

**COLORADO DEPARTMENT OF PUBLIC HEALTH
AND ENVIRONMENT
HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION**

FIVE-YEAR REVIEW

DENVER RADIUM SITE

DENVER, COLORADO



Prepared by:

**Mark Rudolph
CDPHE Denver Radium Site Project Manager**

Approved:

A handwritten signature in black ink, appearing to read 'Carol L. Campbell', is written over a horizontal line.

**Carol L. Campbell
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation**

9/30/08

Date

TABLE OF CONTENTS

List of Acronyms iii
Executive Summary iv
Five-Year Review Summary Form v
Recommendations and Follow-Up Actions vi

1.0 Introduction 1
2.0 Site Chronology 2
3.0 Site Background 3
4.0 Remedial Actions 5
5.0 Progress Since the Last Five-Year Review 14
6.0 Five Year Review Process 16
7.0 Technical Assessment 18
8.0 Issues 20
9.0 Recommendations and Follow-Up Actions 21
10.0 Protectiveness Statements 21
11.0 Next Review 21
12.0 References 22

LIST OF TABLES

Table 1 Site Chronology
Table 2 Operable Unit 2 Properties
Table 3 Operable Unit 3 Properties
Table 4 Operable Units 4 Properties
Table 5 Operable Units 6, 9A and 11 Properties
Table 6 Operable Unit 8 Properties
Table 7 Issues and Recommendations

This Page Intentionally Left Blank

TABLE OF CONTENTS

(Continued)

LIST OF FIGURES

Figure 1	Denver Radium Sites
Figure 2	Denver Radium Site – OU1
Figure 3	Denver Radium Site – OU2
Figure 4	Denver Radium Site – OU2
Figure 5	Denver Radium Site – OU2
Figure 6	Denver Radium Site – OU2
Figure 7	Denver Radium Site – OU2
Figure 8	Denver Radium Site – OU3
Figure 9	Denver Radium Site – OU3
Figure 10	Denver Radium Site – OU4 And OU5
Figure 11	Denver Radium Site – OU6
Figure 12	Denver Radium Site – OU6
Figure 13	Denver Radium Site – OU6
Figure 14	Denver Radium Site – OU6
Figure 15	Denver Radium Site – OU6
Figure 16	Denver Radium Site – OU7
Figure 17	Denver Radium Site – OU7
Figure 18	Denver Radium Site – OU8
Figure 19	Denver Radium Site – OU8
Figure 20	Denver Radium Site – OU9A
Figure 21	Denver Radium Site – OU9B
Figure 22	Denver Radium Site – OU9B
Figure 23	Denver Radium Site – OU10
Figure 24	Denver Radium Site – OU11

APPENDICES

APPENDIX A	Site Photographs
APPENDIX B	Groundwater Monitoring Report – OU8

This Page Intentionally Left Blank

List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirements
CCR	Code of Colorado Regulations
CERCLA	Comprehensive Environmental Response, Compensation Liability Act
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CSR	Central and Sierra Railroad
D&RGW	Denver and Rio Grande Western Railroad
DW	Drinking Water
EMI	Environmental Materials, Inc
EPA	Environmental Protection Agency
ESD	Explanation of Significant Differences
GIS	Geographic Information System
HASP	Health and Safety Plan
HSS	Hospital Shared Services
ICs	Institutional Controls
ICRP	International Commission on Radiological Protection
IHOP	International House of Pancakes
MCL's	Maximum Contaminant Levels
Mrem/year	Milli-rem per year
mSv	Milli-Sievert
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	Superfund National Priorities List
O&M	Operations and Maintenance
OSWER	Office of Solid Waste and Emergency Response
PRP	Potentially Responsible Party
RI/FS	Remedial Investigation/Feasibility Study
ROBCO	Robinson Brick Company
ROD	Record of Decision
ROW	Right of Way
SSC	State Superfund Contract
TBC	To Be Considered
OU	Operable Units

This Page Intentionally Left Blank

Executive Summary

The remedies for the various Operable Units (OUs) of the Denver Radium Superfund Site in Denver, Colorado generally required excavation and off-site disposal of radiologically-contaminated soil, institutional controls for any residual waste, and monitored natural attenuation for those OUs where groundwater is contaminated. One OU, where soil was contaminated with metals, consolidation and capping was the selected remedy. This remedy included institutional controls and groundwater monitoring for natural attenuation. The Site achieved construction completion with the signing of the Final Close Out Report in September, 2006.

The State of Colorado has completed this third Five-Year review of the remedial actions performed at the Denver Radium Site. The assessment of this Five-Year review found that the remedies were constructed as designed. All human health and environmental threats have been addressed and the remedies are expected to be protective as long as institutional controls are effective.

The review was conducted from June through September 2008. This review covers only those properties where waste remains in place and those properties are not available for unrestricted use and unlimited exposure. The results of this third Five-Year review indicate that the remedies at all properties are operating as designed and are protective of human health and the environment.

This Page Intentionally Left Blank

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name (from WasteLAN): Denver Radium Site		
EPA ID (from WasteLAN): COD980716955		
Region: 8	State: CO	City/County: Denver/Denver
SITE STATUS		
NPL Status: <input checked="" type="checkbox"/> Final, <input type="checkbox"/> Deleted, <input type="checkbox"/> Other (specify)		
Remediation Status (choose all that apply): <input type="checkbox"/> Under Construction, <input type="checkbox"/> Operating, <input checked="" type="checkbox"/> Complete		
Multiple OUs? <input checked="" type="checkbox"/> Yes, <input type="checkbox"/> No	Construction Complete date: September 27, 2006	
Has site been put into reuse: Some properties of certain OUs have continued to be used and/or have been redeveloped. Please refer to text description for each OU.		
REVIEW STATUS		
Reviewing Agency: <input type="checkbox"/> EPA, <input checked="" type="checkbox"/> State, <input type="checkbox"/> Tribe, <input type="checkbox"/> Other		
Author Name: Mark Rudolph		
Author Title: Remedial Project Manager	Author Affiliation: CDPHE	
Review period: June 2008 to September 2008		
Date(s) of site inspection: 5/2008 through 6/2008		
Type of Review: <input checked="" type="checkbox"/> Statutory, <input type="checkbox"/> Policy (<input type="checkbox"/> Post-SARA, <input type="checkbox"/> Pre-SARA, <input type="checkbox"/> NPL-Removal Only) <input type="checkbox"/> Non-NPL Remedial Action Site, <input type="checkbox"/> NPL State Tribe Lead		
Review number: <input type="checkbox"/> 1 (first), <input type="checkbox"/> 2 (second), <input checked="" type="checkbox"/> 3 (third), <input type="checkbox"/> Other (specify)		
Triggering action: <input type="checkbox"/> Actual RA Onsite Construction at OU#, <input type="checkbox"/> Actual RA Start at OU#, <input type="checkbox"/> Construction Completion, <input checked="" type="checkbox"/> Previous Five-Year Review, <input type="checkbox"/> Other (specify)		
Triggering action date (from WasteLAN): 09/2003		
Due Date (Five-Years after triggering action date): 9/30/2008		

Recommendations and Follow-up Actions:

Issue	Recommendation and Follow-up Action	Party Responsible	Milestone Date	Affects Protectiveness (Y/N)	
				Current	Future
Tracking of Institutional Controls	CDPHE and the City and County of Denver are developing a tracking system through the city's building permit system for all materials left in place under Supplemental Standards or Area Averaging. This will further strengthen the existing Institutional Controls.	CDPHE and City and County of Denver	1/2010	N	N
Deletion	Construction is complete, institutional controls have been implemented, and performance standards have been met. The Site should be deleted from the NPL.	EPA	6/2009	N	N
OU3 Ground Water	Allow for natural attenuation of site related contaminants.	CDPHE	09/2013	N	N
OU8 Ground Water	Ground water monitoring at OU8 is ongoing. Monitoring frequency should be reduced to an annual basis and allow for natural attenuation of site related contaminants. Monitoring frequency should be changed to twice per year based on low and high water table regimes.	CDPHE	9/2013	N	N
OU9B Ground Water	Ground water monitoring at OU9B is ongoing. Monitoring frequency should be delayed until CDOT has completed the improvements along Interstate 25 adjacent to the site.	CDPHE	09/2013	N	N

Protectiveness Statement:

Because the remedial actions at all OUs are protective, the site is protective of human health and the environment.

