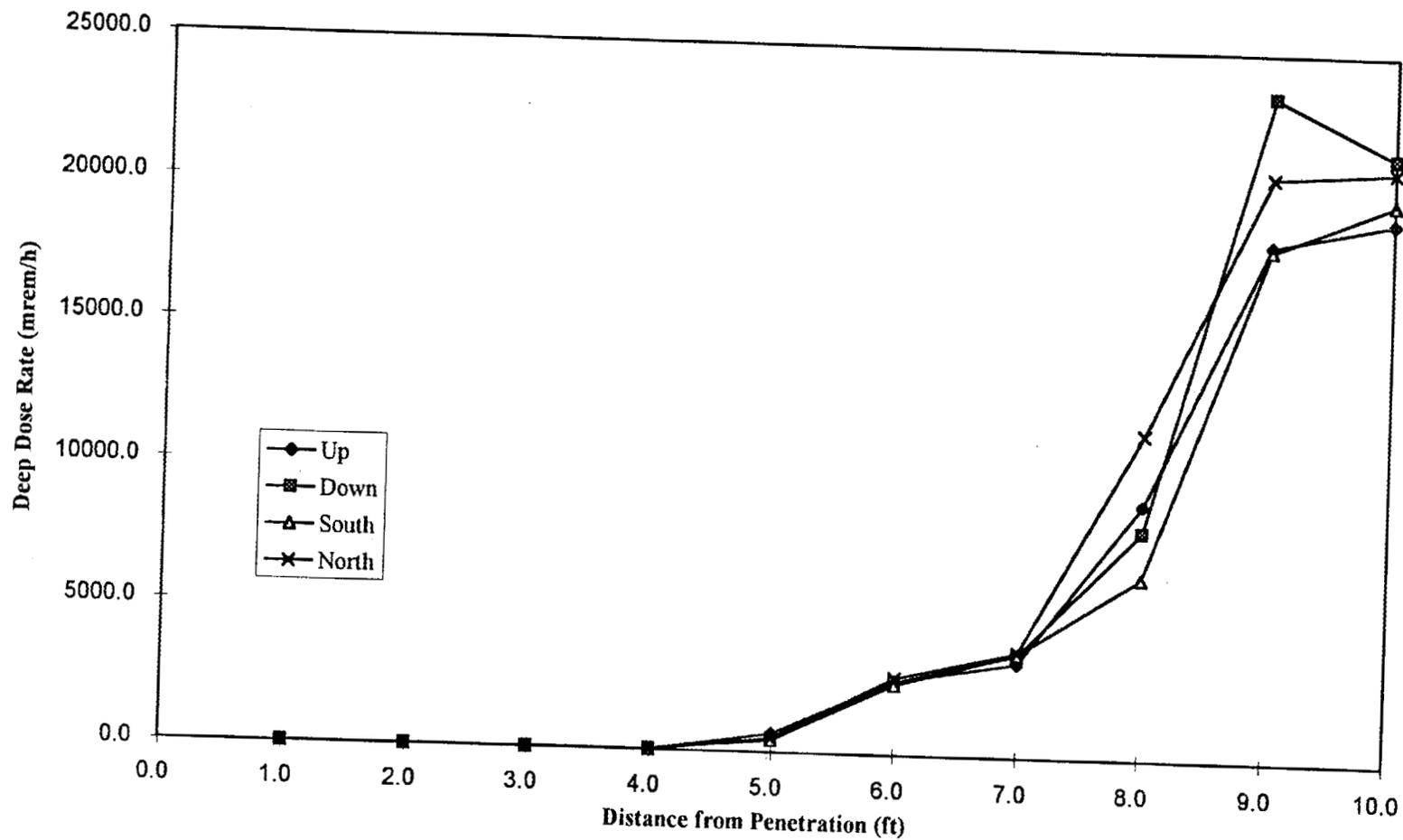


Fig. 6.6. North cell TLD results (deep dose).

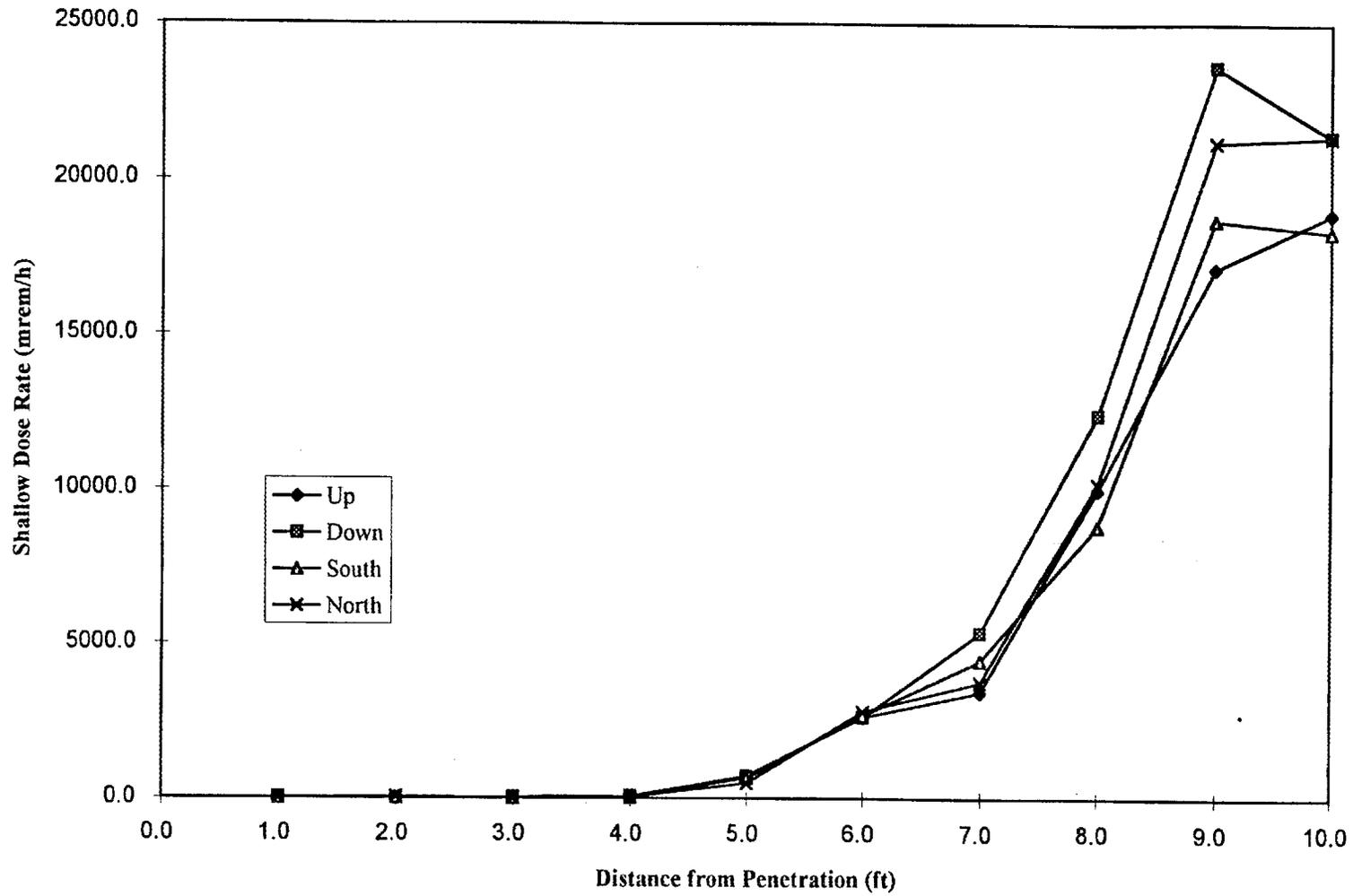


Fig. 6.7. North cell TLD results (shallow dose).

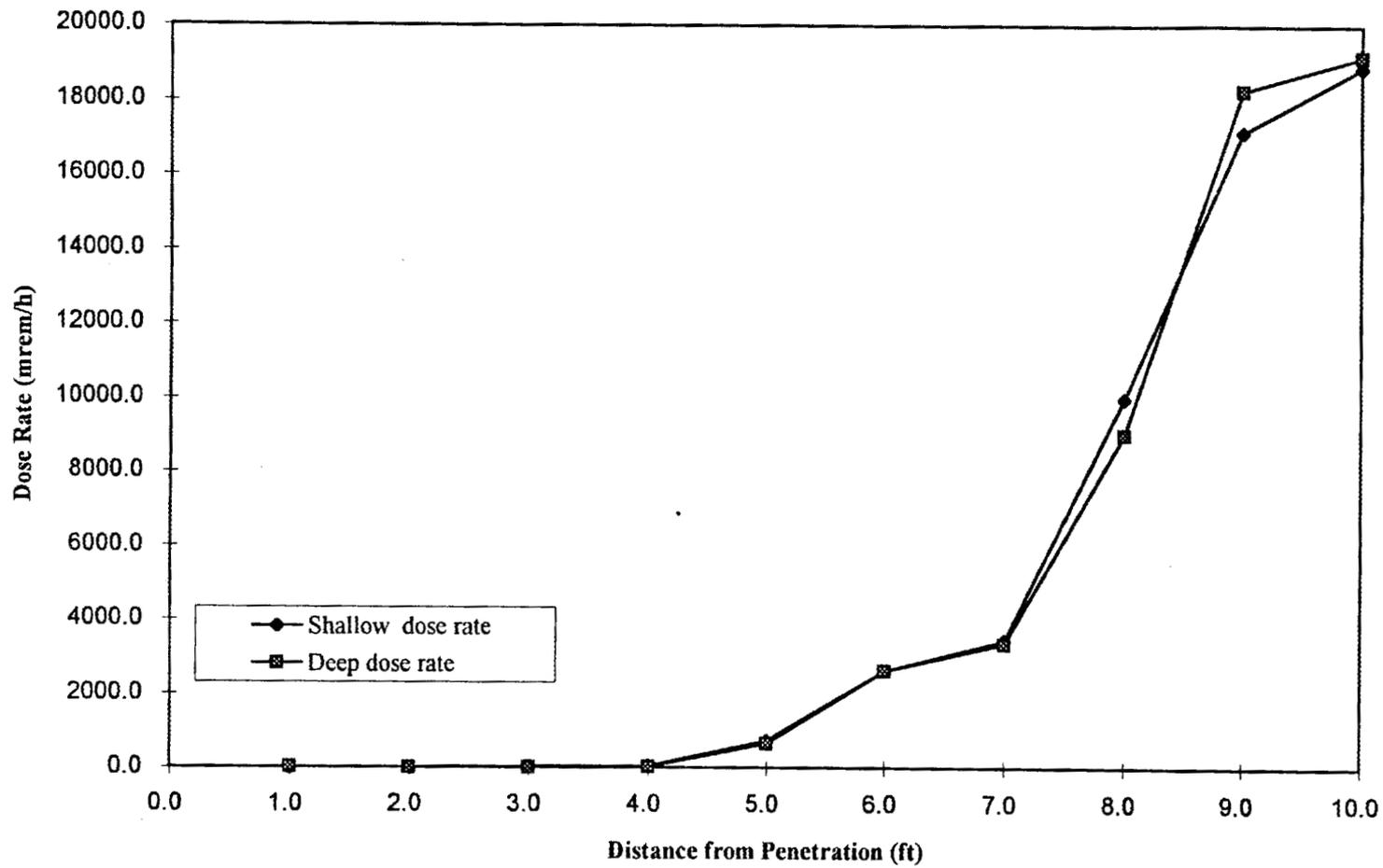


Fig. 6.8. North cell TLD results (up).

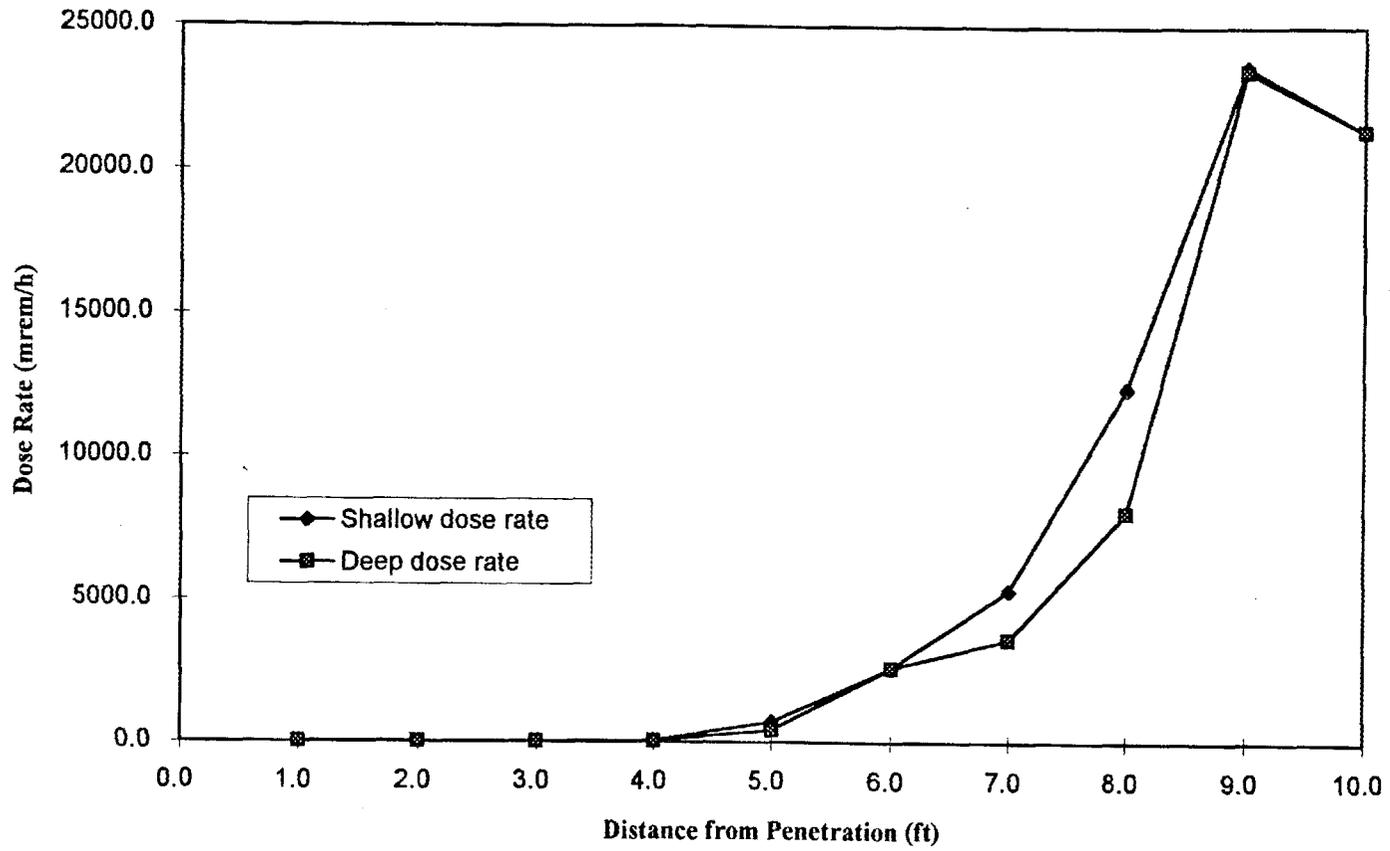


Fig. 6.9. North cell TLD results (down).

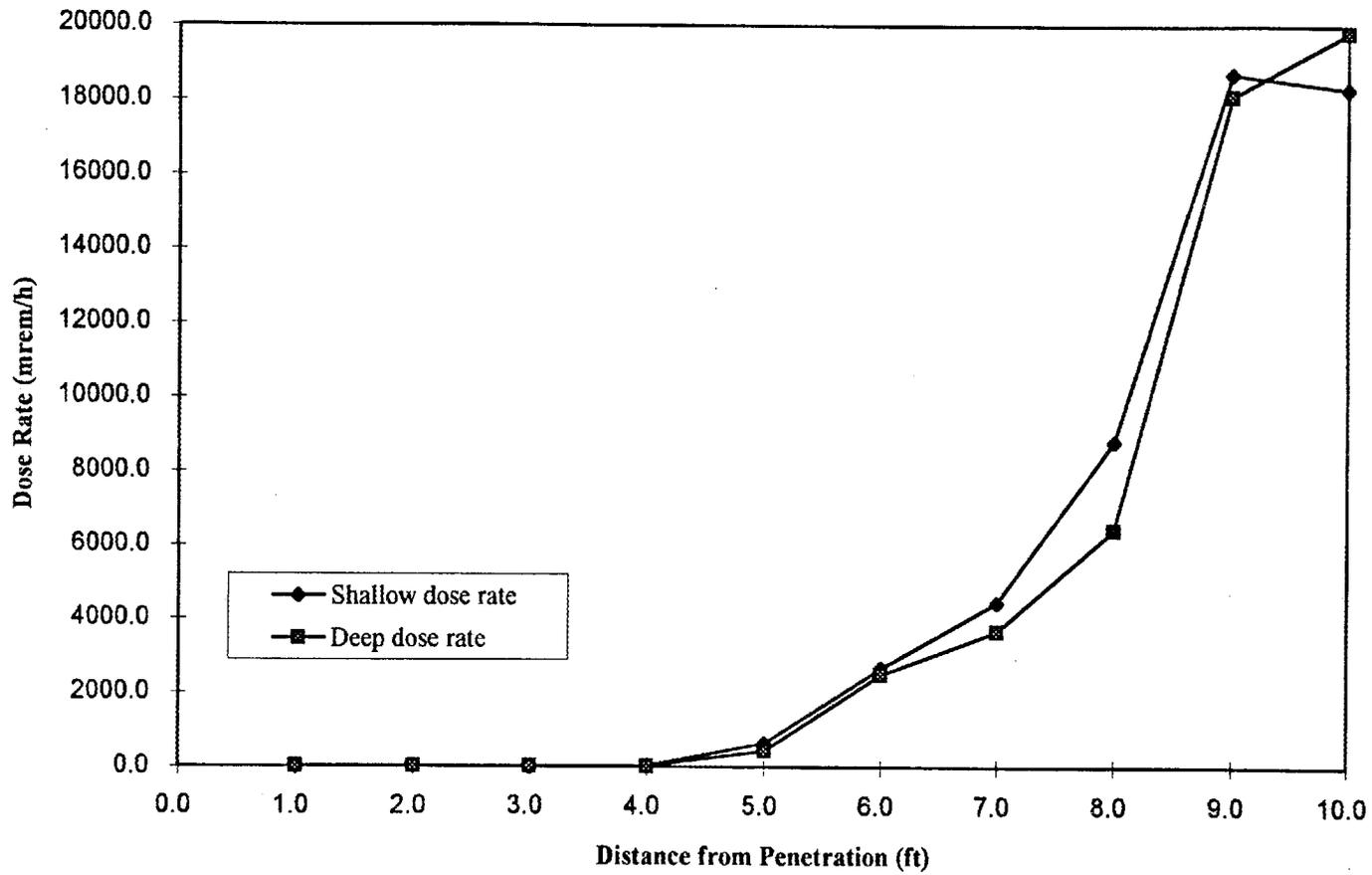


Fig. 6.10. North cell TLD results (south).