This Page Intentionally Left Blank

1.0 INTRODUCTION

The purpose of the five-year review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify issues found during the review, if any, and identify recommendations to address them.

The Agency is preparing this five-year review report pursuant to CERCLA §121 and the National Contingency Plan (NCP). CERCLA §121 states:

If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial no less often than each Five-Years after the initiation of such remedial action to ensure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

The Agency interpreted this requirement further in the NCP; 40 CFR § 300.430(f)(4)(ii) states;

If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above the levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five-years after the initiation of the selected remedial action.

This five-year review examines only those properties where waste remains in place and those properties are not available for unrestricted use and unlimited exposure. The State of Colorado Department of Public Health and Environment (CDPHE) conducted this review. This is the third five-year review completed for the Denver Radium site. In keeping with the requirements of CERCLA §121 (c) and the NCP, the subsequent five-year review triggers from the signature date of the previous five-year review. The first Denver Radium Five-Year Review was completed in 1994. A second five-year review was submitted as draft on November 20, 1998, but was never finalized due to unresolved comments between EPA and the City and County of Denver. The second, finalized, five-year review was completed on September 30, 2003.

The CDPHE Community Involvement Program is committed to promoting communication between citizens and CDPHE. The Community Involvement Plan (CIP) Update completed in 2003 (Appendix A of the 2003 five-year review) describes the community involvement and public participation program developed for the Denver Radium Superfund Site (Denver Radium) in Denver, Colorado. This CIP Update was developed in coordination with the U.S. Environmental Protection Agency (EPA) and updates the previous CIP, dated September 1989.

The results of this third five-year review indicated that because the remedial actions at all OUs are protective, the site is protective of human health and the environment. Another five-year review will be required for those properties where waste is left in place in September 2013.

2.0 SITE CHRONOLOGY

Table1
Chronology of Site Events

GENERAL	
Denver Radium Site Added to National Priorities List (NPL)	September 1983
EPA and the State of Colorado enter into State Superfund Contract (SSC) for remedial action at the Denver Radium site.	May 1988
City and County of Denver ordinance, covering radioactive wastes left in place site-wide, adopted.	August 2004
Colorado State Engineer establishes groundwater notification IC	July 2006
Final Close Out Report	September 2006
Operable Unit 1	
Record of Decision issued	September 1987
Remedial Action Complete and no waste remains in place	July 1991
Operable Unit 2	
Record of Decision issued	September 1987
Explanation of Significant Differences	September 1993
Remedial Action Complete	August 1993
Review of Supplemental Standards Report	May 2005
Atlas Umatilla, LLC – Environmental Covenant	July 2006
Operable Unit 3	
Record of Decision issued	September 1987
Explanation of Significant Differences	December 1993
Remedial Action Complete	September 1991
Review of Supplemental Standards Report	November 2005
OU4/5	
Record of Decision issued	September 1986
Remedial Action Complete and no waste remains in place at OU 5	March 1991
Review of Supplemental Standards	March 1994
Explanation of Significant Differences	December 1994
Home Depot files and records Notice and Covenant	July 1995
Review of Supplemental Standards Report	April 2008
OU 6, OU 9A and OU 11	
Record of Decision issued	September 1987
Explanation of Significant Differences	January 1995
Remedial Action Complete and no waste remains in place	December 1993
Resolution of undocumented Removal Action in OU 6 – Gamma Survey was conducted	January 2004
Letter from City and County of Denver indicating removal of contamination from City streets in OU 6	November 2005

Table1
Chronology of Site Events

Demolition of Environmental Materials structure and removal of all waste for disposal through the City and County of Denver	July 2006
Operable Unit 7	
Record of Decision issued (NO ACTION ROD)	March 1986
Explanation of Significant Differences	September 1992
Notice of remediation from City and County of Denver – Humboldt Street and Lafayette Street segments	March 2005
Notice of remediation from City and County of Denver – Downing Street segment	November 2005
Notice of remediation of all remaining street segments – No wastes remain in place in OU7.	December 2007
Operable Unit 8	
Record of Decision issued	January 1992
Record of Decision Amendment	June 2000
Remedial Action Complete and no waste remains in the soil but the groundwater is contaminated	September 2006
Explanation of Significant Differences	March 2007
Operable Unit 9A (Radiological Portion) See OU 6, 9 & 11)	
Operable Unit 9B ¹	
Record of Decision issued	December 1991
Remedial Action Complete	April 1996
Operable Unit 10	
Record of Decision issued	June 1987
Remedial Action Complete and no waste remains in place	September 1989

3.0 BACKGROUND

This section provides a short summary of the Background for this Site. A more detailed summary can be found in the 2003 Five-year review or the September 2006 Final Close Out Report.

Physical Characteristics

The Denver Radium Site, located in Denver, Colorado, consists of over 65 properties along the South Platte River Valley. Depth to groundwater ranges from about 10 feet to 25 feet. The topography of the site is predominantly flat. The climate of the area is typified by low annual precipitation, averaging about 14 inches per year.

¹ There are two Operable Units that were labeled 9. One is located on E. Colfax Avenue (OU9A) and is discussed as part of the "Open Space" properties (OU 6, 9, 11). The other is located on South Santa Fe Drive (OU9B) and includes the metals contamination discovered at the ROBCO site (OU4 radioactive materials). OU4 and OU9B cover the same property but address different contaminants.

Land and Resource Use

Most of the properties within the Site are either commercial or industrial, although there are a few residential properties and some open space included in the Site, as well. Potable water is provided through a municipal water supply across the Site.

History of Contamination

The Denver Radium Site properties were contaminated by radioactive residues derived from the processing of radium in the early 1900s (Figure 1). In 1913, the National Radium Institute (NRI) was established in Denver as a domestic source of radium, which was in high demand in cancer therapy and research. Subsequently, the radium, vanadium, and uranium industry thrived in Denver until the early 1920s, when rich ore deposits were discovered in Africa.

Initial Response

In 1979, EPA noted a reference to the National Radium Institute in a 1916 United States Bureau of Mines report. Subsequent field research revealed the presence of thirty-one radioactive sites in the Denver metropolitan area. In August, 1981, the Colorado Department of Health, under a Cooperative Agreement with EPA, assumed lead activities and initiated engineering assessments of the majority of the original 31 radioactive sites. In October, 1981, shortly after the Cooperative Agreement was awarded to the State, the Denver Radium Site was placed on the Interim Priorities List. The Site was included on the Final National Priorities List promulgated on September 3, 1983. The radioactive sites were divided into eleven geographically separated OUs to simplify the cleanup process.

Basis for Taking Action

The Site-wide Remedial Investigation, complete in April 1986, focused on radium and uranium processing residues discarded in the early 1900s. These residues contained uranium, radium, and thorium. Of prime interest is radium-226 (Ra-226), its associated radioactivity (gamma radiation and radon-decay products) and its tendency to decay to radon gas, which constitutes the primary health risk associated with residues from processing facilities.

Soil within the Denver Radium properties was considered contaminated when radium-226 concentrations exceeded 5 pCi/g above background in the top 15 cm of soil, or 15 pCi/g above background in any layer below the top 15 cm (i.e., the 40 CFR Part 192 UMTRA standard which was considered the principal ARAR for this Site). The background level used for the Denver Radium Site was 2.0 pCi/g. Additional metals' contamination including radioactive lead-210, thorium-230, and uranium, as well as non-radioactive metals such as lead and arsenic, was also identified in site soil. The majority of the additional contaminants were co-located with the radium-226 contamination.