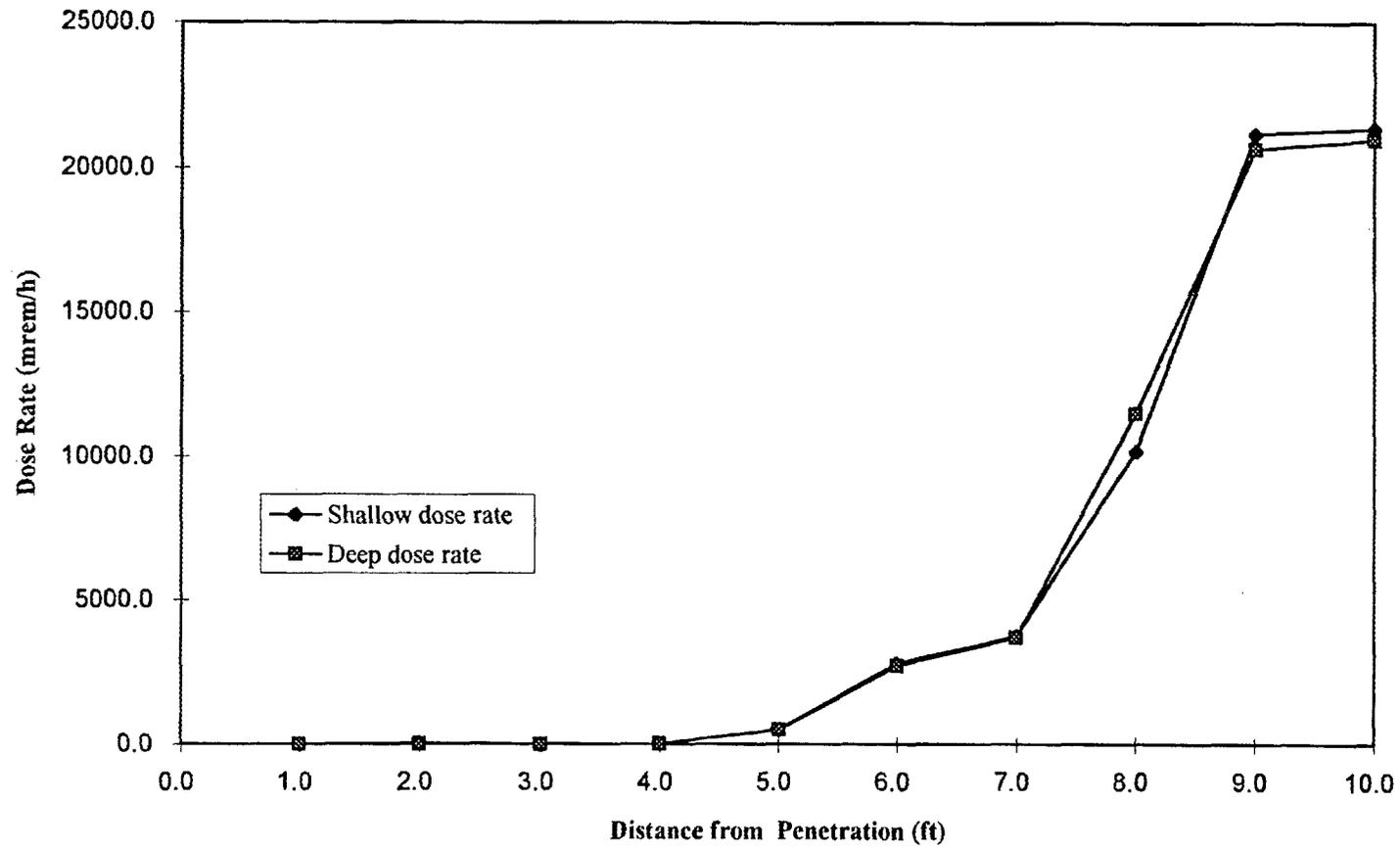


Fig. 6.11. North cell TLD results (north).

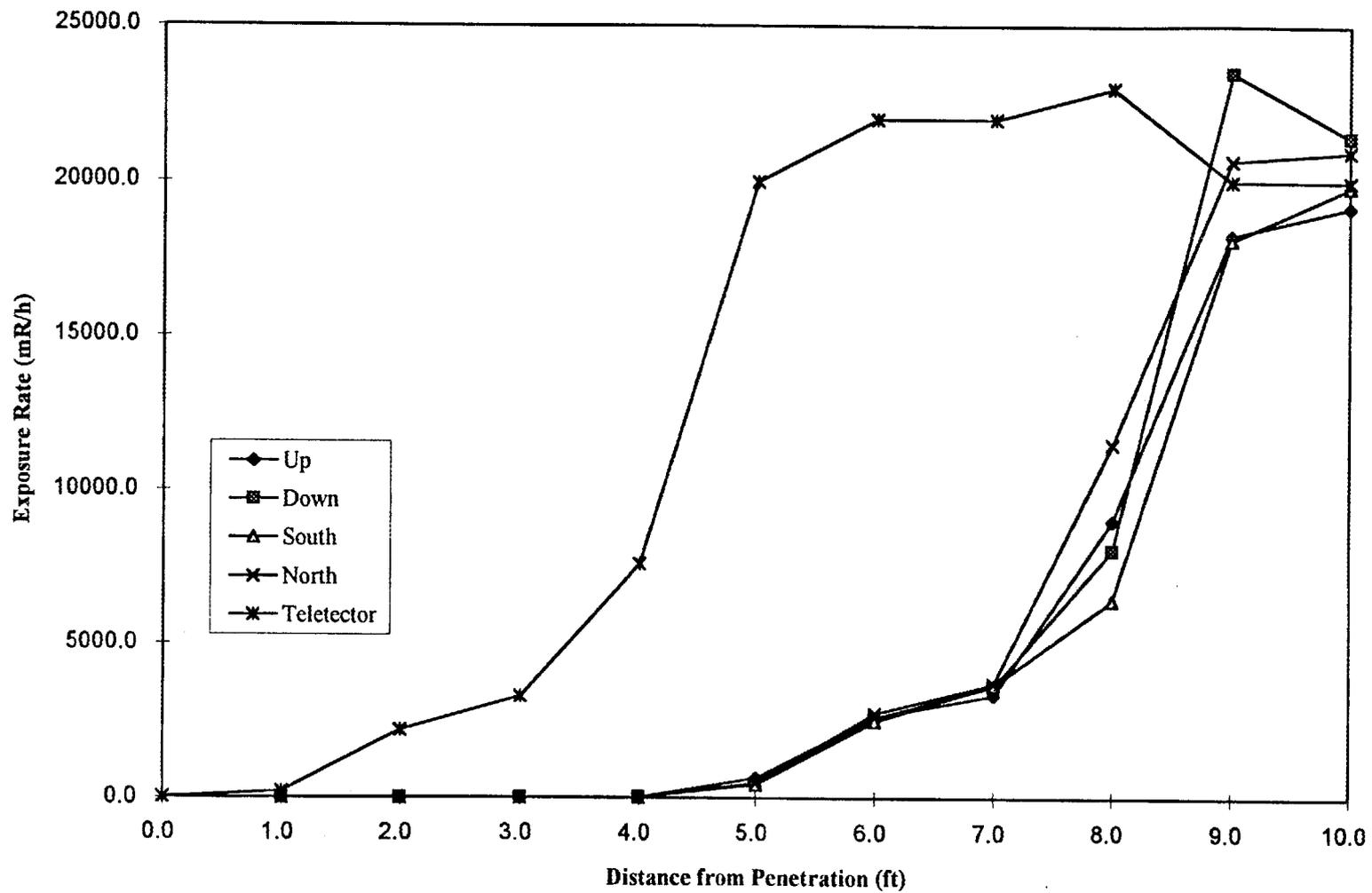


Fig. 6.12. North cell exposure profile from TLDs and teletector probe.

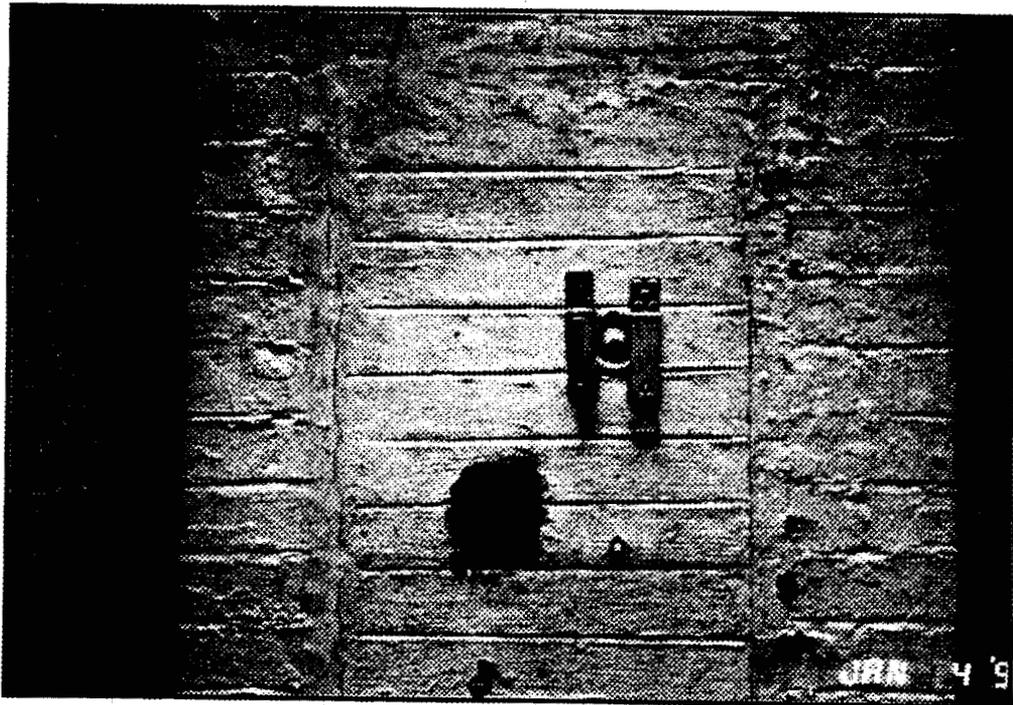


Fig. 6.13. Access to the north cell.

mR/h at 8.5 and 9.5 ft. Results of these measurements are plotted in Fig. 6.14, and detailed results are tabulated in Table E.5.

### 6.3.2.2 Directional gamma measurements (HP-290 and HP-220A)

A directional HP-290 probe took nine horizontal measurements between 2 and 9 ft from the access hole at 1-ft intervals, and at 9.5 ft). At each location, measurements were taken in the up, down, south, and north directions. Three 10-s integrated counts were performed in each direction, and the average of the three counts was used with the calibration data to calculate exposure rate. The probe was shielded by  $\frac{1}{4}$  in. of lead (for gamma shielding) and encased in a  $\frac{1}{4}$ -in.-thick rectangular Plexiglas box (for beta shielding). Figure 6.15 plots results of these measurements as function of distance, and Table E.6 presents detailed results. Exposure rate increased with distance from the access hole between 2 and 6 ft ( $\sim 17$  to  $\sim 480$  mR/h), then decreased, and then increased again between 6 and 9.5 ft. Trends in radiation exposure rate were similar to the teletector results between 2 and 6 ft. The south direction is the major contributor to the exposure field between 5 and 7 ft (in an area relatively crowded with piping), and the down direction is the major contributor past 8 ft (in the region of the cesium crystallizer). The up and north directions are relatively minor contributors.

The opening was large enough, and the HP-220A directional probe was also used to take measurements at 4.5, 6, and 7.33 ft from the access hole. The directional properties of this probe are greatly superior to those of the HP-290 (i.e., back-to-front ratio of approximately 20 for cesium-137/barium-137m gamma line, 662 keV, vs. a ratio of  $\frac{1}{2}$  for the HP-290). Like the HP-290, this probe was encased in a Plexiglas box. Exposure rates ranged from approximately 82 mR/h at 4.5 ft in the north direction to 382 mR/h at 6 ft in the south direction. Figure 6.16 plots results of these measurements as a function of distance, and Table E.7 presents detailed results.

As was the case with the HP-290, the south direction is the major contributor to the exposure field between 5 and 7 ft. The exposure rate for the down direction is equal to that for the south direction at 4.5 ft. However, the down direction exposure rate then decreases by more than a factor of 2 between 4.5 ft (in the area of the cesium transfer vessel) and 6 ft (beyond the edge of the transfer vessel). The opposite effect was seen with the HP-290, but the exposure rate measured by the HP-290 is influenced to a much greater extent by contributions from other directions.

A complete one-to-one comparison of the HP-290 and HP-220A probe results is not appropriate because (1) the two probes have different directionality properties with regard to both shielding and solid angle (rectangular for the HP-290 and conical for the HP-220A); and (2) there were fewer measurement locations for the HP-220A and a complete profile is not available. Figure 6.17 compares teletector and HP-290 profiles.

### 6.3.2.3 TLD measurements

TLD strings deployed on four sides of a 2-in. pole to face up, down, south, and north were used to obtain the horizontal absorbed dose profile of the cell interior. TLDs in each

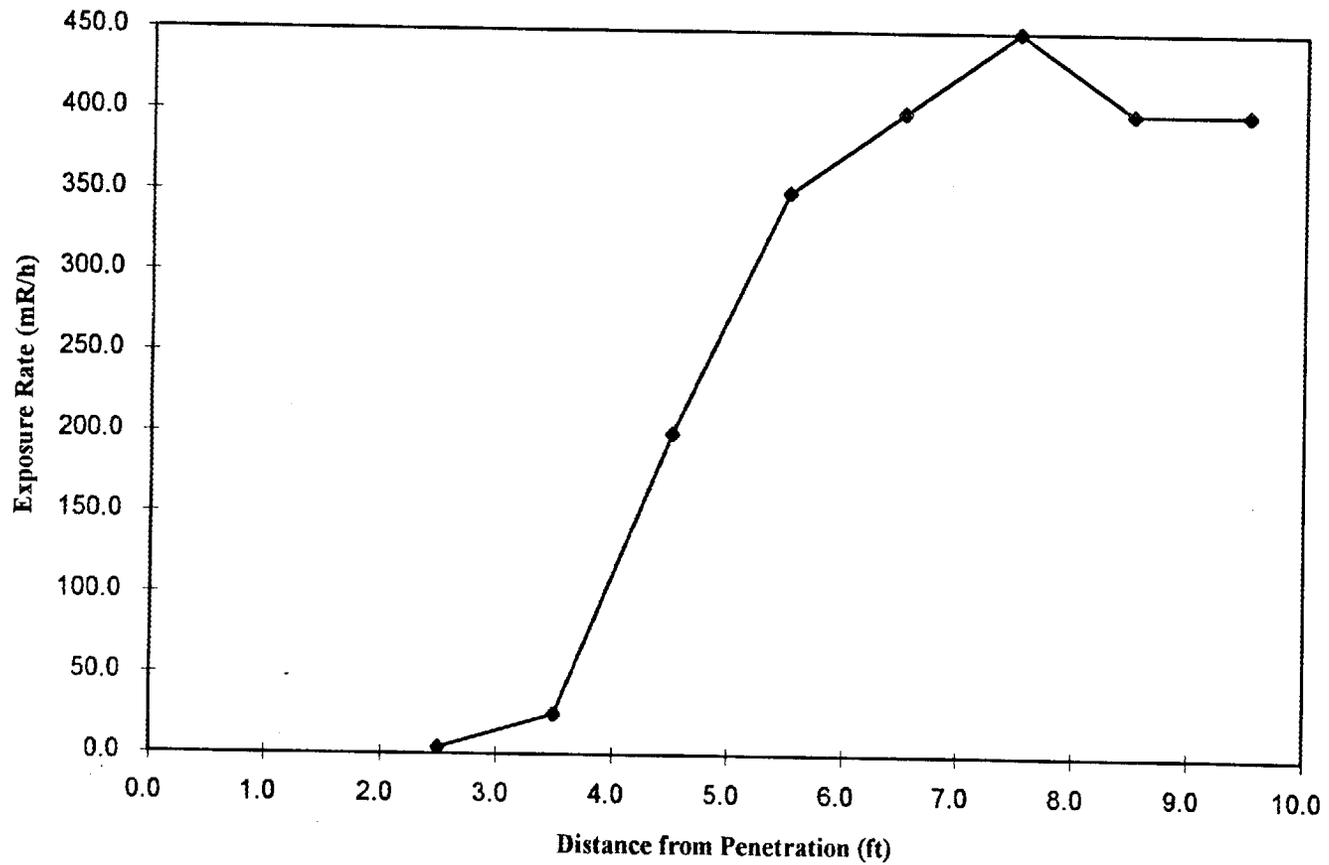


Fig. 6.14. South cell teletector measurement results.

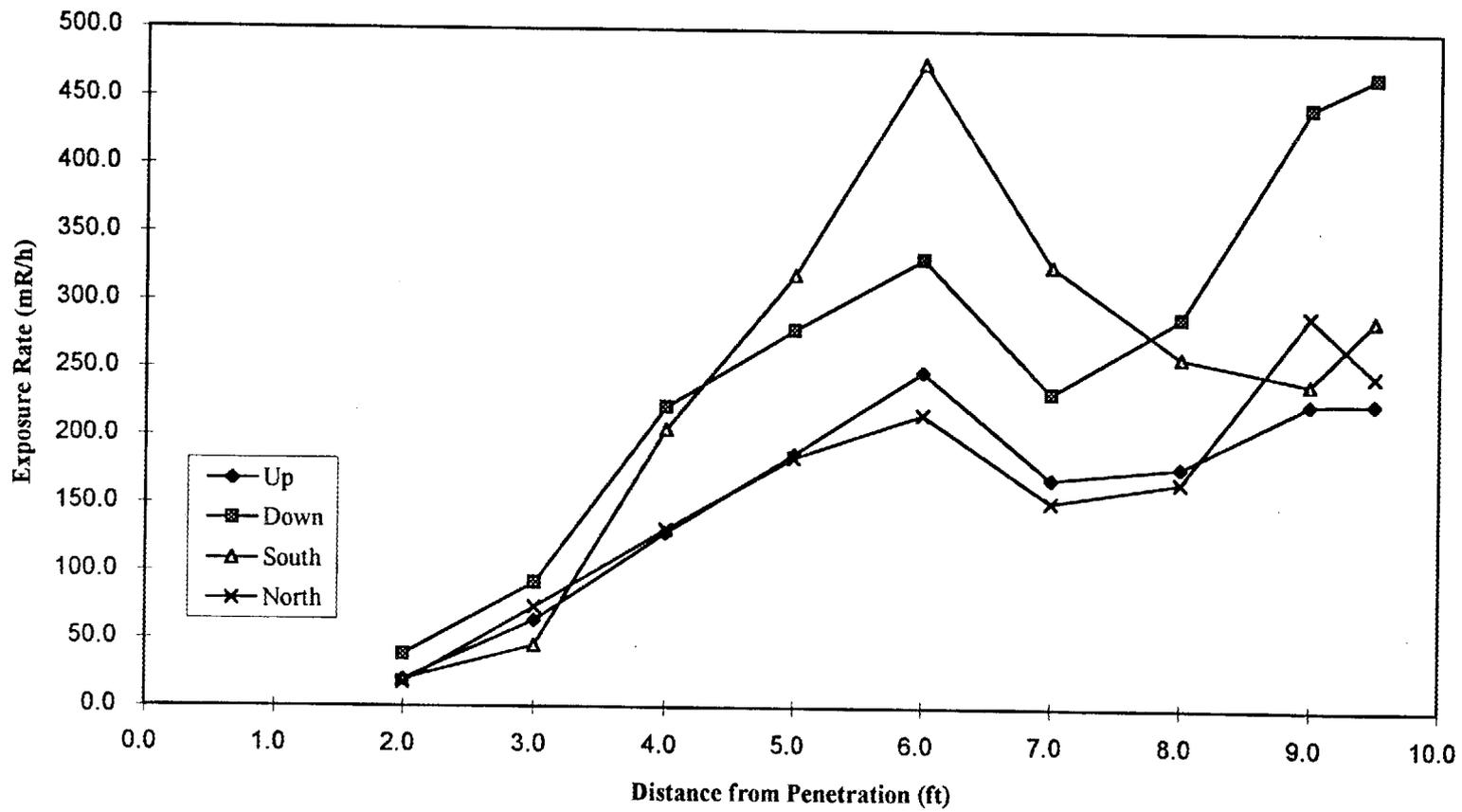


Fig. 6.15. South cell directional HP-290 probe results.