4.0 REMEDIAL ACTIONS

This section describes only those OUs, or portions of OUs, where waste remains in place and properties are not available for unrestricted use and unlimited exposure. The Denver Radium Final Close Out Report, dated September 25, 2006, identified properties within OUs 2, 3, 4, 8 & 9B as properties that will require Five-Year Reviews into the future.

Remedy Selection

There are five OUs (OUs 2, 3, 4, 8, and 9B) where waste remains in place and properties are not available for unrestricted use and unlimited exposure. The dates for the original Records of Decision (RODs) and any Explanations of Significant Differences (ESDs) or ROD amendments for these OUs where waste remains in place are as follows:

OU 2 ROD September 1987, ESD September 1993
OU 3 ROD September 1987, ESD December 1993
OU 4 ROD September 1986, ESD December 1994
OU 8 ROD January 1992, ROD Amendment June 2000, ESD September 2006
OU 9B ROD December 1991,

Remedial Action Objectives (RAOs) were developed in the Site-Wide Remedial Investigation to address the radium and uranium processing residues scattered throughout the Site. Thus the RAOs for the OU 2, 3, 4, and 8 remedies were to prevent: radiation exposure due to inhalation of radon gas and its daughter products; radiation exposure due to inhalation and ingestion of long-lived radionuclides; and direct exposure to gamma radiation. The ESDs and ROD Amendment did not change these RAOs.

OU 9B was established after a substantial volume of metal contaminated soil, not commingled with radioactive residues, was discovered during remedial action at OU 4. The RAOs for the remedy for OU9B, set forth in the ROD for OU 9B, were to prevent direct contact with or ingestion of metals contaminated soil that exceeded health-based action levels and to prevent use of metals-contaminated groundwater.

Operable Units 2, 3, and 4

EPA selected excavation and offsite disposal as the remedy for OUs 2, 3, and 4. At the time the RODs were signed, there were no disposal facilities in the nation that accepted radium waste. For this reason, the RODs included temporary onsite storage of the contaminated material. However, temporary onsite storage was not required since a permanent disposal facility opened before excavation began. The excavated material was shipped by rail to Envirocare of Utah, Inc., a disposal facility in Tooele County, Utah.

The remedies implemented at OUs 2, 3, and 4 differed from the remedies chosen in the respective RODs partially due to the difficulties of estimating the actual volume of material to be excavated and the inability to, or the prohibitive cost to, excavate around and under buildings, buried utilities, and in groundwater. These changes were documented in ESDs prepared and signed at each OU. The primary differences for each OU are described below.

The primary changes documented in the OU 2 ESD are:

- A greater volume of radium-contaminated soil was excavated and removed;
- Small amounts of radium contamination were left on the 1100 Umatilla Street and Burlington Northern Railroad properties pursuant to Supplemental Standards under 40 CFR §192.21(c), thus ICs are required;
- There was no temporary onsite storage; and
- Soil containing commingled radium and lead was solidified in a cement matrix prior to shipment to a permanent, offsite disposal facility.

The primary changes documented in the OU 3 ESD are:

- No temporary storage prior to removal and shipment of contaminated material to the permanent offsite disposal facility;
- Over 52,000 cubic yards of contaminated soil were excavated and the area of contamination extended east of South Jason Street;
- As part of the remediation, the Creative Illumination building was demolished, contaminated material was removed, and the contaminated materials were shipped to the offsite repository; and,
- Contaminated soil was left in place under South Jason Street, around the Packaging Corporation of America building, and along South Platte River Drive pursuant to Supplemental Standards under 40 CFR §192.21(c), thus ICs are required.

The primary changes documented in the OU 4 ESD are:

- The volume of contaminated soil increased; and
- Relatively small volumes of contaminated soil were left in place on the ROBCO property pursuant to Supplemental Standards under 40 CFR §192.21(c), thus, ICs are required.

Operable Unit 8

The original OU 8 ROD, signed in January 1992 selected on-site stabilization and solidification with ICs as the remedy for soil and natural attenuation with monitoring and ICs for groundwater.

EPA conducted a five-year review of the Shattuck Site in 1999 and found site-specific deficiencies in the solidified material cover design, the structural and chemical integrity, and the compliance program. Based on these findings, EPA modified the OU 8 remedy in a June 16, 2000 ROD Amendment that selected excavation and off-site disposal of the soil that had been solidified. The Amended ROD did not fundamentally alter the groundwater remedy. An ESD for the ROD Amendment was signed in September 2006 primarily to document that the costs of the amended remedy were substantially higher than estimated in the ROD Amendment and the volume of waste also were increased.

Operable Unit 9B

The major components of the remedy included: consolidating and capping the metals-contaminated soil; conducting environmental monitoring necessary to ensure effectiveness of the remedial action; and, implementing institutional controls to limit use of the site and maintain the integrity of the cap.

Remedy Implementation

Operable Unit 2

Denver Radium OU2 includes the following properties, where waste remains in place, located near 11th Avenue and Umatilla Street in Denver, Colorado:

Table 2
 Operable Unit 2 Properties

Operable Unit	Property Name at Time of ROD	Address
OU2	DuWald Steel	1100 Umatilla Street
OU2	Burlington Northern Railroad	Between 10 th and 11 th Avenues

Remedial actions at OU2 began in August 1990 and were completed in August 1993. A phased approach to the cleanup allowed onsite businesses to maintain operations throughout the excavation and shipment of 92,731 tons of contaminated soil from OU2. Activities included:

- Excavation of radium contaminated soil in open areas;
- Analysis of the contaminated materials for disposal to ensure compliance with transportation and disposal regulations;
- Shipment of contaminated materials to the permanent offsite disposal facility; and
- Confirmation sampling of excavated area.

The remedy, as implemented, differed in several respects from the remedy chosen in the 1987 ROD. EPA issued an ESD for OU2 in September 1993 to document those implementation differences.

A Supplemental Standards Report was prepared in May 1994 to document that 11,060 cubic yards of radiological contaminated soil were left in place on the Burlington Northern Railroad property and the 1100 Umatilla Street property at OU2. The location of this contamination is shown on Figures 4 and 5.

Pursuant to the terms of an administrative settlement agreement, the current owner of the former DuWald property, Atlas Umatilla, LLC, has prepared and is implementing an O&M Plan and signed and executed an environmental covenant on June 25, 2006. The environmental covenant restricts disturbance of the concrete cap and subsurface soil and prohibits use of groundwater for the 1100 Umatilla Street property. In addition, ICs are

provided at both properties that have wastes left in place by a City and County of Denver Municipal ordinance (Denver Ordinance) that has created special zoning for these properties and prohibits disposal of these materials in Denver without payment of a fee.

Operable Unit 3

OU3 is in the area of West Louisiana Avenue, South Jason Street and South Platte River Drive (Figures 8 and 9). The following properties include residual waste:

Table 3
 Operable Unit 3 Properties

OU3	Packaging Corp of America	1377 South Jason Street
OU3	Central and Sierra Railroad ROW	Between West Louisiana and West Florida Streets
OU3	Kwan Sang Noodle Company, formerly Titan Labels	1140 W Louisiana Ave

Remedial actions at OU3 began in August 1989 and were completed in September 1991. A phased approach to the cleanup allowed onsite businesses to maintain operations throughout the excavation and shipment of 63,672 tons of contaminated material from OU3. Activities included:

- Excavation of radium contaminated soil in open areas;
- Demolition of certain radium-contaminated buildings;
- Analysis of the contaminated materials to be disposed to ensure compliance with transportation and disposal regulations;
- Shipment of contaminated materials to the permanent offsite disposal facility; and
- Confirmation sampling of excavated area.

The remedy, as implemented, differed in several respects from the remedy chosen in the 1987 ROD. An ESD documenting these differences was issued in December 1993.

A Supplemental Standards Report was prepared in June 1995 to document the 5,868 cubic yards of radiological contaminated soil that remain onsite under South Jason Street, around the Packaging Corporation of America building, and along South Platte River Drive at OU3. The location of this contamination is shown on Figures 8 and 9.