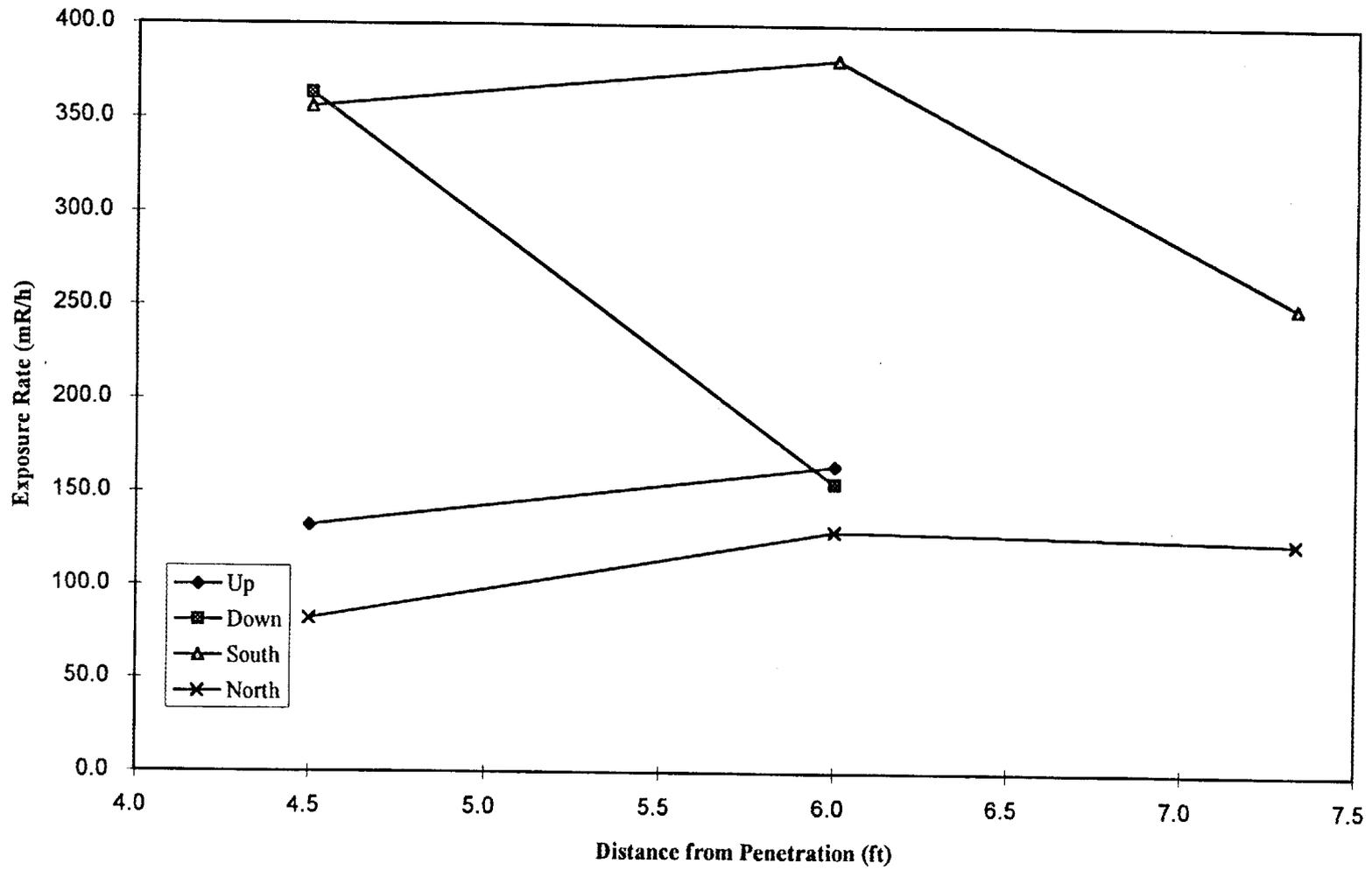


Fig. 6.16. South cell directional HP-220A results.

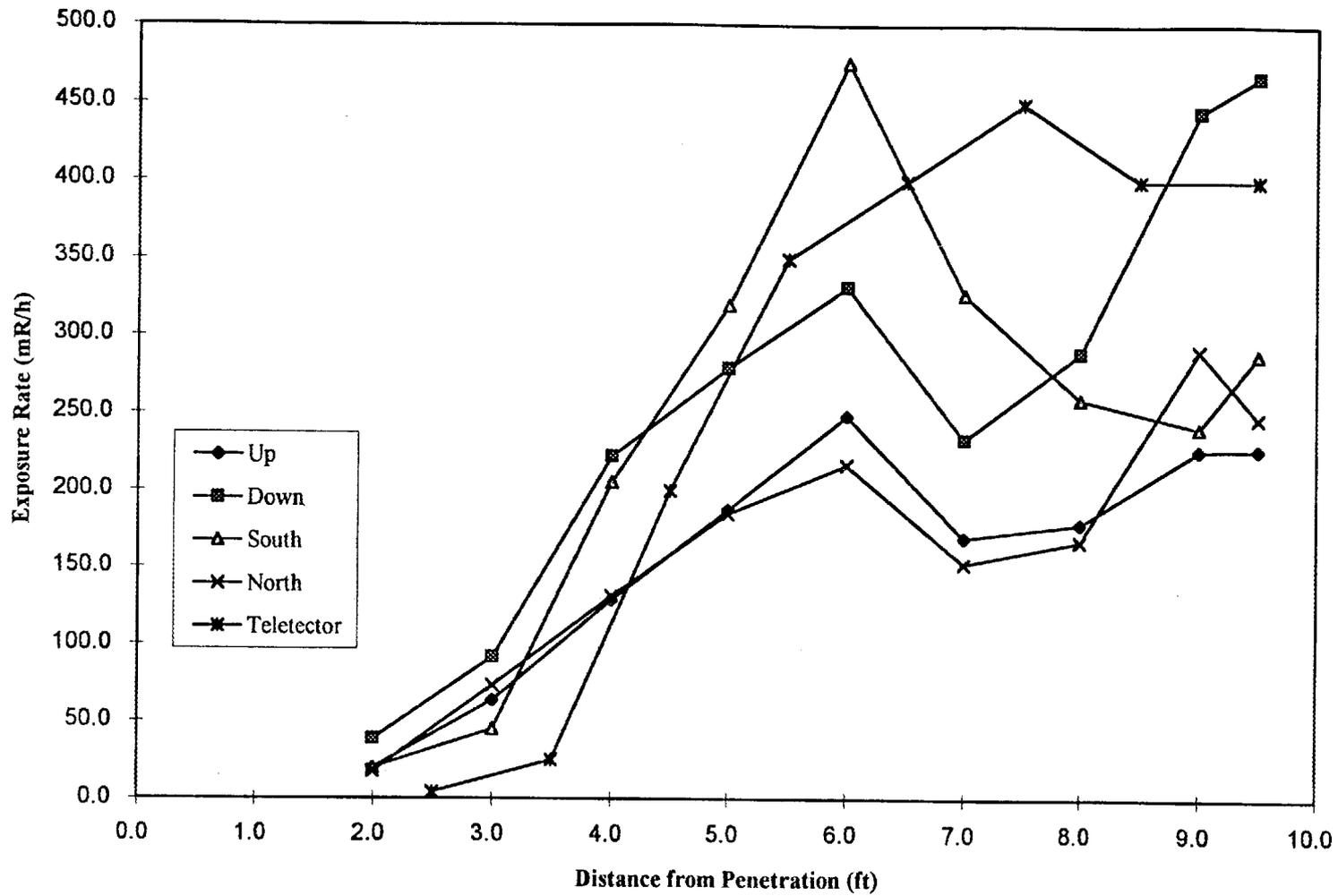


Fig. 6.17. South cell exposure profile from HP-290 and teletector probes.

string were approximately 1 ft apart and approximately 3 to 4 ft above the floor. This assembly was exposed to the cell radiation fields for 15 min. TLDs were analyzed by the Energy Systems External Dosimetry Department, and results ranged from approximately 20 to 585 mrem/h for deep dose rate ( $H_d$ ) and from 4 to 6950 mrem/h for shallow dose rate ( $H_s$ ). Tables E.8 and E.9 present the detailed results of these measurements. Figures 6.18 and 6.19 are plots of shallow and deep dose rate profiles for all four strings; Figs. 6.20 through 6.23 are plots of shallow vs. deep dose rate profiles for individual directions. Trends in radiation exposure rate as a function of distance were similar to those from the HP-290 directional measurement results. Comparison of the deep and shallow dose rate results indicates that most of the exposure is caused by shallow penetrating ionization radiation (e.g., beta particles). The high exposure fields due to the beta particles can be decreased significantly with proper beta particle shielding (e.g., Plexiglas or rubber mat) during D&D implementation. Figure 6.24 compares TLD  $H_d$  and teletector profiles.

#### 6.3.2.4 Smear analyses

The gross smears obtained from this cell (area of each obtained was approximately 10–20 cm<sup>2</sup>) were too hot (600 mrad/h open window and 40 mR/h closed window) to be analyzed at the CSL for gross alpha, gross beta/gamma, and gamma spectroscopy; therefore, a secondary smear was taken from the gross smear (by touching the two smears together, reading approximately 5 mrad/h) and analyzed at the CSL:

- Gross alpha = 3.00E-05  $\mu$ Ci/smear (6.66E+01 dpm/smear).
- Gross beta/gamma = 2.04E-01  $\mu$ Ci/smear (4.53E+05 dpm/smear).
- Cesium-137/barium-137m = 2.59E-02  $\mu$ Ci/smear (5.75E+04 dpm/smear).
- Gross strontium-90 = 3.13E-02  $\mu$ Ci/smear (6.95E+04 dpm/smear).

Results indicate that strontium-90/yttrium-90 activity is higher than or similar to cesium-137/barium-137m activity. Gamma spectroscopy shows that the primary gamma emitter present is cesium-137/barium-137m. In addition, comparison of gross beta/gamma, gamma spectroscopy, and gross strontium analysis results shows that most of the gross beta/gamma activity is due to the strontium-90/yttrium-90 activity rather than the gamma emitters.

Fourteen gross smears collected from equipment, pipes, vessels, and walls of this cell (see Table 6.1 and Fig. 6.25) were measured by field instruments for gross alpha and beta activities (HP-210T and AC-3-7). Results of these measurements ranged from approximately 4400 to 1,000,000 dpm/smear for beta/gamma activities and less than 20 dpm/smear for alpha activities. Smears 48 and 53 (see Table 6.1) were screened at the CSL for strontium-90; results were 1.0E-01 and 4.9E-2  $\mu$ Ci/smear (approximately 100 cm<sup>2</sup>), respectively. These values are a factor of 5 less than the respective beta/gamma activities per smear.

#### 6.3.3 Concrete Core Slit Scanning

Two concrete core samples were obtained from the concrete pad outside Building 3515. The first (73.SB001; see Fig. 3.1) was drilled approximately 3 ft south of the southern wall of the building to a depth of approximately 9.5 in. before a flat metal surface was encountered and coring was stopped. Readings are near the counting area background on

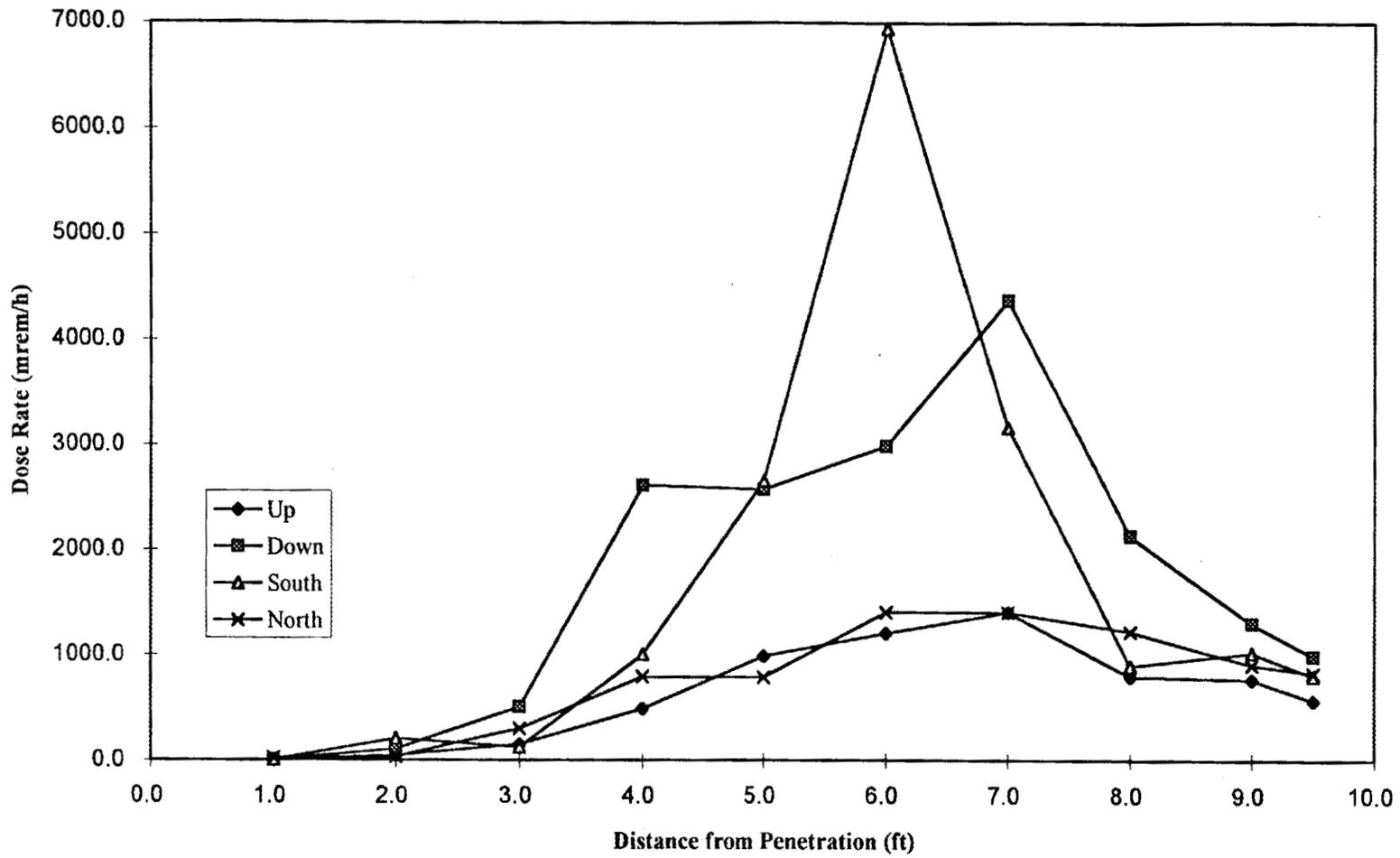


Fig. 6.18. South cell TLD results (shallow dose).

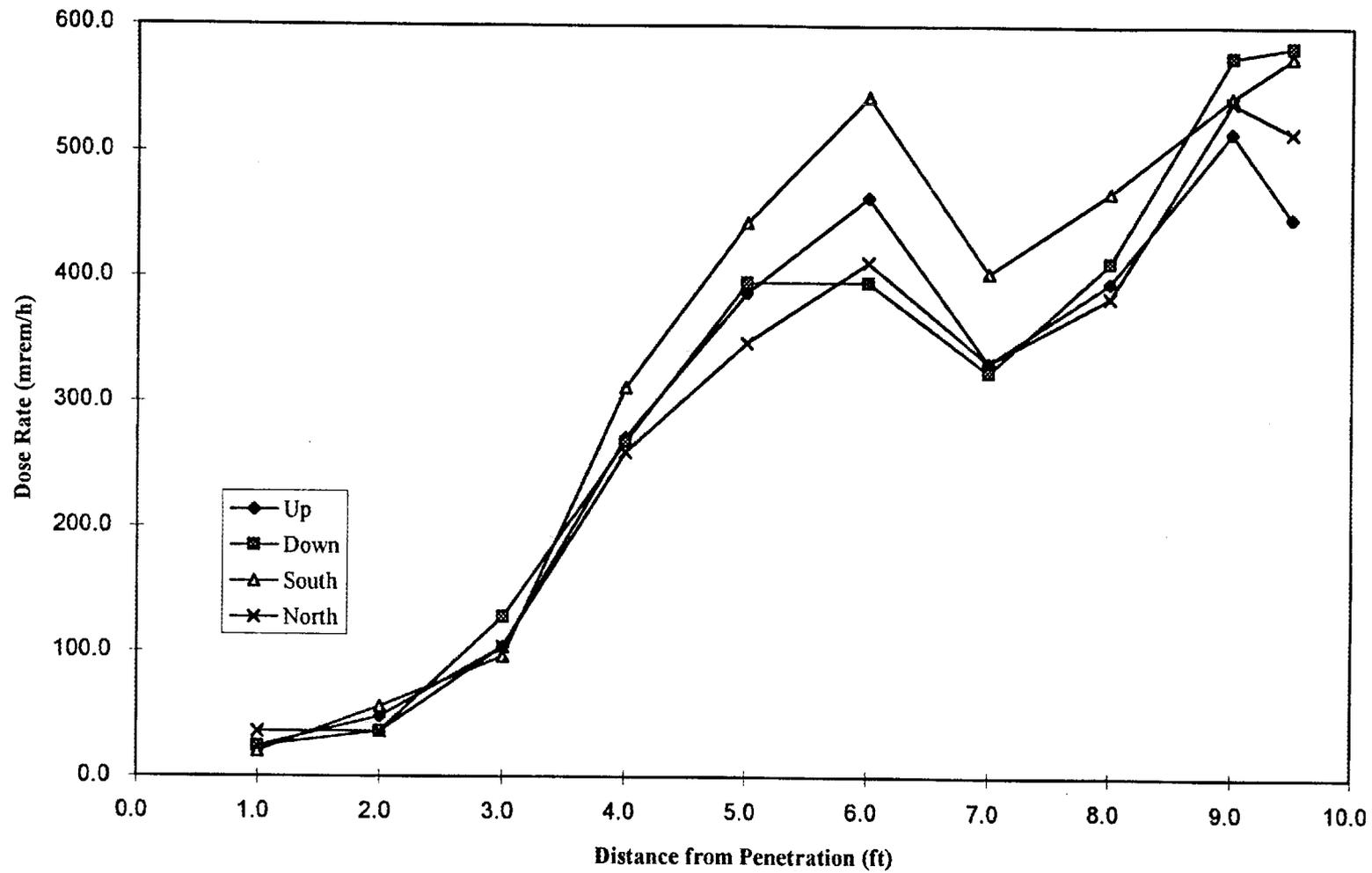


Fig. 6.19. South cell TLD results (deep dose).

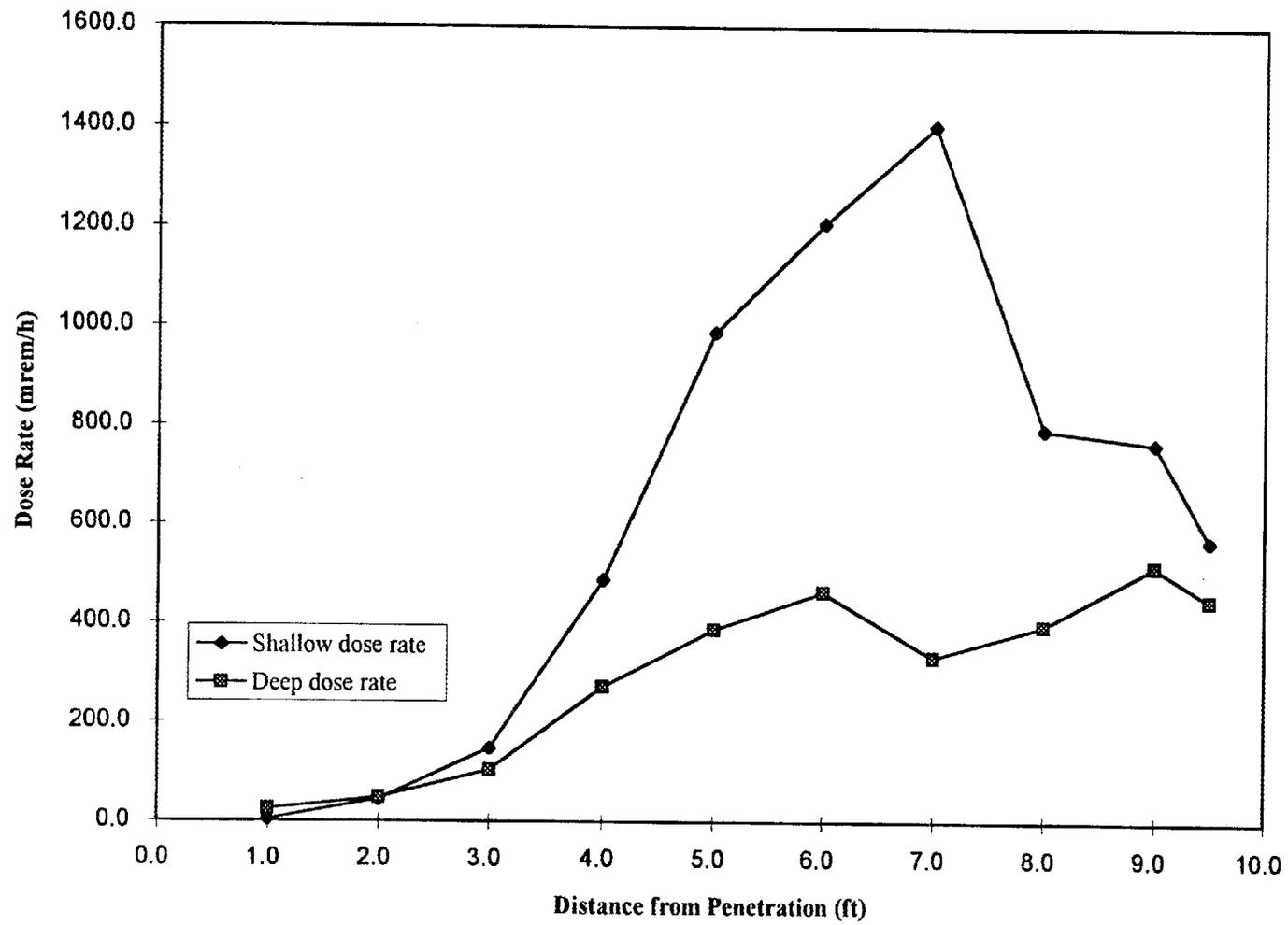


Fig. 6.20. South cell TLD results (up).