ICs are provided at the properties in OU 3 where wastes have been left in place by the Denver Ordinance. An informational IC was established for ground water in the vicinity of OU3 by the Colorado State Engineer. If any person seeks to drill a well into groundwater in this area, the State Engineer notifies that person that the groundwater is contaminated. They are also notified that they should contact EPA and CDPHE and that the State Engineer will send a copy of the well permit to EPA and CDPHE.

Previous sampling conducted in 2001 in the area of OU3 identified a monitoring well at Hospital Shared Services (HSS) with elevated levels of gross alpha and gross beta contamination. In July 2003, five new ground water monitoring wells surrounding the OU3 site were installed and developed. These wells, along with the one existing well located at the Hospital Shared Services property, were then sampled by CDPHE in July, 2003. Analytical results revealed significantly lower concentrations of contaminants in the HSS well as compared to the December 2001 results. Analysis of samples collected in July 2003, February 2004 and June 2006 show that the two monitoring wells that exhibited radionuclide contamination (OU3-GW4 and OU3-GW5) are located directly in wastes left behind under Supplemental Standards (OU3-GW5) or directly down gradient of those wastes (OU3-GW4). The seasonal change in ground water flow is likely the cause of the change in well OU3-GW4 from being above the Drinking Water Standards in July 2003, to being below the Drinking Water Standards in February 2004. In summer months, when the South Platte River is high, the local aquifer is gaining water from the river itself and the water flow gradient may tend to be towards the north. In the winter months, flow gradient may be towards the river as the South Platte River is likely gaining from ground water during those months. The water contours firmly indicate that the groundwater flows from the west off the Terrace Aquifer; when it hits the floodplain aquifer, ground water turns to a northeasterly direction, following the gradient of the South Platte River. The City and County of Denver removed all wastes left in place under Supplemental Standards in 2007 from OU3, Jason Street. While sampling of ground water has not been conducted post removal of these Supplemental Standards Wastes, all wastes have been removed and natural attenuation of residual ground water contamination is expected.

Operable Unit 4/5

OU 4 is located at 500 South Santa Fe Drive in south-central Denver, Colorado (Figure 10) and includes the Robinson Brick Company property (ROBCO - OU4). This OU addresses radiologic contamination found on the ROBCO property. Metals contamination on the ROBCO property is addressed under Operable Unit 9B (ROBCO-Metals) of the Denver Radium Site.

Remedial actions at OU 4/5 included the following:

- Excavation of radium-contaminated soil;
- Demolition of certain radium-contaminated buildings;
- Analysis of the contaminated materials to ensure compliance with transportation and disposal regulations;
- Shipment of contaminated materials to the permanent offsite facility; and
- Confirmation sampling of excavated area.

The remedy, as implemented, differed in two respects from the remedy chosen in the 1986 ROD. EPA issued an ESD in December, 1994 describing those differences.

A Supplemental Standards Report, prepared in March 1994, documented radiological contamination that remains onsite at OU4. The location of this contamination is shown in Figure 10.

Pursuant to the terms of the Agreement and Covenant Not to Sue (July, 1995; also called the Prospective Purchaser Agreement (Home Depot PPA), Home Depot USA (Home Depot) placed a Notice and Covenant on this property. The Notice and Covenant restricts future use of the areas where radiological contamination was left in place under supplemental standards. In addition, the Denver Ordinance provides ICs generally at properties where radium-contaminated soil remains in place under supplemental standards.

In addition, an informational IC was established for ground water in the vicinity of OU4 by the Colorado State Engineer. If any person seeks to drill a well into groundwater in this area, the State Engineer notifies that person that the groundwater is contaminated. They are also notified that they should contact EPA and CDPHE and that the State Engineer will send a copy of the well permit to EPA and CDPHE.

Operable Unit 8

OU8 of the Denver Radium site is located in south-central Denver, Colorado and consists of the Shattuck Chemical Company, Inc. (Shattuck) property located at 1805 South Bannock Street, the adjacent railroad ROW property, a portion of South Bannock Street, and a few properties (vicinity Properties) east of Shattuck where radium contaminated soil were found (Figures 18 and 19).

The Remedial Action at OU8 was substantially completed in September 1998. Remedial actions at OU8 included the following:

- Demolition of radium-contaminated buildings;
- Excavation of radium-contaminated soil from vicinity properties, Bannock Street, the storm sewer located east of Santa Fe Drive, and the Shattuck Chemical property;
- Onsite stabilization/solidification of the radium-contaminated soil into a disposal cell;
- Capping of the stabilized material;
- Installation of monitoring wells to evaluate the effectiveness of the remedy; and
- ICs were established through a Declaration of Covenants and Restrictions filed and recorded by Shattuck that restricted use of the surface and groundwater at the Shattuck property.

Approximately 65,000 loose cubic yards of radiologically contaminated soil, excavated from Shattuck Chemical and the vicinity properties, were stabilized/solidified onsite in a disposal cell. Capping of the stabilized material was completed in June 1998. The Draft Construction Completion Report was submitted on September 29, 1998.

During the excavation of radiologically contaminated soil, oil-impacted soil was also found onsite. The materials were below the action levels established in the ROD. Approximately 2,000 cubic yards of oil-impacted soil were excavated from the Shattuck Chemical Property located at 1805 South Bannock Street during Phase 2 activities. This material was covered and transported by truck to Conservation Services Inc. in Thornton, Colorado.

Bioremediation was used for oil-impacted soil that extended beneath the completed portion of the monolith. A plan addressing the remaining oil-contaminated soil at OU8 was submitted in August 1998. The bio-venting system was approved by EPA and was installed in September 1998.

In 1997, the storm sewer along Santa Fe Boulevard west of the site was remediated. During the remediation, an In-Situ Form Liner was installed into the original pipe to isolate storm water discharges to the South Platte River from the influx of contaminated ground water. This liner system, while in place, has not remedied the problem to date. In 1998, the sewer remediation was investigated by EPA and the City of Denver and determined to be incomplete. At this time, EPA, CDPHE and City and County of Denver personnel are reviewing the remedy in preparation to propose further remediation in the sewer line west of OU8. Ground water characterization has been ongoing for characterization and plume evaluation.

A Management Plan for OU8 Bannock Street was developed and adopted in March 1999 by the City and County of Denver to govern all maintenance, repair, or other construction activities at OU8 Bannock Street.

EPA conducted a five-year review of the Shattuck Site in 1999 and found site-specific deficiencies in the solidified material cover design, the structural and chemical integrity, and the compliance program. Based on these findings, EPA could not be assured of the long-term protection of the original remedy. On June 16, 2000, EPA selected off-site removal in a ROD Amendment because it best met Superfund's nine evaluation criteria. Additionally, the Amended ROD stated that ground water monitoring will continue to address the deficiencies identified in the 1999 Five-Year Review.

The Amended ROD stipulated that the monolith be removed from the site along with any additionally identified contaminants in excess of cleanup levels specified in the Amended ROD. Implementation of the remedy began in September 2002 and was completed in September, 2006. Remedial actions included:

- Cover Material Removal;
- Monolith Demolition and Removal;
- Underlying Soil Investigation and Removal;
- Verification Surveys;
- Bannock Street Remediation;
- Perimeter Soil Excavation;
- Molybdenum Pond Soil Remediation;
- Site Restoration;
- Amendment of the Declaration of Covenants and Restrictions to remove the restrictions on use of the surface of the property; and
- An informational IC was established for ground water in the vicinity of OU8 by the Colorado State Engineer. If any person seeks to drill a well into groundwater in this area, the State Engineer notifies that person that the groundwater in this area is contaminated. They are also notified that they should contact EPA and CDPHE and that the State Engineer will send a copy of the well permit to EPA and CDPHE.

Operable Unit 9B

OU9B, also known as ROBCO metals, is located in south-central Denver near the intersection of Interstate 25 and East Alameda Avenue, at 500 South Santa Fe Drive (Figures 21 and 22). Radiological contamination at this property was addressed as OU 4. OU9B focuses on metals-contaminated soil.

In September 1988, during the course of the radium cleanup, metals contamination was discovered on the ROBCO property. An investigation to characterize the nature and extent of metals contamination was conducted in 1989 and 1990. Approximately 16,500 cubic yards of soil containing elevated levels of arsenic, cadmium, chromium, copper, lead, selenium and zinc were identified.

EPA and the State of Colorado entered into a State Superfund Contract (SSC) for remedial implementation for this portion of the Denver Radium Site on July 24, 1992. Excavations resulting from the radiological cleanup were backfilled, metals-contaminated soil was consolidated and capped, and institutional controls were implemented.

In accordance with the terms of the Home Depot PPA, Home Depot, EPA, and CDPHE implemented the OU9B remedy in a defined "shared" and "phased" manner. Home Depot submitted a Draft O&M Plan on May 30, 1997. CDPHE and EPA approved the O&M Plan on March 17, 1998. Based on the O&M Plan, EPA and CDPHE will perform biannual, offsite ground water monitoring and Home Depot will perform biannual inspections of store facilities and site utilities. In addition, Home Depot placed a Notice and Covenant on this property. The Notice and Covenant restricts future use of the areas where radiological contamination was left in place under supplemental standards and restricts use of the consolidated and capped metals-contaminated soil. In addition, the Denver Ordinance provides ICs generally in OU 9B where radium-contaminated soil remains in place under supplemental standards.

The first ground water monitoring event occurred in April 1998. Since then, four ground water monitoring events have occurred. The most recent ground water monitoring occurred in July 2003. The results indicate that ground water contamination has decreased over time and is migrating and decreasing over time in a northwest direction. The South Platte River is not impacted. An informational IC was established for ground water in the vicinity of OU9B by the Colorado State Engineer. If any person seeks to drill a well into groundwater in this area, the State Engineer notifies that person that the groundwater in this area is contaminated. They will also be notified that they should contact EPA and CDPHE and that the State Engineer will send a copy of the well permit to EPA and CDPHE.

The Prospective Purchaser Agreement (PPA) requires that any breaches of the soil cap system over the consolidated metals-contaminated soil will be reported to EPA and CDPHE with the requirement that new construction, remodeling and site repair generally will not be conducted in this area.

Site Close Out

EPA and the State have determined that all RA construction activities, including the implementation of institutional controls, were performed according to specifications. A Final Close Out Report was signed on September 27, 2006.

Operation and Maintenance

Operable Unit 2

O&M at OU2 is the responsibility of the State of Colorado and is required at the following properties: 1100 Umatilla Street; and along the Burlington Northern Railroad right-of-way immediately east of 1100 Umatilla Street. Atlas Umatilla, LLC agreed to perform O&M for the 1100 Umatilla Street property under the terms of an administrative settlement agreement. The primary activities associated with O&M at the 1100 Umatilla property are to monitor ICs and inspect and maintain a radon venting system in the Office/scale house building on the property.

The primary activities associated with O&M on the Burlington Northern property is to monitor compliance with the IC.

Operable Unit 3

O&M at OU3 is the responsibility of the State of Colorado and is required around the Packaging Corporation of America building at 1377 South Jason Street, the Central and Sierra Railroad ROW between West Louisiana and West Florida Streets, and the Kwan Sang Noodle Company, formerly Titan Labels at 1140 W Louisiana Ave. The primary activity associated with O&M at these properties is to monitor compliance with the IC.

Operable Unit 4

O&M at OU4 is the responsibility of the State of Colorado and is required at 500 South Santa Fe Drive (ROBCO).

Pursuant to the Home Depot PPA, Home Depot has agreed to perform a portion of the O&M under an amended O&M Plan dated August 18, 2003. The primary activities associated with O&M on the Home Depot property is to inspect and maintain the Post Consolidation area of contamination and monitor compliance with all ICs.

In addition, CDPHE monitors groundwater in the vicinity of OU 4 as part of the O&M for OU 9B, and monitors compliance with all ICs.

Operable Unit 8

Remedial actions performed at OU8 were successful in removing all contaminated materials from the soil at the site. As a result, no operation and maintenance activities are necessary to monitor the effectiveness of the soil remedy. O&M for the groundwater at OU 8 is the

responsibility of the State of Colorado. CDPHE is conducting monitoring of the groundwater associated with OU8 as part of the natural attenuation remedy. In comments received during the public involvement portion of this Five-Year Review, there has been concern expressed about the possible impact of remaining mill tailings deposits under the railroad tracks and Bannock Street. These remaining deposits do not appear to be impacting groundwater quality, or serving as a continuing source. A continuing source of uranium should be impacting the two wells closest to the Site, MW-1 and PZ-2. As shown in Figure 4 in Appendix B, these wells now have uranium concentrations below the standard.

Operable Unit 9B

O&M at OU9B is the responsibility of the State of Colorado. Home Depot agreed in the Home Depot PPA to provide O&M at OU9B. Home Depot has an amended O&M Plan as of August 18, 2003.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The last five-year review for the Denver Radium Superfund site was completed in September 2003. That review raised some issues that could affect current or future protectiveness. These issues are summarized below.

Issues from Previous Five-Year Review

Table 4

Issue #	Issue	Resolution
1	Lack of Institutional Controls at Various Properties	<p>Institutional Controls (ICs) have been established wherever waste is left in place to ensure that the selected remedies remain protective into the future. All residual radioactive waste across the Site is addressed by a Denver Municipal Ordinance, established in 2004, which prohibits the permanent disposal and control of radioactive waste and radium contaminated material on property within the City. The ordinance also impose a radioactive waste disposal fee if, not withstanding the prohibition, a person disposes or controls radioactive waste or radium contaminated material on property within the City.</p> <p>In addition to the City Ordinance, restrictive environmental covenants are in place for specific properties at OUs 2, 4, 8, and 9B. An informational IC established by the State Engineer's Office in 2006 provides notice to well permit applicants regarding contaminated groundwater for OUs 3, 8, and 9B.</p> <p>To enhance the effectiveness of ICs, CDPHE and the City and County of Denver are developing a tracking system through the City's building permit system for all materials left in place under Supplemental Standards or Area Averaging. When this is completed, Denver will be able to notify CDPHE upon a potential breach to these materials, thus enforcing Denver's Ordinance governing the disposal of radioactive waste or radium contaminated material on property within the City</p>

Table 4

Issue #	Issue	Resolution
2	GIS Database System for IC Overlay	GIS mapping for the Denver Radium Site was completed in 2005 by HDR Engineering of Denver, Colorado under contract to EPA. The information is shared annually with CDPHE and the City and County of Denver.
3	Assessment and Supplemental Standards	The 2003 Five-Year Review identified a deficiency that the original Risk Assessments for all the Denver Radium OUs, where supplemental standards were applied, did not meet the current ARAR requirements of CRR 1007 Parts 4.61.3.2 and 4.61.3.3 – Standards for Protection Against Radiation. Reassessments of the risk based on the current ARAR standard have been completed for OUs 2, 3, and 4 by CDPHE utilizing current radiation protection standards. The reassessment for OU2 was completed May, 2005, the reassessment for OU 3 was completed in November 2005, and the reassessment for OU 4 was completed in April, 2008. (Reassessments were not completed for OUs 6 or 7 since all waste were subsequently removed.) The existing source data was reused and all original assumptions made of protectiveness were confirmed, with the remedy being protective of public health and environment.
4	OU3 Groundwater Analytical Report	The sampling was completed in February 2004 and a final report was submitted in May, 2004.
5	OU8 Ground Water Investigation	There are elevated levels of contaminants in groundwater including uranium, arsenic, cadmium, selenium, molybdenum, and gross alpha and gross beta radioactivity. An informational IC established by the State Engineer's Office in 2006 provides notice to any well permit applicant regarding contaminated groundwater for OU 8. In addition, ICs were established through a Declaration of Covenants and Restrictions filed and recorded by Shattuck that restricted use of the groundwater at the Shattuck property. Groundwater monitoring by the Colorado Department of Public Health and Environment continues on a quarterly basis.
6	Ground Water Analytical Report	Ground water monitoring at OU8 has been ongoing quarterly since the completion of the final remedy. A Ground Water Monitoring Report has been completed for OU8 and is included in Appendix B of this Five-Year Review. Future monitoring is recommended to occur twice a year based on high and low water table regimes.
7	OU9B Ground Water Monitoring Frequency	The frequency of groundwater monitoring was revised in the November, 2003 Groundwater Monitoring Report to bi-annual. Monitoring previously was annual and was changed to bi-annual. Future monitoring is recommended to be delayed until CDOT has completed the improvements along Interstate 25 adjacent to the site.
8	Undocumented Removal Action at OU6	A document search and interviews were completed to investigate the Removal Action in December, 2003. A gamma survey was conducted in January of 2004. No IC's were required as based on the gamma survey of the site; the removal appeared to have removed all waste at this location.