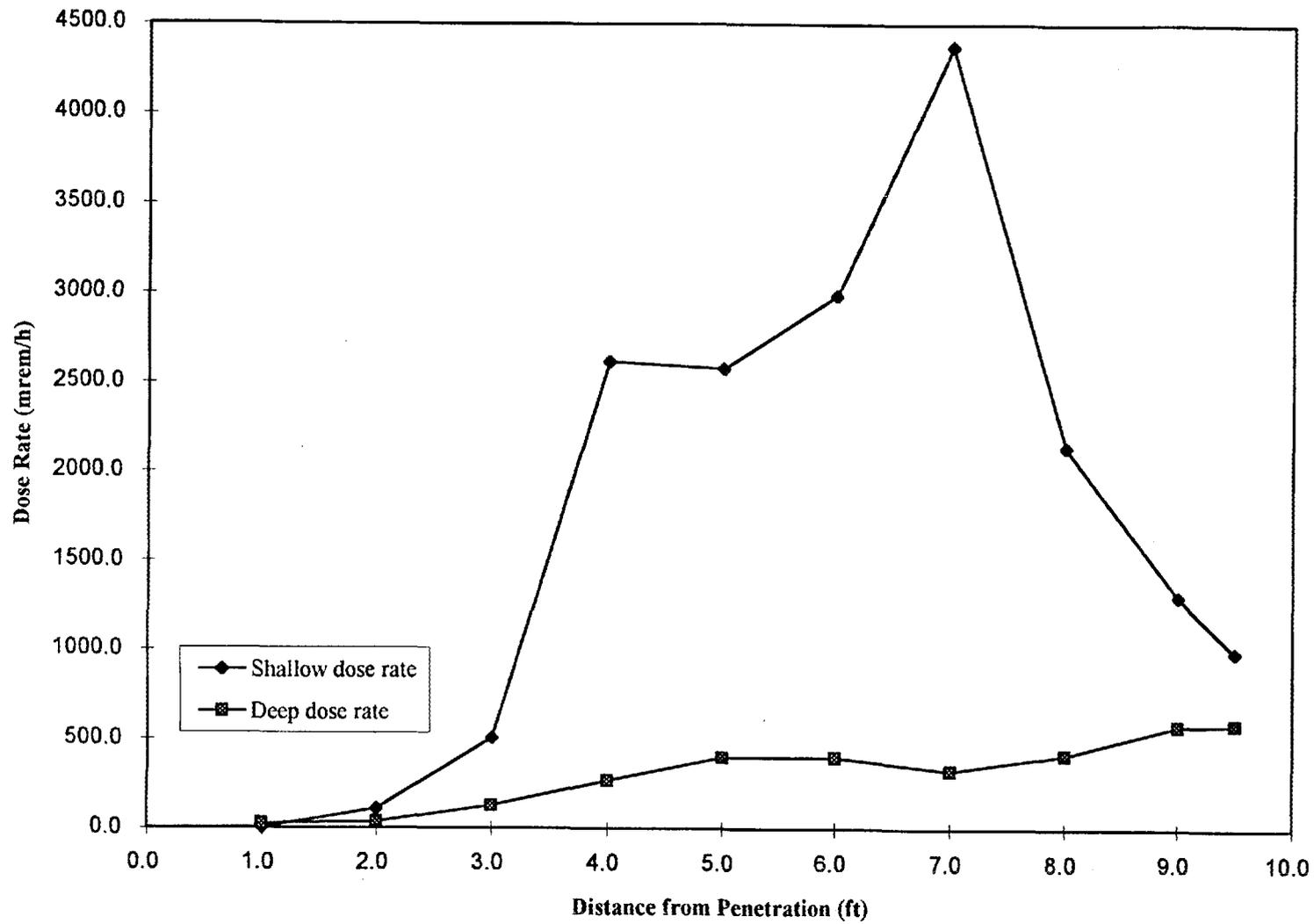


Fig. 6.21. South cell TLD results (down).

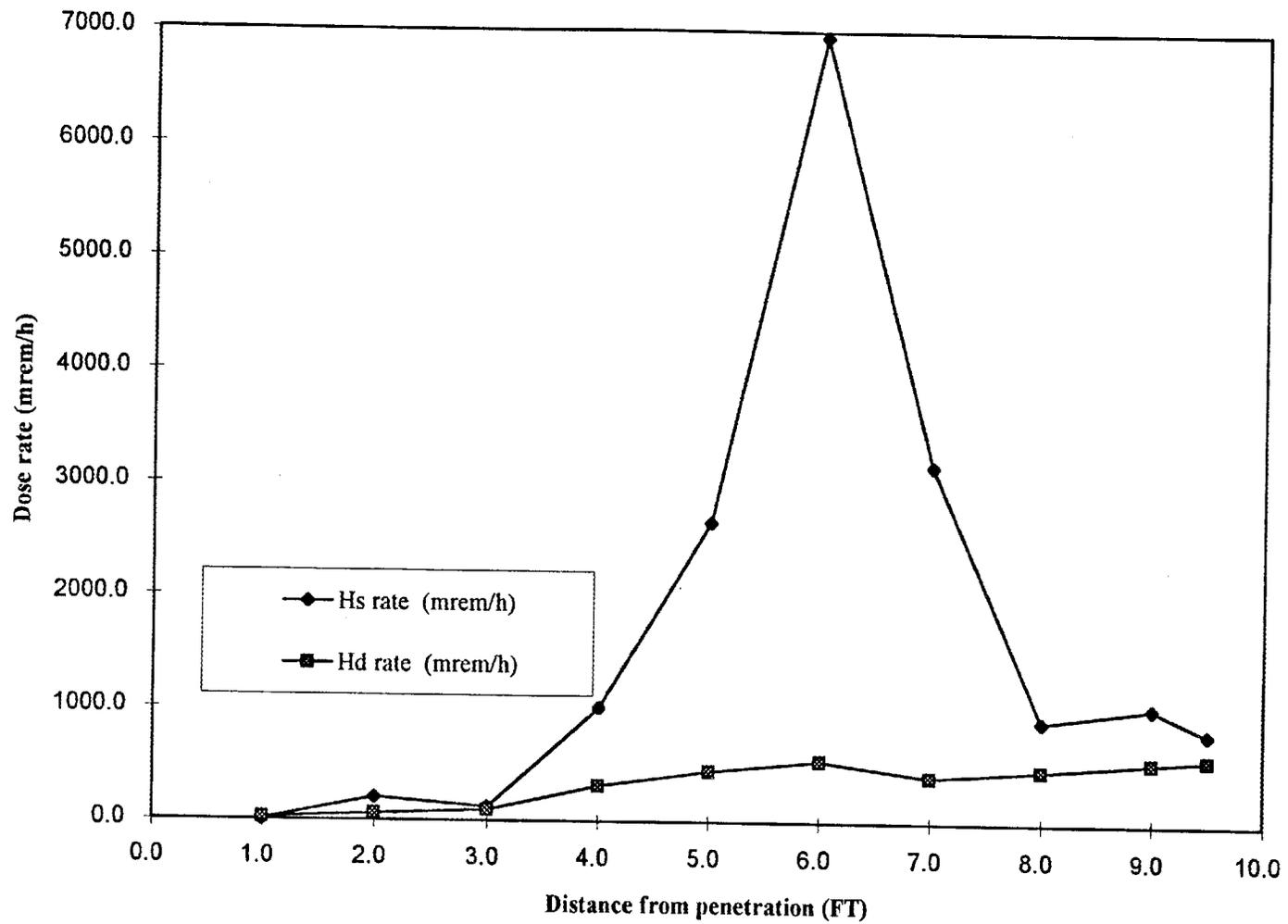


Fig. 6.22. South cell TLD results (south).

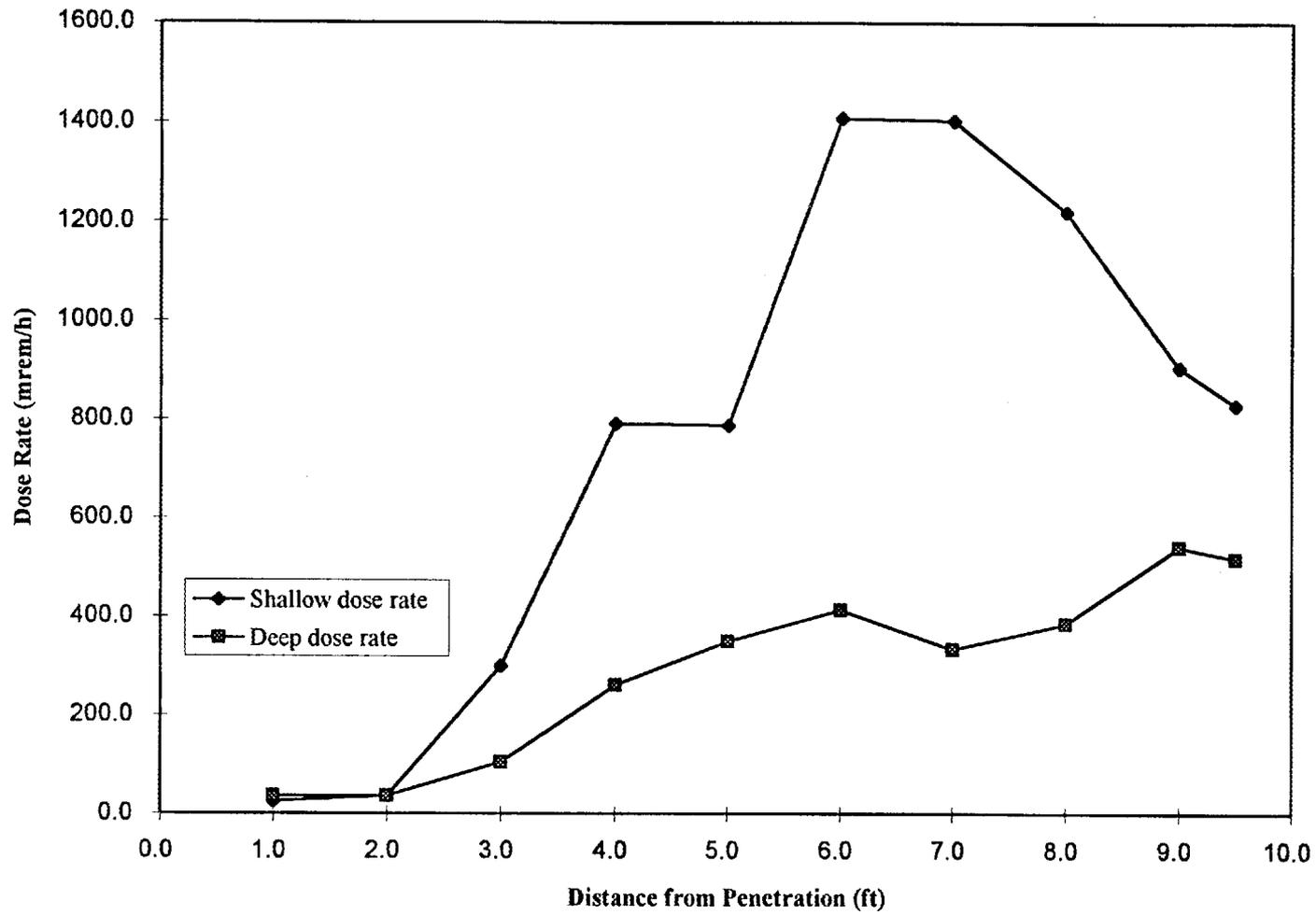


Fig. 6.23. South cell TLD results (north).

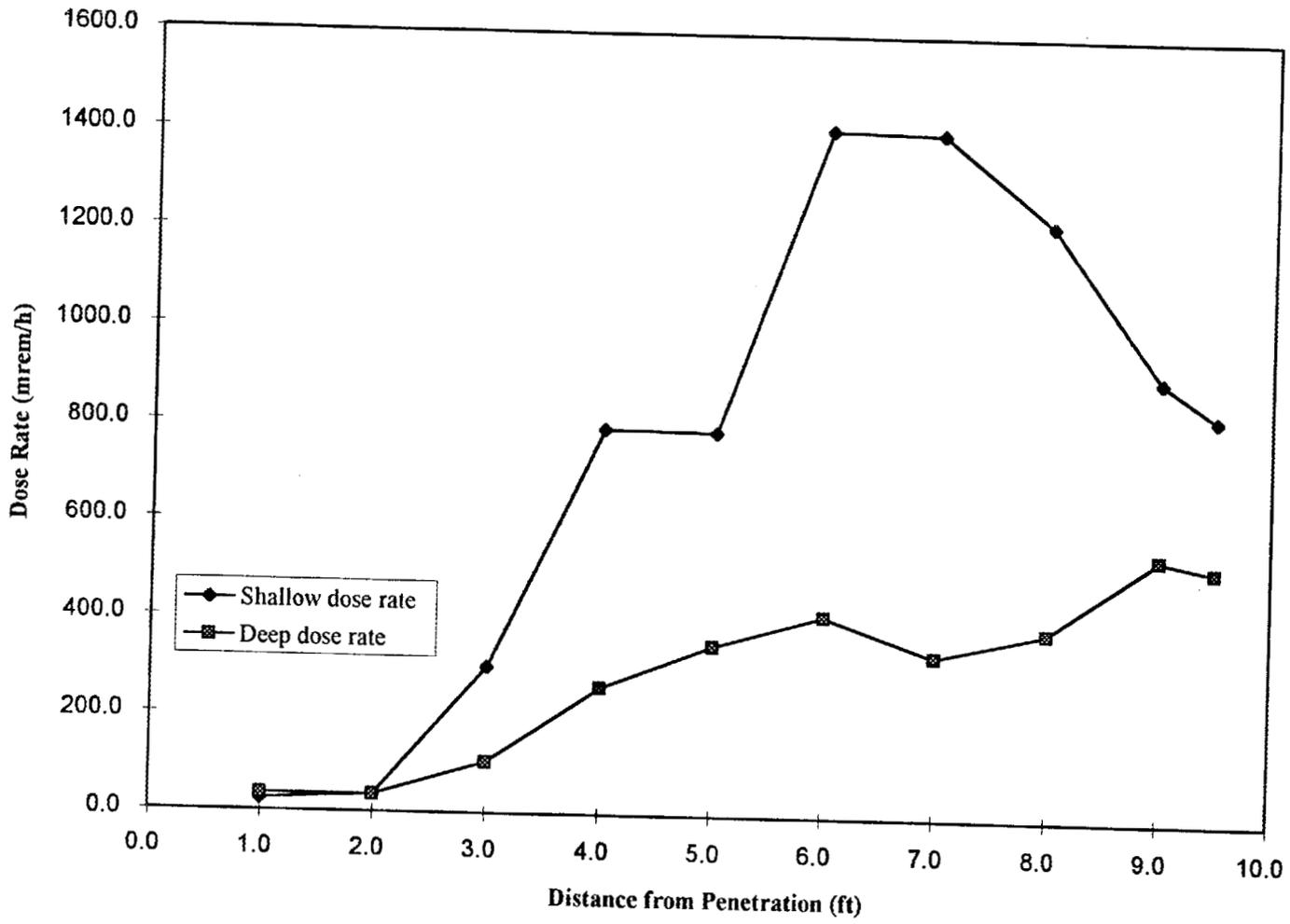


Fig. 6.23. South cell TLD results (north).

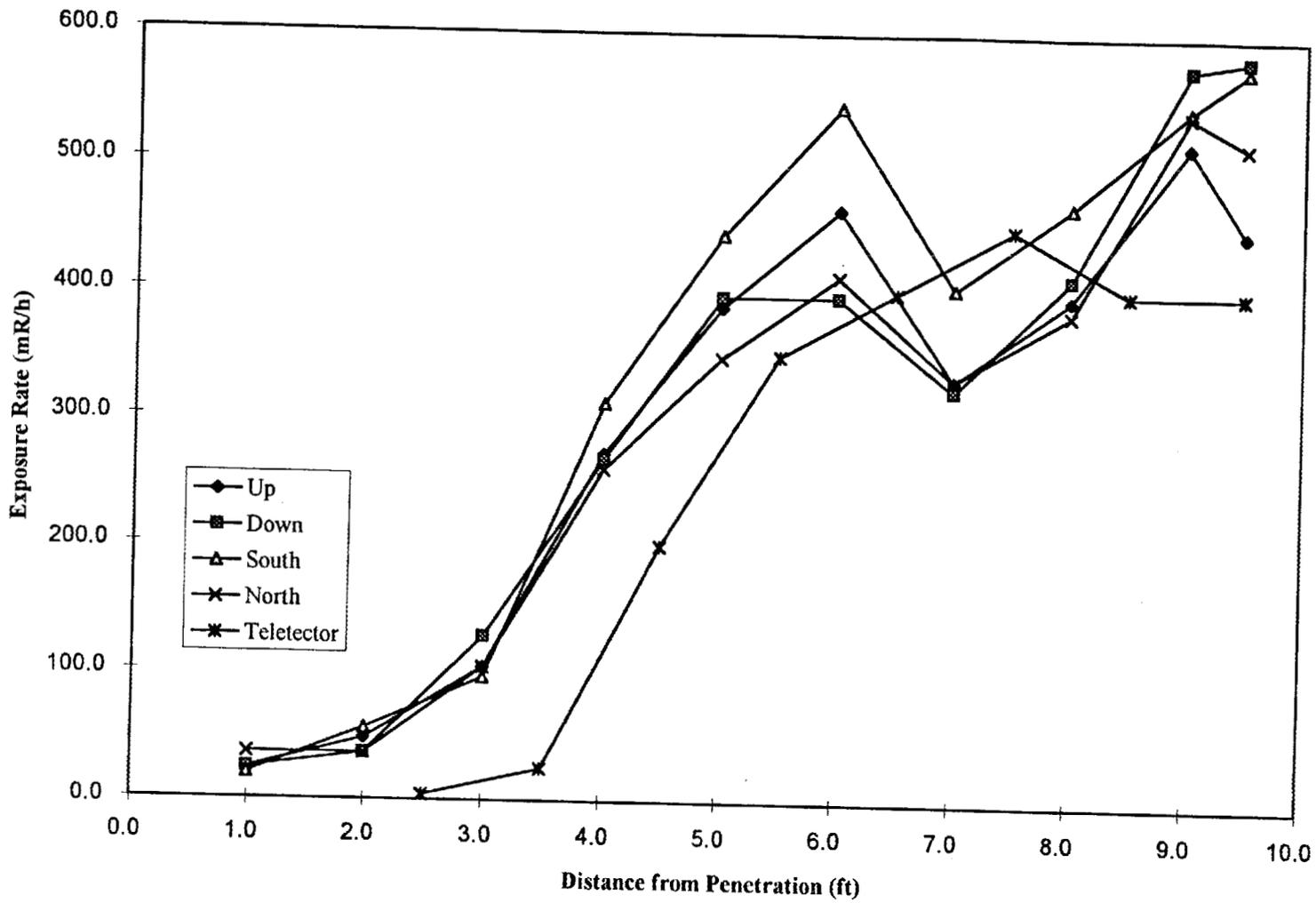


Fig. 6.24. South cell exposure profile from TLDs and teletector probe.