In addition to resolving the eight issues identified in the 2003 Five-year review, other significant progress has been made on the Denver Radium site as summarized below:

- All residual contamination has been removed from: 2301 15th Street and from beneath the Environmental Materials Building (OU6); and, all of the street segments (OU7)
- A Final Close Out Report for the Site was issued on September 25, 2006.

6.0 FIVE-YEAR REVIEW PROCESS

Administrative Components

This is the third five-year review for the Site. The Denver Radium five-year review team was led by Mark Rudolph, State Project Manager for the Site. The following Team Members participated in the review:

- Mark Rudolph, CDPHE Project Manager
- Rebecca Thomas, EPA Remedial Project Manager
- CDPHE Community Involvement Coordinator
- EPA Community Involvement Coordinator

This five-year review consisted of the following activities: a review of relevant documents; risk assessment review; data review; and a Site visit. The schedule for the review extended through September 2008.

Community Involvement

A notice that the third Five-Year Review was underway was placed in Denver newspapers in September, 2008. The public review process included contact with each property owner and with each affected neighborhood organization. Mailings were sent to interested stakeholders with a description of the Denver Radium Site and ongoing actions. Comment cards were included in this mailing that could be returned with comments regarding the Five-year review. A total of 2 comment cards were returned, one email was received, and 5 telephone calls were received. Only one of the comments expressed concern over the protectiveness of the selected remedies. At Shattuck (OU8), a suggestion was made that residual tailing beneath the railroad could serve as a continuing source of contamination and could impact groundwater quality. As determined in the September 10, 2008 Technical Review of Shattuck Groundwater Data, the residual contamination does not appear to be impacting water quality; the two wells closest to the site have uranium concentrations below the standard.

Document Review

This five-year review consisted of a review of relevant documents including decision documents (and any modifications); remedial action objectives and performance standards, applicable or relevant and appropriate requirements (ARARs), monitoring data generated since the last five-year review, supplemental standards reports, and institutional control instruments. No new or changed ARARs were identified that would impact the remedy.

Data Review

Groundwater monitoring data was reviewed for Operable Units 3, 8, and 9B.

For OU3, monitoring conducted in 2003, 2004, and again in 2006 indicates pronounced attenuation of contaminants in the affected aquifer. While one well was above Drinking Water Standards in 2003, that same well was below Drinking Water Standards in 2004.

Additional source material which, had been left in place under Supplemental Standards, and may have contributed to elevated concentrations of contaminants in groundwater, was completely removed in 2007. While sampling of groundwater has not been conducted post removal, all waste has been removed and natural attenuation is expected to continue.

For OU8, groundwater monitoring has been conducted on a quarterly basis for two years since the remaining wastes at the Shattuck Site were excavated and disposed off site. No specific trends have been identified during the previous eight rounds of sampling. Attenuation is forecast to occur slowly; it may take up to 50 years to flush contaminants. It is recommended that monitoring be reduced to an annual basis until the time of the next Five-Year Review when monitoring frequency will be reassessed.

For OU9B, groundwater has been sampled biannually since the 2003 Five-Year Review. A 2006 CDPHE groundwater report shows continued attenuation of metals concentrations in groundwater and no impact to the South Platte River. Based on groundwater trends for OU9B, it is recommended that groundwater monitoring frequency be reduced to biennial until the time of the next Five-Year Review when monitoring frequency may be reassessed.

In addition to a review of analytical data for groundwater, each institutional control instrument was reviewed and evaluated for effectiveness. To date, there have been no breaches of the existing institutional controls.

Site Inspection

CDPHE conducted a site inspection of all OUs, or portions of OUs, where waste has been left in place on July 2, 2008. All properties within OUs 2, 3, 4, and 9B remain under commercial or industrial use.

The property at OU2 continues to be used as a metal recycling facility. Additional utilities and another structure have been added to the property with no negative impact on the protectiveness of the remedy. Institutional controls have been implemented on the property and have preserved the integrity of the remedy.

For OU3, contamination that was left in place beneath Jason Street, pursuant to supplemental standards, has been removed. Residual waste, requiring institutional controls is now limited to three properties within OU3. Institutional controls have been implemented and have preserved the integrity of the remedy. An informational institutional control on the use of groundwater has been implemented by the State Engineer.

All properties at OU4 and OU9B remain under commercial or industrial use. In addition to the Home Depot and adjacent parking lot, two commercial spaces were constructed on the site immediately to the north of Home Depot. These buildings are slab on grade, are not located over any materials where supplemental standards were applied, and did not impact any of the remedial action conducted at this site. An automotive repair facility (Star Tech Mercedes) and an unoccupied building share a sewer line that was placed through the northern end of the contingency zone for ROBCO Metals wastes prior to the 2003 Five-year review. The sewer line was installed properly under the Home Depot O&M Plan.

Currently, the former RTD Maintenance Facility, located immediately to the west of OU9B, is listed as for sale. CDOT is currently planning a highway improvement project in the vicinity of OU9B. This highway improvement project will likely require relocation of all the remaining ground water monitoring wells. Institutional controls have been implemented and have preserved the integrity of the remedy. An informational institutional control on the use of groundwater has been implemented by the Colorado State Engineer's Office.

OU 8 is currently vacant with no structures present on site. Following construction completion, the property was sold for redevelopment. Institutional controls are not required for soil on this property. An informational institutional control on the use of groundwater has been implemented by the State Engineer.

7.0 TECHNICAL ASSESSMENT

OU2

Question A: Is the remedy functioning as intended by the decision documents?

Yes. The review of documents, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is functioning as intended by the ROD, as modified by the ESD. The RAOs have been met by excavating and disposing off-site radiologically-contaminated soil. Any residual waste is governed by institutional controls to prevent contact with soil exceeding action levels.

Question B: Are the Assumptions made at the time of the remedy selection still valid?

Yes. There have been no changes in the physical conditions at the Site that would affect the protectiveness of the remedy.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No. There is no new information that calls into question the protectiveness of the remedy.

OU3

Question A: Is the remedy functioning as intended by the decision documents?

Yes. The review of documents, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is functioning as intended by the ROD, as modified by the ESD. The RAOs have been met by excavating and disposing off-site radiologically-contaminated soil. Any residual waste is governed by institutional controls to prevent contact with soil exceeding action levels. An institutional control on the use of groundwater has been implemented by the State Engineer.

Question B: Are the Assumptions made at the time of the remedy selection still valid?

Yes. There have been no changes in the physical conditions at the Site that would affect the protectiveness of the remedy.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

No. There is no new information that calls into question the protectiveness of the remedy.

OU4

Question A: *Is the remedy functioning as intended by the decision documents?*

Yes. The review of documents, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is functioning as intended by the ROD, as modified by the ESD. The RAOs have been met by excavating and disposing off-site radiologically-contaminated soil. Any residual waste is governed by institutional controls to prevent contact with soil exceeding action levels.

Question B: *Are the Assumptions made at the time of the remedy selection still valid?*

Yes. There have been no changes in the physical conditions at the Site that would affect the protectiveness of the remedy.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

No. There is no new information that calls into question the protectiveness of the remedy.