**Table 6.1. South cell smear measurement results**

Description	No.	Alpha (dpm/smear)	Beta/gamma (dpm/smear)
18 in. inside the opening	42	<20	5400
Right (south) wall	-	<20	4400
8 in. inside, left small pipes	43	<20	23,000
18 in. inside, left side on shield blocks	44	<20	42,000
Stainless steel (SS) pipe, approximately 2-in. diameter, 54 in. inside	45	<20	23,000
Small-diameter SS pipe north of the above pipe	46	<20	15,000
1.5-in. SS angled toward south wall, approximately 4 ft inside	47	<20	27,000
2-in. SS pipe straight in approximately 5 ft 3 in. inside	48	<20	1,000,000
2-in. SS pipe, north of above pipe, approximately 6 ft 4 in. inside	49	<20	34,000
Wall on the right, orange area on the wall, approximately 33 in. inside	50	<20	14,000
On the side of the vessel in the SE corner of the cell, approximately 7 ft 2 in. inside	51	<20	160,000
Blocks around the vessel, 8 ft inside, top of the blocks	52	<20	300,000
Back wall (north wall), 9.5 ft inside	53	<20	600,000
North wall NE corner 9 ft inside	54	<20	24,000
Bottom of the small vessel in upper NE corner of the cell	55	<20	60,000

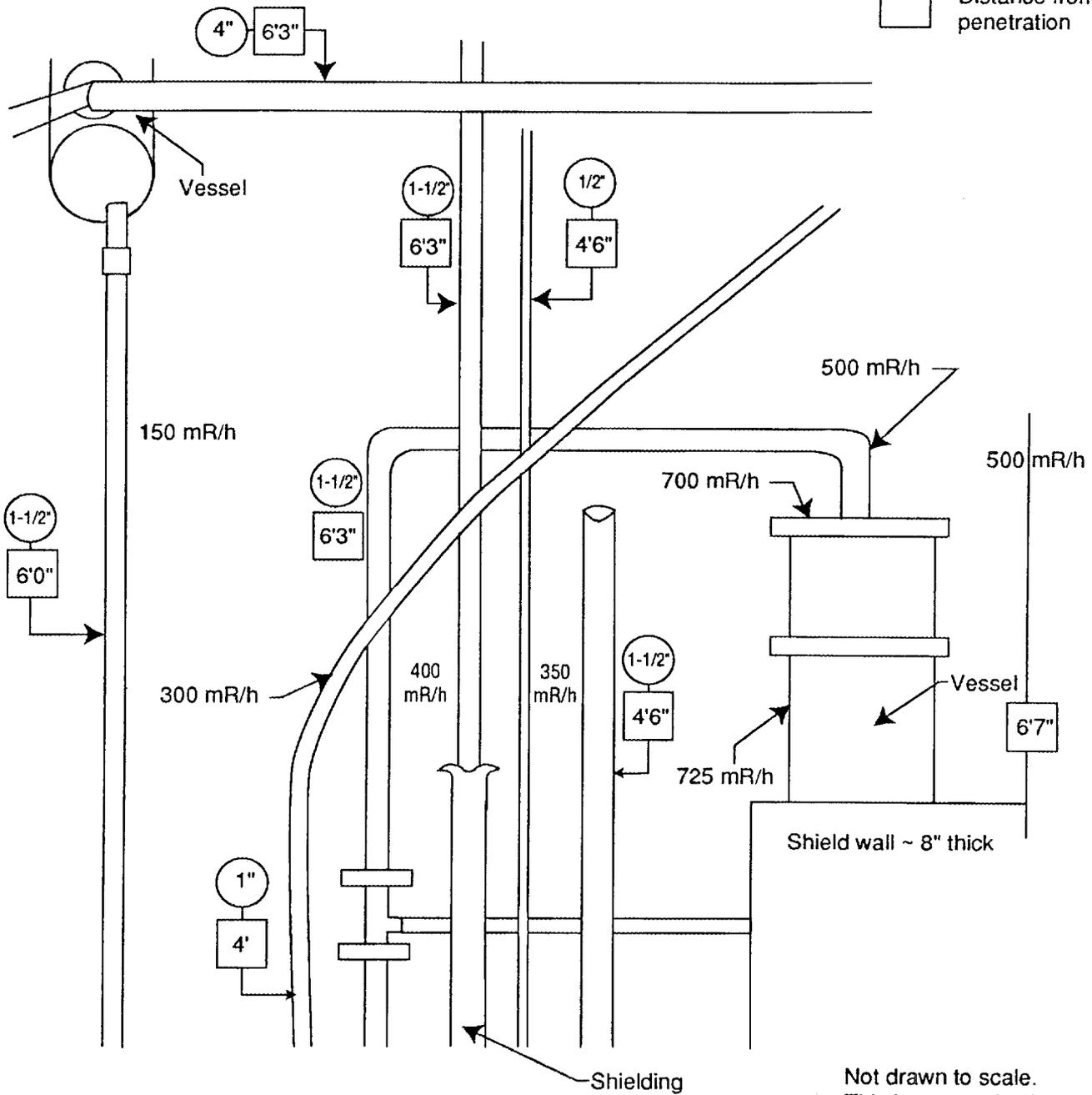
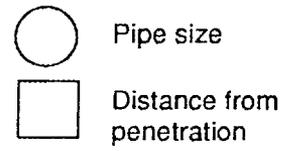


Fig. 6.25. View from penetration, south cell.

the top (surface) and in the middle; however, on the bottom portion (last inch), readings appear to be higher than background by approximately 1 order of magnitude. This core is fairly uniform from one end to the other and is moderately clean and free of loose surface contamination except for the bottom portion, which was in contact with the metal surface.

The second (73.SB002; see Fig. 3.1) was drilled approximately 6 ft from the southwestern corner of the building. This core was recovered in two sections approximately 9 in. long, and there appears to be an interface between them (two different pours). Readings from the top portion are near background from top to bottom, and this portion is fairly uniform from one end to the other. Readings from the second portion are also near background on the top and in the middle; however, the bottom 1 to 1.5 in. was in contact with the underlying soil and appears to exceed background by approximately a factor of 8. This is not unexpected given the statement by Horton (1984) that the building drain line leaked and contaminated liquid sometimes bubbled up through the soil. The second portion is also moderately clean and free of loose contamination at the top and middle, but not at the bottom.

A field HPGe gamma spectroscopy system was used to slit scan the cores before they were shipped to the ASL. The width of the slit was approximately  $\frac{1}{4}$  in., and the distance between the core and the surface of the detector was approximately 8 in. (see Fig. 6.26). The detector was shielded with lead and steel blocks on all sides to minimize the effects of local area background. Each  $\frac{1}{4}$ -in. section of core was scanned for 4 min., and the core was rotated in place by  $\frac{1}{4}$  turn every minute to allow all quadrants to be exposed to the slit for an equal time and make the measurements more uniform. Each  $\frac{1}{4}$ -in. section of core was modeled (cylindrical geometry; 3.75-in. diameter,  $\frac{1}{4}$ -in. length) to estimate the level of contaminant concentration. The model cesium-137 concentration was assumed to be  $1 \mu\text{Ci}/\text{cm}^3$  and uniform within the field of view of the slit, and the core density was assumed to be  $2.35 \text{ g}/\text{cm}^3$  (average concrete density). The cesium-137/barium-137m activity for each section was estimated by ratioing the field gamma spectroscopy results to the model results, taking into account the detector's intrinsic efficiency (approximately 14% for a 662-keV gamma line of cesium-137/barium-137m) and the model curie loading of cesium-137. Background measurements at Building 3505 indicated that there are other sources of cesium in the counting area (approximately 15 counts in 4 min above the continuum in the region of interest, which corresponds to  $1.6 \text{ nCi}/\text{cm}^3$ ).

The slit scanning results provided relative information about contaminant penetration into the concrete surfaces. Tables 6.2 and 6.3 present detailed results, and Figs. 6.27 and 6.28 plot results as a function of distance. Results indicate that the primary gamma emitting isotope is cesium-137/barium-137m.

The slit scanning results and laboratory analytical results are within an order of magnitude of each other. Such a comparison is tenuous, however, given that the laboratory results are based on analysis of a composite sample and the slit scanning results are based on a field measurement coupled with computer modeling. In addition, measurement conditions (e.g., background) in the laboratory and the field differ. Slit scanning provides valuable information about contaminant penetration. However, laboratory analytical results are used to determine the curie content of concrete because they are obtained under more controlled conditions and are more reliable than field measurements.



Fig. 6.26. Gamma spectroscopy (HPGe) slit scanning geometry/configuration.

Table 6.2. Slit scanning results for core 73.SB001

Core Position (in.)	Region of Interest (counts) <sup>a,b</sup>	Activity (nCi/cm <sup>3</sup> )	Measured Activity vs. Bkg. <sup>c</sup> (nCi/cm <sup>3</sup> )
2.13	29.50	0.002	Bkg. level
4.50	32.50	0.003	0.003
6.88	222.00	0.045	0.045

Note: For this core, the slit width was enlarged to 4.25 in.; top, bottom, and middle 4.25-in. sections were scanned.

<sup>a</sup>Counts are for 4 min; core was rotated 90° each minute.

<sup>b</sup>Area background was measured to be 18.8 counts per 4 min in the region of interest.

<sup>c</sup>If ROI counts were less than  $L_C = CTS_B + 2 \sigma_B$ ,

where

$$\sigma_B = \sqrt{CTS_B} ,$$

then the measurement was assumed to be at or below the area background level. Here,  $L_C = 27.5$  counts per 4 min.

Table 6.3. Slit scanning results for core 73.SB002

	Core Position (in.)	Region of Interest (counts) <sup>a,b</sup>	Activity (nCi/cm <sup>3</sup> )	Measured Activity vs. Bkg. <sup>c</sup> (nCi/cm <sup>3</sup> )
Piece #1	0.25	13.50	-0.52	Bkg. level
	3.25	10.00	-0.87	Bkg. level
	5.25	3.00	-1.56	Bkg. level
	7.25	15.50	-0.32	Bkg. level
	8.50	14.00	-0.47	Bkg. level
	8.75	9.00	-0.96	Bkg. level
	9.00	23.00	0.41	Bkg. level
	9.25	22.00	0.31	Bkg. level
Piece #2	9.50	17.00	-0.18	Bkg. level
	16.00	10.00	-0.87	Bkg. level
	16.25	9.50	-0.92	Bkg. level
	17.00	10.00	-0.87	Bkg. level
	17.75	247.00	22.46	22.46
	18.00	945.50	91.22	91.22
	18.25	345.50	32.16	32.16

<sup>a</sup>Counts are for 4 min; core was rotated 90° each minute.

<sup>b</sup>Area background was measured to be 18.8 counts per 4 min in the region of interest.

<sup>c</sup>If ROI counts were less than  $L_C = CTS_B + 2 \sigma_B$ ,

where

$$\sigma_B = \sqrt{CTS_B} ,$$

then the measurement was assumed to be at or below the area background level. Here,  $L_C = 27.5$  counts per 4 min.

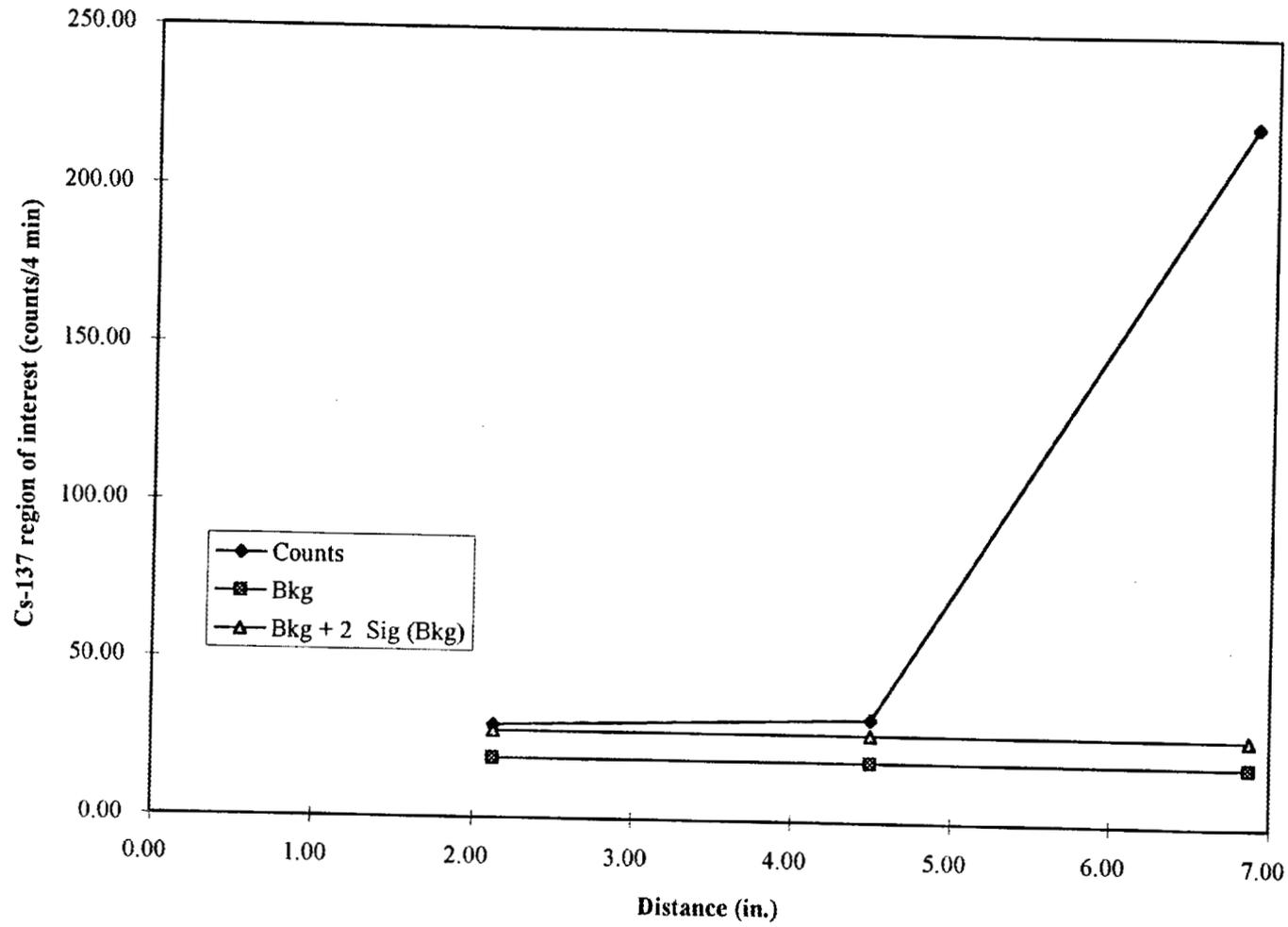


Fig. 6.27. Slit scanning results for concrete core 73.SB001.

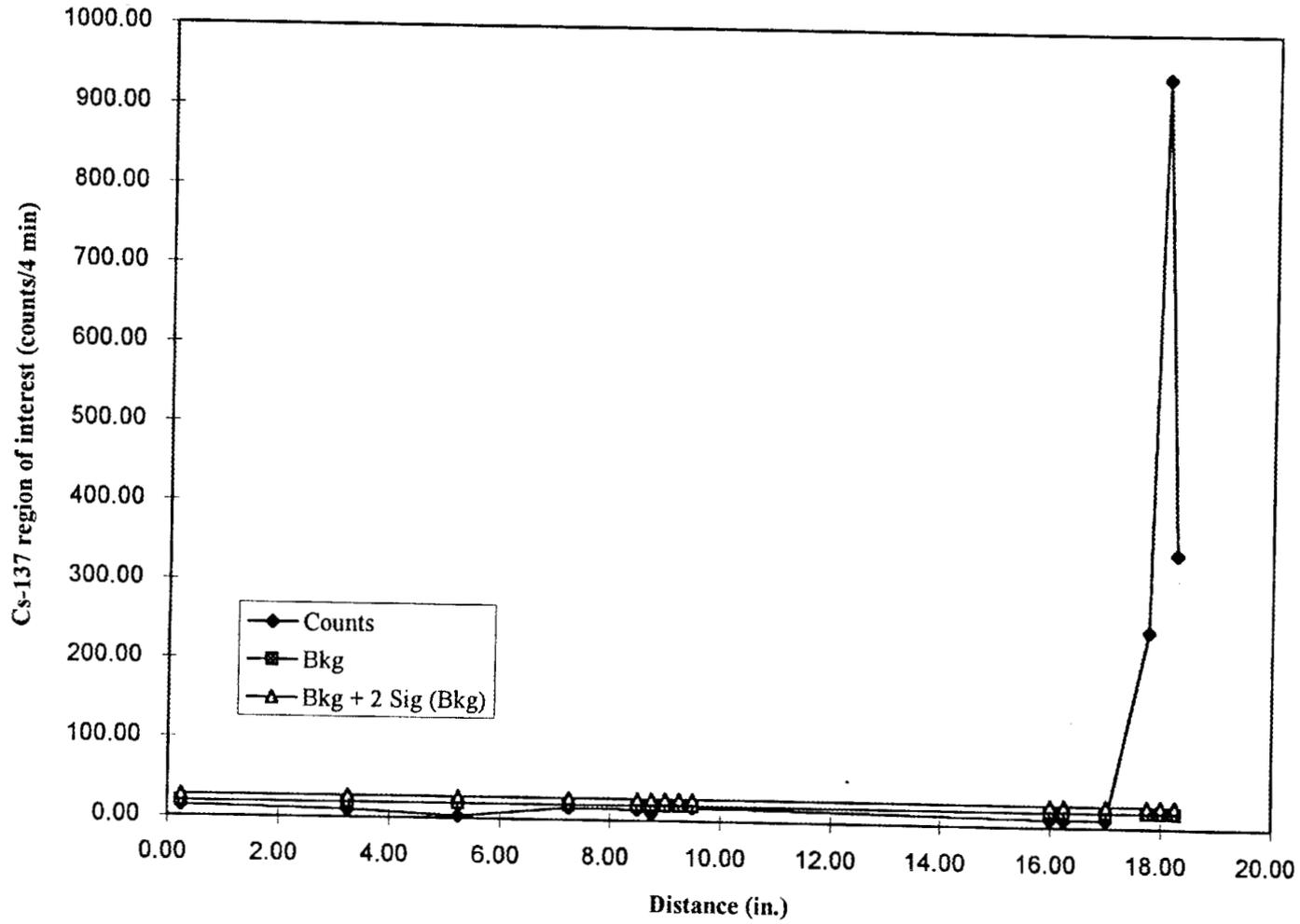


Fig. 6.28. Slit scanning results for concrete core 73.SB002.

## 6.4 OTHER OBSERVATIONS

A health physics survey conducted at the beginning of the investigation of Building 3515 showed that the general area exposure rate was approximately 20 R/h in the north cell and 450 mR/h in the south cell.

Air filter samples from personnel monitoring devices [breathing zone apparatus (BZAs)] outside Building 3515 were collected and analyzed at the CSL. Results from all BZA air filters collected were below the derived air concentration limits reported in Federal Guidance Report No. 11 (ORNL 1988).

## 6.5 SUMMARY

Teletector measurements ranged from approximately 11 to 23,000 mR/h in the north cell and from 4 to 450 mR/h in the south cell. Microshield (Negin and Worku 1992) was used to estimate the reduction in general area radiation exposure in the north cell if a 1-ft layer of concrete were added to the cell floor. Assuming that all the radiation is emitted from the floor, the measured general area exposure rate of 23 R/h would be reduced to approximately 185 mR/h.

HP-290 directional measurements ranged from approximately 400 to 6000 mR/h in the north cell and from 17 to 460 mR/h in the south cell. HP-220A measurements in the south cell (three locations) ranged from approximately 130 to 380 mR/h.

The gross smears were measured by HP-210T and AC-3-7 field instruments for gross alpha and beta activities. Results ranged from approximately 4400 to 1,000,000 dpm/smear beta/gamma and less than 20 dpm/smear alpha.

Gamma spectroscopy slit scanning results for the concrete cores all indicated that the primary isotope present is cesium-137/barium-137m.