OU8

Question A: *Is the remedy functioning as intended by the decision documents?*

Yes. The review of documents, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is functioning as intended by the ROD, as amended. The RAOs have been met by excavating and disposing off-site radiologically-contaminated soil. There is no residual waste in soil. Restrictions on the use of groundwater have been implemented through the State Engineer.

Question B: *Are the Assumptions made at the time of the remedy selection still valid?*

Yes. Ground water at OU8 has been identified as contaminated with site related contaminants. While attenuation has not been observed to date, all waste sources have been removed and disposed off site. Ground water IC's have been put in place limiting beneficial uses of ground water at and around the contaminated ground water plume. Attenuation is expected to occur slowly and monitoring will continue.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

No. There is no new information that calls into question the protectiveness of the remedy.

OU9B

Question A: *Is the remedy functioning as intended by the decision documents?*

Yes. The review of documents, ARARs, risk assumptions, and the results of the site inspection indicates that the remedy is functioning as intended by the ROD, as modified by the ESD. The RAOs have been met by consolidating and capping metals-contaminated soil. Any residual waste is governed by institutional controls to prevent inhalation or ingestion of soil exceeding action levels. Restrictions on the use of groundwater have been implemented through the PPA with Home Depot.

Question B: *Are the Assumptions made at the time of the remedy selection still valid?*

Yes. There have been no changes in the physical conditions at the Site that would affect the protectiveness of the remedy.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

No. There is no new information that calls into question the protectiveness of the remedy.

Technical Assessment Summary

According to the data reviewed, the site inspection, and the evaluation of the effectiveness of institutional controls, the remedy selected for each OU is functioning as intended by the decision documents. There have been no changes in physical conditions at the various impacted properties that would affect the protectiveness of the selected remedies. ARARs for soil and groundwater contamination have been met. There have been no changes in toxicity factors for the contaminants of concern since the last five-year review, and there have been no changes to the standardized risk assessment methodology that could affect the protectiveness of the remedies. There is no other information that calls into question the protectiveness of the remedies.

8.0 ISSUES

A few issues were identified as this Five-Year review was conducted. None of the issues affect current or future protectiveness.

Site-wide

To enhance ICs, complete development and implementation of IC tracking system.
Proceed to delete the Denver Radium Site from the National Priorities List.

Operable Unit 3

Allow potential groundwater contamination to attenuate.

Operable Unit 8

Modify groundwater monitoring frequency.

Operable Unit 9B

Modify groundwater monitoring frequency.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Table 5
Recommendations and Follow-Up Actions

Issue	Recommendation and Follow-up Action	Party Responsible	Milestone Date	Affects Protectiveness (Y/N)	
				Current	Future
Tracking of Institutional Controls	CDPHE and the City and County of Denver are developing a tracking system through the city's building permit system for all materials left in place under Supplemental Standards or Area Averaging. This will further strengthen the existing Institutional Controls.	CDPHE and City and County of Denver	1/2010	N	N
Deletion	Construction is complete, institutional controls have been implemented and performance standards have been met. The Site should be deleted from the NPL.	EPA	06/2009	N	N
OU3 Ground Water	Allow for natural attenuation of site related contaminants.	CDPHE	09/2013	N	N
OU8 Ground Water	Ground water monitoring at OU8 is ongoing. Monitoring frequency should be reduced to an annual basis and allow for natural attenuation of site related contaminants. Monitoring frequency should be changed to twice per year based on low and high water table regimes.	CDPHE	9/2013	N	N
OU9B Ground Water	Ground water monitoring at OU9B is ongoing. Monitoring frequency should be delayed until CDOT has completed the improvements along Interstate 25 adjacent to the site.	CDPHE	09/2013	N	N

10.0 PROTECTIVENESS STATEMENTS

Because the remedial actions at all OUs are protective, the site is protective of human health and the environment.

11.0 NEXT REVIEW

The next five-year review for the Denver Radium Superfund Site is required by September 2013, Five-Years from the date of this review.

12.0 REFERENCES

General

Colorado Department of Public Health and Environment, 2003. Five-Year Review for Denver Radium Superfund Site. September 30, 2003.

U.S. Environmental Protection Agency. 1991. OSWER Directive 9355.7-02, Structure and Components of Five-Year Reviews.

U. S. Environmental Protection Agency. 1994a. OSWER Directive 93 5 5.7-02A, Supplemental Five-Year Review Guidance.

U. S. Environmental Protection Agency. October 4, 1995. Denver Radium Superfund Site Five-Year Review.

Morrison Knudsen Corporation. November 20, 1998. Denver Radium Superfund Site Five-Year Review.

U. S. Environmental Protection Agency. 2001. OSWER Directive 9355.7-03B-P. Comprehensive Five-Year Review Guidance.

US EPA. September 25, 2006. Superfund Final Close Out Report, Denver Radium Superfund Site, Denver County, Colorado, September 25, 2006.

OU 1

United States Environmental Protection Agency. 1987. Superfund Record of Decision: Denver Radium/12th & Quivas, CO.

RUST Geotech Inc. 1992. Denver Radium Site Operable Unit 1 Close Out Report for the U.S. Environmental Protection Agency.

OU 2

United States Environmental Protection Agency. September 1987. Superfund Record of Decision: Denver Radium /11th & Umatilla, CO.

United States Environmental Protection Agency. September 1993. Explanation of Significant Differences for September 29, 1987 Record of Decision, Denver Radium Site Operable Unit 2

RUST Geotech Inc. May 1994. Denver Radium Site Supplemental Standards Report for Operable Unit 2, DuWald Steel Property.

RUST Geotech Inc. July 1994. Denver Radium Site Operable Unit 2 - Interim Close Out Report for the U.S. Environmental Protection Agency Five-Year Review Site.

Colorado Department of Public Health and Environment (CDPHE). May 5, 2005. Denver Radium OU2 Risk Re-Evaluation.

City and County Denver. November 4, 2005. Application for De-Listing of OU-II and OU VI Denver Radium Site, Denver, CO.

OU 3

United States Environmental Protection Agency. September 1987. Superfund Record of Decision: Denver Radium 3, Colorado.

United States Environmental Protection Agency. November 1993. Explanation of Significant Differences, Denver Radium Site Operable Unit 3, 1000 West Louisiana Properties.

RUST Geotech Inc. April 1994. Denver Radium Site Operable Unit 3 Interim Close Out Report for the U.S. Environmental Protection Agency Five-Year Review Site.

RUST Geotech Inc. June 1995. Denver Radium Superfund Site Supplemental Standards Report, Operable Unit 3.

ERM-Rocky Mountain, Inc. April 1996. Phased Remedial Response Action Closure Report, Phases 1, 2 and 3, Robinson Brick Company, 500 South Santa Fe Drive, Denver, Colorado 80223.

Metro Wastewater Reclamation District. October 1998. Sanderson Gulch Common Interceptor System Rehabilitation Plan and Profile Sheet 3 of 25.

HDR Engineering Inc., November 8, 1999. Soils Management Plan Sanderson Gulch Common Interceptor System Rehabilitation Project.

HDR Engineering Inc., June 19, 2000. Status Letter to CDPHE of Interceptor Project and Soils Disposition.

U.S. Department of Energy. December 2001. Letter Report - Shattuck Chemical Ground Water Project.

Colorado Department of Public Health and Environment (CDPHE). March 2002. Denver Radium OU9 Ground Water Monitoring Report. March 8, 2002

Colorado Department of Public Health and Environment (CDPHE). June 12, 2003. Denver Radium OU3 Sample and Analysis Plan for Ground Water Monitoring.

Colorado Department of Public Health and Environment (CDPHE). November 10, 2005. Denver Radium OU3 Risk Re-Evaluation.

Colorado Department of Public Health and Environment. November 10, 2005. Denver Radium Superfund Site, Supplemental Standards Report, Operable Unit III, W. Louisiana Avenue S. Jason Street & S. Platte River Drive.

OU 4 and 5

United States Environmental Protection Agency. September 1986. Superfund Record of Decision: Denver Radium/ROBCO, CO.