North cell TLD results ranged from approximately 5 to 23,400 mrem/h for deep dose rate and 0.0 to 23,600 mrem/h for shallow dose rate; south cell results were approximately 20 to 576 mrem/h for deep dose rate and 4 to 6900 mrem/h for shallow dose rate.

In general, the north cell seems to be highly contaminated with cesium-137/barium-137m and some alpha emitters. The south cell also seems to be highly contaminated with cesium-137/barium-137m; however, most of the dose rate is caused by beta particles and some alpha emitters. The level of contamination is fairly high, and D&D of the structure will probably need to be done remotely.

## 7. WASTE TYPES AND VOLUME ESTIMATES

### 7.1 WASTE DISPOSAL TYPES

Solid and liquid wastes at ORNL are divided into four general categories: radioactive, hazardous, mixed, and sanitary. The waste categories can be further broken down into subcategories that have been defined in waste management plans and for which some protocols and waste acceptance criteria are available (Energy Systems 1993a,b; Gilpin 1992). If a final waste form resulting from D&D of Building 3515 matches the definition and waste acceptance criteria of an ORNL waste subcategory, then disposal or storage of the waste can proceed according to the waste management protocols.

#### 7.1.1 Radioactive

The principal wastes expected to be generated during D&D are radioactive—specifically, solid low-level waste (SLLW) and perhaps liquid low-level waste remaining in piping and equipment, if any. SLLW is defined as waste containing beta/gamma activity and/or alpha activity [in concentrations  $< 1 \text{ g/ft}^3$  or  $< 1 \text{ g total and transuranic (TRU) radionuclide specific activity } < 100 \text{ nCi/g}$ ] and is not classified as high-level waste, TRU waste, or spent fuel. The SLLW category is divided into various subcategories; those subcategories with potential application to Building 3515 D&D are defined below (Energy Systems 1993a).

- Contact-Handled (CH) SLLW—Packaged waste with an unshielded container surface radiation dose equivalent rate of  $\leq 2 \text{ mSv/h}$  (200 mrem/h). CH waste is divided into two groups: compactible (e.g., plastic bags and sheets, paper, cardboard, cloth, rubber gloves and shoe coverings, plastic bottles) and noncompactible (e.g., wood, scrap metal, glass bottles, metal tools, equipment).
- Very-Low-Activity (VLA) Waste—Waste that contains no measurable contamination by radiation survey but, because of past history and inaccessibility, is judged by ORNL Radiation Protection to be possibly contaminated in excess of defined free release limits.
- Asbestos Waste—Any waste that contains commercial asbestos or asbestos material that is radioactively contaminated.
- Remote-Handled (RH) SLLW—Packaged waste with an unshielded container surface radiation dose equivalent rate of  $> 2 \text{ mSv/h}$  (200 mrem/h). RH waste is divided into two groups: (1)  $2 \text{ mSv/h}$  (200 mrem/h) to  $10 \text{ mSv/h}$  (1 rem/h) and (2)  $> 10 \text{ mSv/h}$  (1 rem/h). RH SLLW  $> 10 \text{ mSv/h}$  (1 rem/h) will be placed in retrievable storage. The RH SLLW subcategory is expected to apply to Building 3515 because the general area exposure rate measured in the building was approximately 24 R/h in the north cell and 450 mR/h in the south cell, which is approximately a factor of 2 to 100 greater than the 200 mrem/h lower limit.

The CH SLLW, VLA, and asbestos waste, assuming that all the waste acceptance criteria are satisfied, are currently disposed of at ORNL's Interim Waste Management Facility at Solid Waste Storage Area (SWSA) 6. Small quantities of RH SLLW are retrievably stored

in wells at SWSA 6; large, bulky quantities are generally placed in 4 ft × 4 ft × 6 ft boxes, overpacked in concrete, and then temporarily stored in a Class III-IV above-ground storage facility at SWSA 6.

Those subcategories of radioactive waste that were reviewed and, based on available information, do *not* apply to Building 3515 D&D are discussed below (Energy Systems 1993a).

- **TRU Waste**—Waste contaminated with alpha emitting transuranic radionuclides (atomic number > 92) with half-lives > 20 years and specific activities > 100 nCi/g at the time of assay. Californium-252, curium-244, and uranium-233 are also managed as TRU waste at ORNL. Most of the existing solid TRU waste storage facilities at ORNL are in the north area of SWSA 5; the wastes are stored there pending development of an approved strategy for permanent disposal. A review of Building 3515 sample results indicates that the specific activities of alpha emitting radionuclides are orders of magnitude less than the 100 nCi/g limit for a TRU waste.
- **Fissile Waste Material**—Solid waste that contains the isotopes uranium-233, uranium-235, plutonium-238, plutonium-239, plutonium-241, and/or the elements neptunium, americium, curium, berkelium, and californium. If the amount of fissile isotopes placed in a package exceeds 1 g of uranium-235 equivalent, or the concentration of fissile isotopes is greater than 1 g/ft<sup>3</sup> uranium-235 equivalent, then it will be handled as fissile waste and will be stored retrievably. A review of sample data indicates that to be classified as a fissile waste, Building 3515 material would need quantities of the target isotopes orders of magnitude greater than thus far discovered.

### 7.1.2 Hazardous

The primary regulatory driver for ORNL hazardous waste management operations is RCRA; the secondary driver is TSCA. "Hazardous" compounds/substances are those that are listed in Subpart D of 40 CFR 261, and/or exhibit any of the characteristics of a hazardous waste as defined in Subpart C of 40 CFR 261 and 40 CFR 268, or fail the TCLP. If a waste is determined to be a hazardous waste, it must be handled in strict accordance with RCRA. The State of Tennessee, under the auspices of EPA, has implemented hazardous waste laws essentially equivalent to those of RCRA (Gilpin 1992). TSCA waste includes those compounds and substances contaminated with PCBs, as described in 40 CFR 761; nonradioactive asbestos is also regulated under TSCA. Several ORNL facilities are used for short-term storage of hazardous waste. Although it is possible that small amounts of hazardous materials may be generated from Building 3515 D&D, it is considerably more probable that any chemical contamination is mixed with radiological contamination.

### 7.1.3 Mixed

Mixed waste is hazardous waste found to contain radioactive contamination. Examples include cleaning fluids or oils found in a radioactive environment and surface-contaminated lead. No on-site treatment for solid mixed wastes is currently available, and storage capacity at the Oak Ridge Reservation is limited.

#### 7.1.4 Sanitary

If some of the construction debris (including concrete, asphalt, and asbestos) resulting from D&D of Building 3515 is nonradioactive and nonhazardous, it may be disposed of at the Sanitary Landfill II at the Y-12 Plant, or at an equivalent facility available at the time D&D is performed. Given the nature and extent of radiological contamination, however, it is expected that most construction debris will be considered radioactive waste and not eligible for release as sanitary waste.

#### 7.1.5 Summary and Uncertainties

In summary, the waste categories most relevant and applicable to Building 3515 D&D include RH and CH SLLW, VLA, radioactively contaminated asbestos, and mixed waste. Uncertainties or issues with regard to waste categorization include the following.

- The nature and extent of contamination of individual equipment items, and the level of contamination as a function of depth through the roof, walls, and much of the foundation have not been determined. Given the available characterization information, it is not currently possible to assign portions of the equipment or the building to specific SLLW categories (e.g., RH, CH, or VLA). (The waste disposal volumes estimated in the following section are based on stated assumptions rather than deterministic characterization data.)
- Potential RCRA constituent metals were identified in the paint chip sample and in the soil sample from below the slab on the south side of Building 3515. TCLP analysis may be needed to determine RCRA applicability for the paint and for the soil (if the soil is excavated as part of D&D).

## 7.2 WASTE DISPOSAL VOLUMES

The waste disposal volume estimates include the entire building, plus the foundation and equipment or materials within the building; they do not include the soils underneath and surrounding the building or the ancillary external piping or drains leading to or from the building. Remediation of the soils and ancillary external piping has been assigned to the GAAT OU and is not currently considered a part of D&D implementation. Also not included in the estimates is investigation-derived waste (e.g., protective clothing and equipment used during D&D implementation). The disposal volume was estimated on the basis of as-built conditions determined through field investigation and Energy Systems design drawings.

The concrete volume estimates include the walls, foundation/floor slab, and ceiling. The steel volume estimate includes the steel sheet on the roof, ceiling plates and I-beams, process piping and vessels (see Table 2.1; glass vessels were excluded from the estimate), equipment rack, north cell roof hatch, and other miscellaneous items. The lead volume estimate includes lead brick shielding around the sampling and removal station, lead bricks around the

cesium crystalizer, lead shielding for the north cell roof hatch, lead plate on the ground on the east side of the building, miscellaneous lead pipe, and lead poured in pipe culverts.

Some of the building material volumes were multiplied by the following swell factors to establish a disposal volume: concrete 1.25, steel 1.35, and lead 1.35. Swell factors for materials other than concrete, steel, and lead were assumed to be unity.

Because of the high exposure rates recorded in Building 3515, it is recommended that D&D activities be performed in steps. Isolate, decontaminate, and remove the sources that contribute to exposure rates; perform a quick characterization survey; and repeat these steps again until the D&D objectives are attained.

Two sets of waste volume estimates were prepared, each for a complete dismantlement option where all the above- and below-ground materials are demolished and removed. No partial dismantlement options were considered.

**Option 1.** The concrete rubble is not segregated according to relative activity but is instead all designated as RH SLLW. The steel in the building interior is also assumed to be RH SLLW.

**Option 2.** All material (i.e., concrete or steel) added to the original building after it ceased operations in the late 1950s is segregated and categorized as CH SLLW (or VLA waste if surveys indicate no measurable contamination). Also segregated as CH SLLW are the product sample and removal station portions of the original roof and the pad surrounding (but not under) the original building. The original (preclosure) building and enclosed piping and equipment are categorized as RH SLLW. Scabbling of interior surfaces to further segregate RH SLLW, which would likely need to be performed remotely, is not included as a preferred approach.

Table 7.1 shows disposal volume estimates for the waste removal and segregation options as a function of waste category and building material.

### 7.3 TOTAL CURIE ESTIMATES

The total volumes estimated for concrete and sediment and the radionuclide concentrations reported by the ASL were used to estimate the total curie content of the radionuclides in concrete and soil. The calculations assumed densities of approximately 1.1 g/cm<sup>3</sup> and 2.3 g/cm<sup>3</sup> for soil and concrete, respectively.

Concentrations of radionuclides in the building pad and added shield concrete around the building were assumed to be represented by the pad core samples (73.SB001 and 73.SB002). The radionuclide concentrations for the cell walls and floor were ratioed to outside cores based on the exposure rate. The total curie content was calculated for the two volume estimates described in Sect. 7.2; the total curie content for various radionuclides is listed in Table 7.2.

Table 7.1. Disposal volume estimates (ft<sup>3</sup>)

Waste Category	Building Material	Waste Removal and Segregation Options	
		Option 1: Complete Dismantlement; No Concrete Rubble Segregation	Option 2: Complete Dismantlement; Concrete Fill/Block Surrounding Original Building is Segregated
RH SLLW	Concrete rubble Steel	6,674 77	2,464 77
CH SLLW <sup>a</sup>	Concrete rubble Steel	0 6	4,170 6
Mixed Waste	Lead shielding	27	27
Asbestos <sup>b</sup>	Unidentified	Minor (no estimate)	Minor (no estimate)

<sup>a</sup> May be categorized as VLA waste if surveys find no measurable contamination.

<sup>b</sup> Asbestos is assumed to be radioactively contaminated.

Table 7.2. Curie estimate for concrete in Building 3515

Radionuclide	Total Activity per Concrete Group (Ci)			Total Activity in Building 3515
	Lower Part of Pad <sup>a</sup>	Added Shield <sup>b</sup>	Original Building Walls/Floors <sup>c</sup>	
<sup>239/240</sup> Pu	2.40E-06	2.75E-05	2.02E-05	5.02E-05
<sup>238</sup> Pu	3.00E-06	3.92E-05	2.53E-05	6.75E-05
<sup>228</sup> Th	1.02E-05	8.25E-05	8.60E-05	1.79E-04
<sup>230</sup> Th	1.28E-05	1.84E-04	1.08E-04	3.04E-04
<sup>232</sup> Th	4.20E-06	9.63E-05	3.54E-05	1.36E-04
<sup>234</sup> U	1.23E-05	2.18E-04	1.04E-04	3.34E-04
<sup>235</sup> U	1.35E-06	1.48E-05	1.14E-05	2.76E-05
<sup>238</sup> U	2.06E-05	2.20E-04	1.73E-04	4.14E-04
<sup>137</sup> Cs	3.61E-02	3.91E-03	9.31E+02	9.31E+02
<sup>40</sup> K	5.81E-05	1.94E-03	4.90E-04	2.49E-03
<sup>90</sup> Sr	2.06E-02	9.63E-05	5.30E+02	5.30E+02
Tritium	9.31E-06	1.38E-04	7.85E-05	2.25E-04

<sup>a</sup> Estimate is based on concentration of bottom 9 in. of 73.SB002 and bottom 3 in. of the pad.

<sup>b</sup> Estimate is based on concentrations of 73.SB001 and the upper 9 in. of 73.SB002, the added concrete shield, the building roof, and the upper 1.25 ft of pad.

<sup>c</sup> Estimate is based on the model prediction and volume of the original walls and floors. On the basis of smear data and core results, it is expected that the order of magnitude of activity of the alpha emitters is the same as that of other areas.

Radionuclide concentrations in the concrete cores and soils and volumes of a 55-gal drum or low-specific-activity (LSA) box were used to determine whether the waste generated from demolition of the pad and removal of soil materials would be in the TRU or fissile waste categories. These calculations indicated that waste packaged in 55-gal drums or LSA boxes would not be considered TRU or fissile. Based on the gross smear results from the cell floors and equipment, this is expected to be the case for the building construction material and equipment.

Exposure rates generated by the soil and concrete pad material packaged in 55-gal drums and LSA boxes were calculated using Microshield; results indicated that waste packages would be CH SLLW for concrete ( $< 1$  mR/h for both container types) and RH SLLW for soil ( $> 200$  mR/h for both container types). The exterior walls of the building are expected to behave the same as the outside pad, especially the added concrete shield. The interior of the building (general area exposure rate of 24 R/h and 0.45 R/h for the north and south cell, respectively) is expected to generate RH SLLW.

## 8. SUMMARY AND CONCLUSIONS

Site characterization consisted of three primary activities: inspections (including a videotape of the cell interiors), radiological measurements, and radiological and chemical sampling and analyses. Because of the high radiological contamination and dose rates, however, the site characterization for the building interior was limited in accordance with a tiered ALARA approach outlined in the approved characterization plan (Bechtel 1993a). The characterization tasks for the building interior were performed using long-handled tools inserted through holes in the cell doorways and were limited to general area survey measurements and gross smears.

This section summarizes key planning information gathered during site characterization that may assist in the engineering of D&D approaches, the protection of D&D workers, and the management of D&D-generated wastes. The summaries presented here are organized by the data needs identified in the site characterization plan. The organization is somewhat arbitrary, as much of the data collected can and will be used for engineering, personnel protection, and waste management.

### 8.1 ENGINEERING PLANNING

- No decontamination was performed on Building 3515 after it was abandoned in the late 1950s. The building interior, including the process piping and equipment, remains essentially unchanged. Alterations to the building were made circa 1964 to seal the doorways and add exterior shielding (e.g., increase wall thicknesses), and again in 1988 to repair cracks in the roof (see Sect. 2).
- Based on an exterior survey, the structural integrity of the building is adequate (i.e., the building will remain structurally intact) for safe decontamination or demolition. However, according to early ORNL drawings, a portion of the south wall and a portion of the roof of the south cell may consist of stacked (unmortared) concrete block. Stacked blocks also fill portions of the cell entrance ways. Road access and the sealed doorways are on the west side of the building (see Appendix B).
- Based on a concrete core, the foundation pad extending out from the building's south side measures 1.5 ft deep and is composed of two separate pours of approximately equal depth. A horizontal steel plate was discovered at mid-thickness at one of the two coring locations on the south side of the building foundation. The purpose and extent of the steel plate is unknown, but the plate should be considered during engineering planning (see Sect. 3).
- Slit scanning performed on the concrete cores indicates that most of the measured activity is at the bottom (where core is in contact with underlying soil). The activity distribution along the length of the core is relatively uniform and near measurement area background levels from surface to near the bottom, where the activity increases (see Sect. 6).
- Comparison of direct measurements and gross smears indicates that most of the contamination is fixed or inside the process equipment (see Sect. 6).

- North cell TLD string results ranged from approximately 12 to 21,400 mrem/h for deep dose rate and 12 to 21,420 mrem/h for shallow dose rate. South cell TLD string results ranged from approximately 20 to 584 mrem/h for deep dose rate and 4 to 6952 mrem/h for shallow dose rate. The deep dose results indicated that the floor exhibited higher activity than the walls in both cells, but the shallow dose results in the south cell indicated that the south wall exhibited the highest dose rate. The dose profile from the cells showed that dose rate increased with increasing distance from the access hole. Comparison of deep vs. shallow dose rates in the north cell showed no appreciable difference, indicating that most of the dose rate was due to penetrating ionizing radiation fields, but the south cell results indicated the opposite (see Sect. 6).
- It was not possible to investigate the product sample and recovery station on the north face of Building 3515 without destructive access; however, it was probably filled with concrete during the building alterations circa 1964. Contamination of process piping, process equipment, concrete-embedded piping, or underground piping also was not investigated (see Sect. 6).

## 8.2 PERSONNEL PROTECTION PLANNING

- The general area exposure rate in the north cell ranges from approximately 0.2 to 23 R/h at 1 and 8 ft from the penetration. A radiation transport computer code was used to estimate the reduction in general area radiation in the north cell if a 1-ft layer of concrete were added to the cell floor. Assuming that all the radiation is emitted from the floor, the measured general area exposure rate of 23 R/h would be reduced to approximately 185 mR/h. The general area exposure rate in the south cell ranges from approximately 25 mR/h at 3.5 ft from the penetration to 450 mR/h at 7.5 ft from the penetration (see Sect. 6).
- Alpha activity in the south cell smears is fairly low [ $< 9$  pCi/smear ( $< 20$  dpm/smear)] for equipment, piping, and walls (see Table 6.10). The secondary smear obtained from the south cell floor indicated an alpha activity of 30 pCi/smear (66.6 dpm/smear); the smear for the north cell floor indicated an alpha activity level of approximately 40 pCi/smear (88.8 dpm/smear). The low alpha activity in the cells is expected, given the known process history (ORNL 1994) (see Sect. 6).
- Directional measurements in the north cell show that the exposure rates due to the floor are higher than those due to walls. This is also the case in the south cell except 5 and 7 ft from the penetration, where the south direction produced higher exposure rates, perhaps due to some of the piping in that direction (see Sect. 6).

## 8.3 WASTE MANAGEMENT PLANNING

- Concrete rubble will be by far the largest volume of waste generated. Classification of the concrete waste (RH SLLW for interior original walls, CH SLLW for exterior pad and

outside added shield concrete, or VLA) depends on the D&D techniques used (see Sect. 7).

- The total curie content of all concrete material was estimated for the following major isotopes (see Sect. 7).

Isotope	Activity (Ci)
Cesium-137	9.31E+02
Strontium-90	5.30E+02
Uranium (total)	7.76E-04
Thorium (total)	6.18E-04
Plutonium (total)	1.18E-04

- Waste generated from demolition of building construction materials (e.g., concrete, soil, or sediment) and packaged in 55-gal drums or LSA boxes would not be considered fissile or TRU waste. This conclusion was reached using the maximum contaminant concentration results (soil and concrete cores) and the volumes of a 55-gal drum or LSA box to calculate mass of fissile or TRU material that might be present in each type of container (see Sect. 7).
- No RCRA constituent metals were found in the core samples from the concrete pad outside the building. One of the cores contained aroclors at 1.56J mg/kg, which is below the TSCA criterion. Since no core samples were taken from the building interior because of the prohibitively high radiation readings, these chemical findings for the "outside" cores should not be considered representative of the concrete comprising the walls and floors of the cells (see Sect. 4).
- Analyses for inorganics indicated two potential RCRA constituent metals (lead and mercury) in a soil sample from under the concrete pad and two (barium and lead) for a paint chip sample. A TCLP test can determine whether they are RCRA constituents; however, it is unlikely that the paint will fail the TCLP test based on its relatively low leachability (see Sect. 4).
- Drawings and photographs indicate lead shielding, considered a mixed low-level radioactive waste, at several building locations. Most of the lead is in the form of bricks around the cesium crystallizer in the south cell and around the product sample and recovery station on the north face of the building. A thick lead plate may also lie on the ground (under a gravel cover) on the east side of the building (see Sect. 4).

## 8.4 CONCLUSIONS

- Due to the limited remote characterization performed for the building interior, planning for D&D implementation may require that additional characterization information be obtained, either prior to implementation or during phased implementation. Additional characterization to address data needs could include core sampling from the cell walls and floor, smears from the core locations, detritus samples from the floor, and directional surveys of the equipment and specific floor areas to better define the source term.
- The north and south cells are highly contaminated, and general area exposure rates are as high as 23 R/h and 450 mR/h, respectively.
- Because of the high exposure rates, it is recommended that D&D activities be performed in steps. Isolate, decontaminate, and remove the sources that contribute to exposure rates; perform a quick characterization survey; and repeat the steps until the D&D objectives are attained.
- Further investigation or future remediation of the soils underlying and surrounding Building 3515 may be advantageously postponed to coincide with the remediation of other WAG 1 operable units.

## 9. REFERENCES

- Bechtel 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, ORNL/ER/Sub/87-99053/59, Oak Ridge, Tennessee.
- Bechtel 1993a. *Site Characterization Plan for the Decontamination and Decommissioning of Buildings 3506 and 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, ORNL/ER/Sub/87-99053/69, Oak Ridge, Tennessee.
- Bechtel 1993b. *Technical Specification for Analytical Laboratory Services: Oak Ridge National Laboratory Remedial Investigation/Feasibility Study, Oak Ridge, Tennessee*, Specification 19118-99-SP-03, Rev. 4, Oak Ridge, Tennessee.
- Energy Systems 1993a. *Waste Acceptance Criteria for Radioactive Solid Waste Disposal at SWSA 6, WMRA-WMPC-203, Oak Ridge, Tennessee*.
- Energy Systems 1993b. *Waste Acceptance Criteria for Remote Handled Solid Low Level Waste Storage, WMRA-WMPC-205, Oak Ridge, Tennessee*.
- EPA 1988. *Laboratory Data Validation: Functional Guidelines for Evaluating Inorganics Analyses*.
- EPA 1990. *USEPA Contract Laboratory Program: National Functional Guidelines for Organic Data Review*.
- EPA 1991a. *USEPA Contract Laboratory Program: Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration*, Document Number OLM01.0, including Revisions OLM01.1, OLM01.2, OLM01.3, OLM01.4, OLM01.5, OLM01.6, OLM01.7, and OLM01.8.
- EPA 1991b. *USEPA Contract Laboratory Program: Statement of Work for Inorganic Analyses, Multi-Media, Multi-Concentration*, Document Number OLM02.0, including Revision ILM02.1.
- Etnier, E. L., E. P. McDonald, and L. M. Houlberg 1993. *Applicable or Relevant and Appropriate Requirements (ARARs) for Remedial Action at the Oak Ridge Reservation: A Compendium of Major Environmental Laws*, ES/ER/TM-1/R2, Oak Ridge, Tennessee.
- Gilpin, J. K. 1992. *Oak Ridge National Laboratory Waste Management Plan*, ORNL/TM-11433/R2, Oak Ridge, Tennessee.
- Horton, J. R. 1984. *Preliminary Decommissioning Study Reports, Vol 14: Old Waste Evaporator (3506) and Fission Product Pilot Plant (3515)*, X-OE-231, Oak Ridge, Tennessee.

Negin, C. A. and G. Worku 1992. *Microshield*, Version 4.0, Grove Engineering, Inc., Rockville, Maryland.

ORNL 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11, Oak Ridge, Tennessee.

ORNL 1994. Personal communication between Bob Lampton, a former ORNL process design engineer, and Daniel Sloan, Bechtel team (Bechtel CCN 027260; August 2, 1994).

Simpson, D. R. 1984. *Preliminary Radiological Characterizations of the Waste Evaporator Facility (3506) and the Fission Product Pilot Plant (3515)*, ORNL/CF-84/93, Oak Ridge, Tennessee.

**Appendix A:**

**Listing of historical ORNL Drawings and Photographs of  
Building 3515**

Number <sup>a</sup>	Date	Drawing Title
A-RD-373	12/06/50	EV Process COLUMNS
A-RD-375	12/18/50	EV Project COLUMN
A-RD-376	10/19/50	EV Project COLUMN
A-RD-382	None	EV Process COVER PLATE FOR G. L. NOZZLE
A-RD-383	None	EV Project TOP FOR G. L. TANKS
A-RD-393	None	EV Process MIRROR & FRAME
A-RD-394	01/10/51	EV Process ADAPTER FLANGES FOR 6"-COLUMN
A-RD-395	01/10/51	EV Process ADAPTER FLANGES FOR 6"-COLUMN
A-RD-396	01/10/51	EV Process ADAPTER TUBE
A-RD-397	01/11/51	EV Process ADAPTER FLANGE FOR 6"-COLUMN
A-RD-399	01/12/51	EV Process BOTTOM ADAPTER FLANGE FOR 6"-COLUMN
A-RD-400	None	EV Process SUPPORT PL. FOR RESIN BED
A-RD-404	01/16/51	EV Project SHELF FOR SOLN. ADDITION BOTTLES
A-RD-406	01/18/51	EV Process 3" FLANGE FOR 6" COLUMN NOZZLE
A-RD-407	01/18/51	EV Project 1-½" FLANGE FOR 6" COLUMN NOZZLE
A-RD-418	01/24/51	EV Process DRIP PAN FOR GLASS LINED TANK

Number <sup>a</sup>	Date	Drawing Title
A-RD-419	01/24/51	EV Process DRIP PAN FOR GLASSWARE RACK
A-RD-420	01/25/51	EV Project SAMPLE TRANS. VESSEL
A-RD-424	01/26/51	EV Process MOTOR DRIVEN PINCH CLAMP
A-RD-430	01-30-51	EV Project R. E. COND. RECEIVER
A-RD-431	None	ASPIRATOR BOTTLE TRAY
A-RD-432	None	VANTON PUMP BOX
A-RD-433	05/18/51	EV Process SAMPLE CARRIER
A-RD-434	05/28/51	EV Process SHIELD
A-RD-437	06/06/51	EV Process A. E. HCL TRANS. FLASK
A-RD-439	06/06/51	EV Process DEMINEALIZED WATER SYSTEM
A-RD-441	07/02/51	EV Process RU TRANSFER POT
A-RD-443	07/02/51	EV Process GLASSWARE CLAMPS
A-RD-444	07/02/51	EV Process STOPCOCKS FOR SAMPLING
A-RD-513	07/02/51	EV Process PINCH CLAMP SUPPORT
A-RD-611	12/29/51	Caesar Process MICRO METALLIC GLASS WALLED FILTER
A-RD-612	01/02/52	Caesar Process MICRO METALLIC GLASS WALLED FILTER
A-RD-617	01/14/52	Caesar Process ALTERATIONS TO PRECIPITATOR #1

Number <sup>a</sup>	Date	Drawing Title
A-RD-620	01-24-52	Caesar Process VESSEL SUPPORT
A-RD-635	None	Caesar Process VALVE ASSEMBLY
A-RD-637	02/29/52	Caesar Process SPRAY TUBE
A-RD-644	04-10-52	Caesar Process SAMPLE METERING VESSEL
A-RD-647	04-10-51	Caesar Process BAROMETRIC LEG FOOT TANKS
A-RD-667	09/05/52	Caesar Process INSULATORS
A-RD-702	None	Caesar Process SELAS FILTER ASSEMBLY
A-RD-703	None	Caesar Rev. P-2 PRODUCT FILTER
A-RD-817	06/04/54	CUBICLE FRAME
A-RD-820	None	CUBICLE LINERS
A-RD-821	06/14/54	LEAD SLABS FOR CUBICLES
A-RD-822	06/15/54	LOW LEVEL CUBICLE COVERS
A-RD-823	06/15/54	HIGH LEVEL CUBICLE COVERS
A-RD-856	09/03/54	BOTTLER SAMPLER MECHANISM FOR CUBICLES
A-RD-2108	03/25/64	BLDG. 3515 ALTERATION
B-RD-372	12/07/50	EV Process Bldg 3515 WATER ION-EXCHANGE COLUMN W.O. 380955 CHARGE 3902-999
B-RD-379	12/19/50	EV Process Bldg 3515 ADAPTERS FOR G.L. TANKS
B-RD-387	01/05/51	EV Process Bldg 3515 FUMING HNO <sub>3</sub> TANK SR PURIFICATION

Number <sup>a</sup>	Date	Drawing Title
B-RD-388	01/09/51	EV Process Bldg 3515 FUMING HNO <sub>3</sub> CONDENSER SR. PURIFICATION
B-RD-391	01/09/51	EV Process Bldg 3515 FUMING NITRIC TRANSFER VESSEL SR. PURIFICATION
B-RD-604	11/05/51	DETAIL OF PERISCOPE SHIELD
B-RD-621	01/25/52	Caesar Process PRECIPITATOR STAND
B-RD-630	02/21/52	Caesar Process SAMPLE DILUTION VESSEL
B-RD-642	04/17/52	Caesar Process - Bldg 3515 DURCO VALVE ALTERATIONS
B-RD-643	04/16/52	Caesar Process - Bldg 3515 GLASS CONDENSER AND CONNECTOR
B-RD-651	04/21/52	Caesar Process - Bldg 3515 FILTER VESSEL ADAPTER PIPES
B-RD-808	05/18/54	EV Process - Bldg 3515 SAMPLER TONGS
C-RD-371	11/20/50	EV Project Bldg 3515 GLASSWARE RACK
C-RD-392	01/10/51	EV Process Bldg 3515 VACUUM TRAP SHIELDING
C-RD-398	01/18/51	EV Process Bldg 3515 SUPPORT FOR GLASS LINED COL.
C-RD-402	01/17/51	EV Project - Bldg 3515 SAMPLE STATION ASSEMBLY
C-RD-403	01/17/51	EV Project Bldg 3515 SAMPLE STATION DETAILS
C-RD-405	01/18/51	EV Project Bldg 3515 TOP ADAPTER FLANGE FOR 6" COLUMN ASSEMBLY & DETAILS
C-RD-528	07/26/51	METAL RECOVERY WASTE TANKS JET AND PIPING TO 3515

Number <sup>a</sup>	Date	Drawing Title
C-RD-614	01/10/52	Caesar Process FILTRATE VESSEL #1
C-RD-615	01/10/52	Caesar Process FILTRATE VESSEL #2
C-RD-616	01/10/52	Caesar Process SAMPLER TRANSFER VESSEL
C-RD-618	01/21/52	Caesar Process ALTERATIONS TO PRECIPITATOR #1
C-RD-622	01/28/52	Caesar Process SAND FILTER
C-RD-629	02/19/52	Caesar Process PRODUCT TRANSFER VESSEL
C-RD-631	02/23/52	Caesar Process CESIUM COLUMN
C-RD-632	01/25/52	Caesar Process REVISIONS TO CELL FLOORS
C-RD-633	02/26/52	Caesar Process VACUUM SCRUBBER
C-RD-634	02/28/52	Caesar Process - Bldg 3515 RUTHENIUM CONDENSER TRAP FOR F.V. #2
C-RD-636	02/29/52	Caesar Process - Bldg 3515 SOLUTION ADDITION FUNNELS
C-RD-638	03/01/52	Caesar Process - Bldg 3515 SOLUTION MAKE-UP VESSEL
C-RD-648	04/28/52	Caesar Process - Bldg 3515 PIPING DIAGRAM - CELL I
C-RD-649	04/09/52	Caesar Process - Bldg 3515 PRODUCT & SAMPLE REMOVAL STATION TONGS
C-RD-656	06/04/52	Caesar Process - Bldg 3515 DECAPPER & SHIELD
D-337	05/23/50	Cesium 137 Tank Farm CELL CONSTRUCTION (MODIFICATION OF RUTHENIUM SITE)

Number <sup>a</sup>	Date	Drawing Title
D-338	05/23/50	Cesium 137 Tank Farm SECTIONS OF CELL CONSTRUCTION
D-339	05/21/50	Cesium 137 Tank Farm SLEEVE LOCATIONS
D-340	05/23/50	Cesium 137 Tank Farm PIPING LAYOUT
D-341	05/23/50	Cesium 137 Tank Farm TRANSFER VESSEL (MODIFICATION OF EXISTING TANK)
D-8382	11/13/50	Alteration & Additions PLAN & SECTION
D-9257	06/14/51	Alterations & Additions PLANS & SECTIONS
D-RD-421	01/25/51	EV Process Bldg 3515 FLOW SHEET
D-RD-435	06/06/51	EV Process Bldg 3515 EVAPORATOR
D-RD-436	06/08/51	EV Process Bldg 3515 EVAPORATOR DETAILS
D-RD-438	06/15/51	ALTERATIONS & ADDITIONS PLANS & SECTIONS
D-RD-609	11/23/51	Fipex-Bldg 3515 SKETCH SHOWING LOCATION OF HOLES THRU GALLERY WALL TO CELLS 1 & 2
D-RD-613	01/03/52	Caesar Process - Bldg 3515 BUILDING ALTERATIONS
D-RD-639	03/03/52	Caesar Process - Bldg 3515 SOLUTION MAKE-UP TABLE
D-RD-640	04/10/52	Caesar Process - Bldg 3515 PIPING DIAGRAM - CELL II
D-RD-641	04/10/52	Caesar Process - Bldg. 3515 CELL II PROCESS AND ELECTRICAL EQUIPMENT LOCATION

Number <sup>a</sup>	Date	Drawing Title
D-RD-645	03/25/52	Caesar Process Bldg 3515 PRODUCT & SAMPLE REMOVAL STATION
D-RD-646	03/25/52	Caesar Process Bldg 3515 PRODUCT & SAMPLE REMOVAL STATION - DETAILS
D-RD-652	04/22/52	Caesar Process Bldg 3515 CRYSTALLIZER SAMPLING STATION
D-RD-653	05/06/52	Caesar Process - Bldg 3515 CARRIER
D-RD-655	06/03/52	Caesar Process - Bldg 3515 FILTER VESSEL
D-RD-657	07/25/52	Caesar Process Bldg 3515 FLOW DIAGRAM
D-RD-732	09/11/53	FPP Process - Bldg 3515 FLOW DIAGRAM
<sup>a</sup> For drawings, the first letter of the number indicates original drawing size: A = 8-1/2 in. by 11 in. B = 11 in. by 17 in. C = 17 in. by 22 in. D = 22 in. x 34 in.		

Number	Date	Description of Photograph
10491	10/31/52	Gallery interior/control room
10492	10/31/52	North cell interior
10493	10/31/52	South cell interior
10494	10/31/52	North cell interior
10495	10/31/52	North cell interior
10496	10/31/52	North cell interior
10497	10/31/52	North cell interior
10498	10/31/52	North cell interior
10499	10/31/52	Product and sample removal station
10500	10/31/52	North wall exterior
10501	10/31/52	North cell interior
10502	10/31/52	North cell interior
10503	10/31/52	South cell interior
10504	10/31/52	North cell interior
10505	10/31/52	North cell interior
10506	10/31/52	North cell interior
11643	09/15/53	North cell interior
11644	09/15/53	North cell interior
11645	09/15/53	North cell interior
11646	09/15/53	North cell interior
11647	09/15/53	North cell interior
11648	09/15/53	North cell interior
11649	09/15/53	North cell interior
11650	09/15/53	North cell interior
11651	09/15/53	North cell interior
11652	09/15/53	North cell interior

## A-10

<b>Number</b>	<b>Date</b>	<b>Description of Photograph</b>
11653	09/15/53	North cell interior
11654	09/15/53	North cell interior
11655	09/15/53	North cell interior
11656	09/15/53	North cell interior
11657	09/15/53	North cell interior
11658	09/15/53	North cell interior
11659	09/15/53	North cell interior
11660	09/15/53	North cell interior
11661	09/15/53	North cell interior
2077-86	1986	Aerial photograph of the South Tank Farm area and Building 3515
3117-88	1988	Building exterior, blocked-up entrance to south cell
3122-88	1988	Building exterior, southwest corner
7435-88	1988	Building exterior, south and west walls

**Appendix B:**  
**Structural Condition Assessment for  
Decontamination and Decommissioning of  
Building 3515**

## 1. PURPOSE

Building 3515 is being decommissioned and eventually will be dismantled. The purpose of this structural condition assessment is to determine the current condition of the facility so that worker safety concerns are appropriately considered and addressed during the dismantlement process, and to facilitate planning the sequence of dismantlement activities.

## 2. FACILITY DESCRIPTION

### 2.1 LOCATION AND USE

Building 3515 is south of Central Avenue and west of Fourth Street, at the eastern end of the South Tank Farm (STF). Approximate ORNL coordinates are N21938 and E31032. A single-wide trailer that is approximately 30 ft long, and ancillary steel that was used to support the Gunitite Tank Sluicing Project, are near the building. The facility, which was first known as the  $^{106}\text{Ru}$  Tank arrangement and was subsequently named the Fission Product Pilot Plant (FPPP), was used to extract radioisotopes of elements such as ruthenium and strontium from liquid radioactive waste.

### 2.2 CONSTRUCTION AND DESCRIPTION

The facility was constructed in 1948 and originally consisted of a concrete pad with tanks, surrounded by stacks of concrete blocks three rows high, covered by a tent (Ref. 1). The facility was built of concrete masonry walls and cast-in-place reinforced cement concrete (RCC) floors and roof. It was modified during 1950 and 1951 and now consists of the building and a hot cell, internally divided into two rooms with RCC walls approximately 18 in. thick and a 24-in.-thick roof slab. The facility was entombed by a concrete block wall outside the building and filled with concrete to provide shielding and containment. The overall thickness of the walls varies from 3½ to 4½ ft (Ref. 1).

The facility has been out of service since 1958, and most of the equipment associated with the FPPP operation, including a 40-gal cesium crystallizer, remains in place. The entrances to the building have been sealed. The plan dimensions of the building are approximately 18 ft wide, 25 ft long, and 14 ft high, surrounded by a concrete slab that is 23 ft wide and 38 ft long. The facility is divided into two areas: the north cell area and the south cell area. Operational details of the facility are discussed in the Site Characterization Plan (Ref. 2).

### 3. INSPECTION

#### 3.1 METHODOLOGY

The existing condition of the facility was inspected during November 1993. The physical inspection was limited to a walk-through of the exterior of the building by a structural engineer. Some portions of the interior of the building were viewed through a small opening that was provided for inserting small characterization tools and instruments. Detailed construction drawings were not available for review; the layout of the building was extrapolated using the limited available drawings and sketches. Calculations were not performed to support the assessment noted herein. Material samples were not retrieved for laboratory testing to establish physical characteristics of the building materials. The scope of the inspection did not include nondestructive testing such as re-bar survey, Schmidt Hammer tests, re-bar potential tests (corrosion testing), etc. The existing condition of the facility is documented by photographs and videotape. References 3 and 4 were used as guides to perform the inspection.

#### 3.2 BUILDING INTERIOR

Observations of the interior surfaces of the walls indicated that the walls were not finished and appeared to be rough. The walls are painted, and the paint appears to be peeling off in several places. Several piping and instrument tubes penetrate the walls, and the penetrations are unfinished. Stacked masonry units without mortar were also observed. A masonry containment wall surrounds a vessel within the building and extends approximately 4 ft above the floor. There are some floor drains within the cell areas. Structural defects such as cracks deterioration of the walls and floors were not eminent.

#### 3.3 BUILDING EXTERIOR

The exterior surfaces of the facility appear to be in good condition. Periodic maintenance has been performed since 1976 (Ref. 1). In 1988, some cracks in the roof were repaired and stainless steel sheeting was installed to protect against weather and to prevent migration of contamination.

Except for the westernmost wall, all exterior walls exhibit fine vertical cracks (widths less than 1 mm) in the masonry. The cracks appear randomly and vary in length from 6 in. to full wall height. Some horizontal cracking is present and is often associated with the vertical cracking. There is extensive vertical cracking at the western corner of the south wall.

A fine vertical crack, continuous from grade to roof, is 3 ft from the eastern end of the north wall, and diagonal (stair-step-like) cracks appear on the northern end of the east wall. Mortar grout between masonry appears to be friable and crumbling.

The visible portion of the foundation is roughly constructed and contains numerous voids and extrusions and encrustation of cementitious materials. An orange discoloration on the exterior could be leaching of paint materials from inside the wall or rust from corrosion of reinforcement materials. Black leach deposits are also present on the west wall.

Overhead power lines are near the facility, and an active steam line on the east side of the building runs north-south. It is not apparent whether the building connections with outside utilities are sealed off and terminated.

Access to the facility is on the west side from Third Street. Underground utilities appear to surround the facility; review of these utilities was outside the scope of this inspection.

#### 4. SUMMARY AND CONCLUSIONS

The vertical cracks in the outer walls indicate possible differential settlement in the foundation system. There is a possibility that the exterior walls on the northeastern corner of the building are unstable and may require temporary shoring to prevent potential safety hazards during decommissioning. However, the exterior walls may not have any structural significance since the walls are not part of the original building. (These walls were constructed only for shielding and entombment purposes.) It may be prudent to consider the conditions of these walls in planning the decommissioning activities.

The structural condition of the roof and ceiling could not be assessed because of access restrictions and the absence of design drawings. It is recommended that the live loads on the roof be evaluated for the lay-down of tools and personnel during the decommissioning.

The underground utility connections from the facility should be reviewed and appropriately terminated to prevent cross contamination.

Limited access; available lay-down area; and presence of overhead, aboveground, and underground utilities may cause difficulties for movement of heavy equipment during the dismantlement operations but will not adversely affect the planned decommissioning and dismantlement activities.

#### 5. REFERENCES

1. J. R. Horton, 1984. *Preliminary Decommissioning Study Report, Volume 14: Waste Evaporator Facility (3506) and Fission Product Pilot Plant (3515), X-OE-231.*

2. Bechtel, 1993. *Site Characterization Plan for the Decontamination and Decommissioning of Buildings 3506 and 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, ORNL/ER/Sub/87-99053/69.
3. ACI 201.R, "Guide for Making a Condition Survey of Concrete in Service."
4. ANSI/ASCE 11-90, "Guidelines for Structural Condition Assessment of Existing Buildings."

**Appendix C:**  
**Field Investigation Measurement Equipment**

<b>Instrument</b>	<b>Manufacturer</b>	<b>Model</b>
Alpha probe	Eberline	AC-3
Gamma probe	Eberline	HP-290
Directional gamma probe	Eberline	Modified HP-220A
Portable readout ratemeter/scaler	Eberline	ESP-2
Portable readout ratemeter/scaler	Eberline	SRM-100
Beta/gamma survey meter	Eberline	RO-2 or RO-2A
Portable gamma spectroscopy detector	CANBERRA	Coaxial HPGe with beryllium window
Portable multichannel analyzer	EG&G ORTEC	7500 and 7500B
Soil sample collection tool		2- and 3-in. hand augers
Concrete core drill	Diamond Tool and Fastener; Black & Decker	4-in. diamond bit drill
Teletector	W. B. Johnson & Associates	2000W
TLD string	HARSHAW	Beta/gamma dosimeter

**Appendix D:**

**Contract-Required Detection Limits**

**for TAL Inorganics**

**and**

**Contract-Required Quantitation Limits**

**for TCL VOCs, SVOCs, and Pesticides/PCBs**

**Contract Required Detection Limits (CRDLs) for TAL Inorganics**

Metals	CRDLs <sup>a</sup> for Liquids ( $\mu\text{g/L}$ )
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Cyanide	10
Iron	100
Lead	3
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
<sup>a</sup> The CRDLs for solids will be higher than those for liquids and will be a function of the percent moisture present in the sample.	

**TARGET COMPOUND LIST (TCL) AND CONTRACT-REQUIRED  
QUANTITATION LIMITS (CRQL)**

Analyte	CAS Number	Quantitation Limits <sup>a</sup>			
		Water ( $\mu\text{g/L}$ )	Low Soil ( $\mu\text{g/kg}$ )	Med. Soil ( $\mu\text{g/kg}$ )	On Column (ng)
<b>VOLATILES</b>					
1. Chloromethane	74-87-3	10	10	1200	(50)
2. Bromomethane	74-83-9	10	10	1200	(50)
3. Vinyl Chloride	75-01-4	10	10	1200	(50)
4. Chloroethane	75-00-3	10	10	1200	(50)
5. Methylene Chloride	75-09-2	10	10	1200	(50)
6. Acetone	67-64-1	10	10	1200	(50)
7. Carbon Disulfide	75-15-0	10	10	1200	(50)
8. 1,1-Dichloroethene	75-35-4	10	10	1200	(50)
9. 1,1-Dichloroethane	75-34-3	10	10	1200	(50)
10. 1,2-Dichloroethene (total)	540-59-0	10	10	1200	(50)
11. Chloroform	67-66-3	10	10	1200	(50)
12. 1,2-Dichloroethane	107-06-2	10	10	1200	(50)
13. 2-Butanone	78-93-3	10	10	1200	(50)
14. 1,1,1-Trichloroethane	71-55-6	10	10	1200	(50)
15. Carbon Tetrachloride	56-23-5	10	10	1200	(50)
16. Bromodichloromethane	75-27-4	10	10	1200	(50)
17. 1,2-Dichloropropane	78-87-5	10	10	1200	(50)
18. cis-1,3-Dichloropropene	10061-01-5	10	10	1200	(50)
19. Trichloroethene	79-01-6	10	10	1200	(50)
20. Dibromochloromethane	124-48-1	10	10	1200	(50)
21. 1,1,2-Trichloroethane	79-00-5	10	10	1200	(50)
22. Benzene	71-43-2	10	10	1200	(50)
23. trans-1,3-Dichloropropene	10061-02-6	10	10	1200	(50)
24. Bromoform	75-25-2	10	10	1200	(50)
25. 4-Methyl-2-pentanone	108-10-1	10	10	1200	(50)
26. 2-Hexanone	591-78-6	10	10	1200	(50)
27. Tetrachloroethene	127-18-4	10	10	1200	(50)
28. Toluene	108-88-3	10	10	1200	(50)
29. 1,1,2,2-Tetrachloroethane	79-34-5	10	10	1200	(50)
30. Chlorobenzene	108-90-7	10	10	1200	(50)
31. Ethyl Benzene	100-41-4	10	10	1200	(50)
32. Styrene	100-42-5	10	10	1200	(50)

Analyte	CAS Number	Quantitation Limits <sup>a</sup>			
		Water ( $\mu\text{g/L}$ )	Low Soil ( $\mu\text{g/kg}$ )	Med. Soil ( $\mu\text{g/kg}$ )	On Column (ng)
33. Xylenes (Total)	1330-20-7	10	10	1200	(50)
<b>SEMIVOLATILES</b>					
34. Phenol	108-95-2	10	330	10000	(20)
35. bis(2-Chloroethyl) ether	111-44-4	10	330	10000	(20)
36. 2-Chlorophenol	95-57-8	10	330	10000	(20)
37. 1,3-Dichlorobenzene	541-73-1	10	330	10000	(20)
38. 1,4-Dichlorobenzene	106-46-7	10	330	10000	(20)
39. 1,2-Dichlorobenzene	95-50-1	10	330	10000	(20)
40. 2-Methylphenol	95-48-7	10	330	10000	(20)
41. 2,2'-oxybis (1-Chloropropane) <sup>b</sup>	108-60-1	10	330	10000	(20)
42. 4-Methylphenol	106-44-5	10	330	10000	(20)
43. N-Nitroso-di-n-propylamine	621-64-7	10	330	10000	(20)
44. Hexachloroethane	67-72-1	10	330	10000	(20)
45. Nitrobenzene	98-95-3	10	330	10000	(20)
46. Isophorone	78-59-1	10	330	10000	(20)
47. 2-Nitrophenol	88-75-5	10	330	10000	(20)
48. 2,4-Dimethylphenol	105-67-9	10	330	10000	(20)
49. bis(2-Chloroethoxy) methane	111-91-1	10	330	10000	(20)
50. 2,4-Dichlorophenol	120-83-1	10	330	10000	(20)
51. 1,2,4-Trichlorobenzene	120-82-1	10	330	10000	(20)
52. Naphthalene	91-20-3	10	330	10000	(20)
53. 4-Chloroaniline	106-47-8	10	330	10000	(20)
54. Hexachlorobutadiene	87-68-3	10	330	10000	(20)
55. 4-Chloro-3-methylphenol	59-50-7	10	330	10000	(20)
56. 2-Methylnaphthalene	91-57-6	10	330	10000	(20)
57. Hexachlorocyclopentadiene	77-47-4	10	330	10000	(20)
58. 2,4,6-Trichlorophenol	88-06-2	10	330	10000	(20)
59. 2,4,5-Trichlorophenol	95-95-4	25	800	25000	(50)
60. 2-Chloronaphthalene	91-58-7	10	330	10000	(20)
61. 2-Nitroaniline	88-74-4	25	800	25000	(50)
62. Dimethylphthalate	131-11-3	10	330	10000	(20)
63. Acenaphthylene	208-96-8	10	330	10000	(20)

Analyte	CAS Number	Quantitation Limits <sup>a</sup>			
		Water ( $\mu\text{g/L}$ )	Low Soil ( $\mu\text{g/kg}$ )	Med. Soil ( $\mu\text{g/kg}$ )	On Column (ng)
64. 2,6-Dinitrotoluene	606-20-2	10	330	10000	(20)
65. 3-Nitroaniline	99-09-2	25	800	25000	(50)
66. Acenaphthene	83-32-9	10	330	10000	(20)
67. 2,4-Dinitrophenol	51-28-5	25	800	25000	(50)
68. 4-Nitrophenol	100-02-7	25	800	25000	(50)
69. Dibenzofuran	132-64-9	10	330	10000	(20)
70. 2,4-Dinitrotoluene	121-14-2	10	330	10000	(20)
71. Diethylphthalate	84-66-2	10	330	10000	(20)
72. 4-Chlorophenyl-phenyl ether	7005-72-3	10	330	10000	(20)
73. Fluorene	86-73-7	10	330	10000	(20)
74. 4-Nitroaniline	100-01-6	25	800	25000	(50)
75. 4,6-Dinitro-2-methylphenol	534-52-1	25	800	25000	(50)
76. N-nitrosodiphenylamine	86-30-6	10	330	10000	(20)
77. 4-Bromophenyl-phenylether	101-55-3	10	330	10000	(20)
78. Hexachlorobenzene	118-74-1	10	330	10000	(20)
79. Pentachlorophenol	87-86-5	25	800	25000	(50)
80. Phenanthrene	85-01-8	10	330	10000	(20)
81. Anthracene	120-12-7	10	330	10000	(20)
82. Carbazole	86-74-8	10	330	10000	(20)
83. Di-n-butylphthalate	84-74-2	10	330	10000	(20)
84. Fluoranthene	206-44-0	10	330	10000	(20)
85. Pyrene	129-00-0	10	330	10000	(20)
86. Butylbenzylphthalate	85-68-7	10	330	10000	(20)
87. 3,3'-Dichlorobenzidine	91-94-1	10	330	10000	(20)
88. Benzo(a)anthracene	56-55-3	10	330	10000	(20)
89. Chrysene	218-01-9	10	330	10000	(20)
90. bis(2-Ethylhexyl)phthalate	117-81-7	10	330	10000	(20)
91. Di-n-octylphthalate	117-84-0	10	330	10000	(20)
92. Benzo(b)fluoranthene	205-99-2	10	330	10000	(20)
93. Benzo(k)fluoranthene	207-08-9	10	330	10000	(20)
94. Benzo(a)pyrene	50-32-8	10	330	10000	(20)
95. Indeno(1,2,3-cd)pyrene	193-39-5	10	330	10000	(20)
96. Dibenz(a,h)anthracene	53-70-3	10	330	10000	(50)
97. Benzo(g,h,i)perylene	191-24-2	10	330	10000	(50)

Analyte	CAS Number	Quantitation Limits <sup>a</sup>		
		Water ( $\mu\text{g/L}$ )	Low Soil ( $\mu\text{g/kg}$ )	On Column (ng)
<b>PESTICIDES/AROCLORS</b>				
98. alpha-BHC	319-84-6	0.05	1.7	5
99. beta-BHC	319-85-7	0.05	1.7	5
100. delta-BHC	319-86-8	0.05	1.7	5
101. gamma-BHC (Lindane)	58-89-9	0.05	1.7	5
102. Heptachlor	76-44-8	0.05	1.7	5
103. Aldrin	309-00-2	0.05	1.7	5
104. Heptachlor epoxide	1024-57-3	0.05	1.7	5
105. Endosulfan I	959-98-8	0.05	1.7	5
106. Dieldrin	60-57-1	0.10	3.3	10
107. 4,4'-DDE	72-55-9	0.10	3.3	10
108. Endrin	72-20-8	0.10	3.3	10
109. Endosulfan II	33213-65-9	0.10	3.3	10
110. 4,4'-DDD	72-54-8	0.10	3.3	10
111. Endosulfan sulfate	1031-07-8	0.10	3.3	10
112. 4,4'-DDT	50-29-3	0.10	3.3	10
113. Methoxychlor	72-43-5	0.50	17.0	50
114. Endrin ketone	53494-70-5	0.10	3.3	10
115. Endrin aldehyde	7421-36-3	0.10	3.3	10
116. alpha-Chlordane	5103-71-9	0.05	1.7	5
117. gamma-Chlordane	5103-74-2	0.05	1.7	5
118. Toxaphene	8001-35-2	5.0	170.0	500
119. Aroclor-1016	12674-11-2	1.0	33.0	100
120. Aroclor-1221	11104-28-2	2.0	67.0	200
121. Aroclor-1232	11141-16-5	1.0	33.0	100
122. Aroclor-1242	53469-21-9	1.0	33.0	100
123. Aroclor-1248	12672-29-6	1.0	33.0	100
124. Aroclor-1254	11097-69-1	1.0	33.0	100
125. Aroclor-1260	11096-82-5	1.0	33.0	100

<sup>a</sup>Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher. There is no differentiation between the preparation of low and medium soil samples in this method for the analysis of pesticides/aroclors.

<sup>b</sup>Previously known by the name bis(2-Chloroisopropyl)ether.

**Appendix E:**  
**Detailed Field Measurement Results**

**Table E.1. Teletector readings in the north cell as a function of distance**

Penetration into cell (ft)	Exposure rate (mR/h)
10	20,000
9	20,000
8	23,000
7	22,000
6	22,000
5	20,000
4	7600
3	3300
2	2200
1	200
0	11

**Table E.2. HP-290 directional detector results for north cell as a function of distance**

Penetration into cell (ft)	Exposure rate (mR/h)			
	Up	Down	South	North
7.0	2420.5	3742.4	1676.0	3985.7
6.0	3029.2	5796.6	3037.3	4066.9
4.0	1492.8	2418.8	1408.9	2026.6
2.0	406.5	623.1	464.2	432.9

**Table E.3. TLD string results for north cell, shallow dose ( $H_s$ )**

Penetration into cell (ft)	Shallow dose rate, $H_s$ (mrem/h)			
	up	down	south	north
10.0	18886.2	21401.2	18305.4	21371.3
9.0	17143.7	23634.7	18706.6	21197.6
8.0	9958.1	12401.2	8796.4	10167.7
7.0	3425.1	5335.3	4437.1	3736.5
6.0	2604.8	2604.8	2658.7	2802.4
5.0	724.6	712.6	652.7	497.0
4.0	47.9	65.9	29.9	29.9
3.0	29.9	29.9	0.0	6.0
2.0	0.0	18.0	12.0	53.9
1.0	0.0	18.0	0.0	0.0

**Table E.4. TLD string results for north cell, deep dose ( $H_d$ )**

Penetration into cell (ft)	Deep dose rate, $H_d$ (mrem/h)			
	up	down	south	north
10.0	19167.7	21419.2	19820.4	20964.1
9.0	18263.5	23485.0	18113.8	20670.7
8.0	8994.0	8047.9	6407.2	11491.0
7.0	3329.3	3610.8	3652.7	3706.6
6.0	2610.8	2586.8	2485.0	2730.5
5.0	652.7	419.2	431.1	491.0
4.0	24.0	35.9	24.0	24.0
3.0	6.0	18.0	12.0	6.0
2.0	6.0	12.0	12.0	6.0
1.0	12.0	12.0	12.0	6.0

**Table E.5. Teletector readings for south cell as a function of distance**

Penetration into cell (ft)	Exposure rate (mR/h)
9.5	400.0
8.5	400.0
7.5	450.0
6.5	400.0
5.5	350.0
4.5	200.0
3.5	25.0
2.5	4.0

**Table E.6. HP-290 directional detector results for south cell as function of distance**

Penetration into cell (ft)	Exposure rate (mR/h)			
	Up	Down	South	North
9.5	226.9	467.1	288.3	247.0
9.0	226.0	444.5	240.8	290.7
8.0	178.3	289.3	259.5	167.0
7.0	169.2	233.1	326.9	152.2
6.0	248.5	332.0	476.2	216.6
5.0	187.4	279.4	320.2	184.8
4.0	128.8	222.4	205.3	131.4
3.0	63.5	91.6	45.0	73.4
2.0	19.7	38.5	19.8	17.4

**Table E.7. HP-220A directional detector results for south cell as a function of distance**

Penetration into cell (ft)	Exposure rate (mR/h)			
	Up	Down	South	North
7.3			250.3	123.9
6.0	164.5	154.9	381.7	129.3
4.5	131.9	363.1	356.1	82.0

**Table E.8. TLD string results for south cell, shallow dose ( $H_p$ )**

Penetration into cell (ft)	Shallow dose rate, $H_p$ (mrem/h)			
	Up	Down	South	North
9.5	568.0	988.0	800.0	828.0
9.0	764.0	1300.0	1024.0	904.0
8.0	792.0	2136.0	896.0	1220.0
7.0	1404.0	4376.0	3164.0	1404.0
6.0	1208.0	2988.0	6952.0	1408.0
5.0	988.0	2580.0	2660.0	788.0
4.0	488.0	2616.0	1004.0	792.0
3.0	148.0	504.0	124.0	300.0
2.0	44.0	108.0	204.0	36.0
1.0	4.0	4.0	4.0	24.0

**Table E.9. TLD string results for south cell, deep dose ( $H_d$ )**

Penetration into cell (ft)	Deep dose rate, $H_d$ (mrem/h)			
	Up	Down	South	North
9.5	448.0	584.0	576.0	516.0
9.0	516.0	576.0	544.0	540.0
8.0	396.0	412.0	468.0	384.0
7.0	332.0	324.0	404.0	332.0
6.0	464.0	396.0	544.0	412.0
5.0	388.0	396.0	444.0	348.0
4.0	272.0	268.0	312.0	260.0
3.0	104.0	128.0	96.0	104.0
2.0	48.0	36.0	56.0	36.0
1.0	24.0	24.0	20.0	36.0

## DISTRIBUTION

1. H. L. Boston
2. K. L. Brady
3. T. W. Burwinkle
4. S. L. Cross
5. J. H. Hooyman
6. R. L. Jeffers
7. L. L. Kaiser
- 8-12. G. J. Mandry
- 13-15. D. M. Matteo
16. P. E. Moor
- 17-18. P. T. Owen
19. G. A. Person
20. A. W. Saulsbury
21. P. A. Schrandt
- 22-23. I. Smith
24. P. S. Wood
25. ORNL ER Document Management Center
26. Central ER Document Management Center
27. Laboratory Records Department
28. ORNL Patent Section
29. Central Research Library
30. M. R. Jugan, DOE Oak Ridge Operations Office, P.O. Box 2001, Oak Ridge, TN 37831-8541
31. A. P. Kelsey, Bechtel National, Inc., 151 Lafayette Drive, Oak Ridge, TN 37830
32. W. H. Snedaker, Enserch Environmental, 111 Union Valley Road, Oak Ridge, TN 37830
33. Office of Assistant Manager for Energy Research and Development, DOE Oak Ridge Operations Office, P.O. Box 2001, Oak Ridge, TN 37831-8600
- 34-35. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831