RUST Geotech Inc. March 1994. Denver Radium Site Supplemental Standards Report for Operable Units 4 and 5, ROBCO Property.

RUST Geotech Inc. April 1994. Denver Radium Site Operable Units 4 and 5 Interim Close Out Report for the U.S. Environmental Protection Agency Five-Year Review Site.

United States Environmental Protection Agency. November 1994. Explanation of Significant Differences, Denver Radium Superfund Site Operable Unit 4 and 5.

Letter from E.K. Demos, City of Denver Environmental Services, to Lawrence Bruskin, CDPHE. November 18, 1996.

URS Operating Service, Inc. April 1998. Trip Report, ROBCO groundwater and surface water sampling.

URS Operating Services. July 6, 1998. Analytical Results for Denver Radium OU 9 (ROBCO), Denver, Colorado, Revision 1.

Colorado Department of Public Health and Environment (CDPHE). April 14, 2008. Denver Radium OU4/5 Risk Re-Evaluation.

OU 6, 9A and 11

United States Environmental Protection Agency. September 1987. Superfund Record of Decision: Denver Radium Open Space, CO.

RUST Geotech Inc. November 1993. Denver Radium Site Operable Unit 9 Close Out Report for the U.S. Environmental Protection Agency.

United States Environmental Protection Agency, Region 11. March 29, 1994.

Remedial Action Completion Report, Denver Radium Superfund Site Operable Unit 6 - Phase D, Denver Colorado.

RUST Geotech Inc. April 1994. Denver Radium Site Supplemental Standards Report for Operable Unit VI, 15th Street Property.

RUST Geotech Inc. April 1994. Denver Radium Site Operable Unit 11 Close Out Report for the U.S. Environmental Protection Agency.

GEI Consultants, Inc. February 1995. Materials Handling Plan for Radium Contaminated Soils Excavated During Utility Improvement Activities at OU6-Denver Superfund Site.

Walsh Environmental Scientists. January 3, 1995. Memorandum to Jamie Harvey (Kiewit Western) from David Gerow regarding: results of soil sampling from F&G Pipe Excavation-Platte River Improvements Project.

Slosky & Company, Inc. November 10, 1995. Limited Phase 2 Environmental Site Assessment, 1560-1620 Platte Street, Denver, Colorado.

Hydrokinetics, Inc. September 17, 1996, Letter to John Ausburn (Phoenix Property Company) from Pat O'Brien regarding: Test drilling and sampling at 2315 15th Street, Denver.

City and County of Denver. March 19, 1997. Letter to John Ausburn (Phoenix Property Company) from E.K. Demos regarding: Potential for radium contaminated soils.

City and County of Denver. October 29, 1997. Letter to John Ausburn (Phoenix Property Company) from Thomas Stauch regarding: Underground utility installation and potential for radioactive contamination in subsurface materials.

Phoenix Contractors, Inc. December 29, 1997. Letter to John Student (Denver Department of Health and Environment) from Scott Reynolds regarding: Intent to test soils.

City and County of Denver. March 31, 1998. Letter to Leonard Slosky (Slosky and Company, Inc.) from John Student regarding: Planned utility excavation across Denver Radium OU 6.

Slosky and Company, Inc. May 11, 1998. Site Health and Safety Plan-Park Commons West Storm Sewer Installation.

City and County of Denver. August 3, 1998. Interoffice Memorandum from Nick Ioannides to Jim Geist regarding: Results of soil sampling activities associated with 16th Street bridge project.

URS Operating Services, Inc. July 6, 1998. Final Analytical Results Report for Denver Radium OU9.

Slosky and Company, Inc. October 1998. Commons Park West Radiological Monitoring Report for 1550 and 1620 Platte Street, Denver, Colorado.

OU 7

United States Environmental Protection Agency. March 1986. Superfund Record of Decision: Denver Radium Site Streets, CO.

United States Environmental Protection Agency. September 1992. Explanation of Significant Differences, Denver Radium Superfund Site Operable Unit 7 - Streets.

City and County of Denver. October 1993. Management Plan, Denver Radium Site Operable Unit 7, Denver Streets.

RUST Geotech Inc. June 1994. Denver Radium Site Operable Unit 7 Interim Close Out Report for the U.S. Environmental Protection Agency Five-Year Review Site.

City and County of Denver. September 1996. Proposed Revisions to Management Plan, Denver Radium Site Operable Unit 7, Denver Streets.

City and County of Denver. February 18, 1998. Letter to D. Arthur Burnham at CDPHE from E.K. Demos at the City and County of Denver regarding: Submittal of Application to Obtain a Radioactive Material License.

City and County of Denver. July 10, 2002. Management Plan, Denver Radium Site Operable Unit 7, Denver Streets.

GEI Consultants, Inc. November 2002. Curbstone Preservation and Decontamination Pilot Study Data Report.

City and County of Denver. 2003. Personal Communication between Ali Sogue, City and County of Denver Radium Site Project Manager, and Mark Rudolph, CDPHE Denver radium Site Project Manager between January 2003 and September 2003.

City and County of Denver. March 10, 2005. Application for partial de-listing of Humboldt Street – 7th Avenue to 10th Avenue and Lafayette Street, 1st Avenue to 10th Avenue, Denver Radium Streets – Operable Unit VII, Denver, Colorado.

City and County of Denver. November 4, 2005. Letter Report: Application for partial de-listing of Downing Street – 7th to 10th Avenue, Denver Radium Streets – Operable Unit VII, Denver, Colorado.

OU 8

United States Environmental Protection Agency, Region 8. January 1992. Record of Decision, Denver Radium Site Operable Unit 8, Denver, Colorado.

Earth Sciences Consultants, Inc. January 1994. Remedial Design/Remedial Action Activities, Flanagan Ready Mix, Ltd.

Earth Sciences Consultants, Inc. January 1994. Remedial Design/Remedial Action Activities, South Bannock Street and West Colorado Avenue Shoulders.

United States Environmental Protection Agency. June 1994. Remedial Action Completion Report, Denver Radium Superfund Site, Operable Unit 8 - Shattuck Chemical Company, Phase 1 Remedial Action.

Earth Sciences Consultants, Inc. June 1994. Remedial Design/Remedial Action Activities, Atchison, Topeka and Santa Fe Railroad Right-of-Way.

Harding Lawson Associates. June 9, 1997. Construction Completion Report, Sewer Remediation Plan, Denver Radium Site, Operable Unit 8, Denver County, Colorado.

Fluor Daniel GTI. August 12, 1997. Construction Completion Report South Bannock Street Denver Radium Sites, Operable Unit 8.

Earth Sciences Consultants, Inc. Remedial Design/Remedial Action Activities. Danielson Construction Company, RJR Circuits, and Kroonenberg Lumber Properties.

Shattuck Chemical Company, Inc. August 11, 1998. Letter to Rebecca Thomas (EPA) from Robert Oliver regarding submittal of the proposal for bioremediation of oil-impacted soils along the western boundary of the site.

Shattuck Chemical Company, Inc. September 29, 1998. Construction Completion Report. Denver Radium Site OU 8I, Denver, Colorado.

Shattuck Chemical Company, Inc. October 14, 1998. Construction Completion Report Plates 1-12. Denver Radium Site OU 8, Denver, Colorado.

United States Environmental Protection Agency, Region 8. 1999. Shattuck OU8 Site Investigation Plan 1999.

United States Environmental Protection Agency, Region 8. 1999. Working Draft Five-Year Review Report - OU8 Shattuck Chemical Site. September 22, 1999.

United States Environmental Protection Agency, Region 8. 2000. Record of Decision Amendment for OU8 Shattuck Chemical Site. June 16, 2000.

U.S. Department of Energy. December 2001. Letter Report - Shattuck Chemical Ground Water Project.

OU 9

United States Environmental Protection Agency. December 1991. Superfund Record of Decision: Denver Radium (Operable Unit 9), Colorado.

United States Environmental Protection Agency. May 7, 1993. Memorandum to Diana Shannon from Victor Ketellapper regarding Denver Radium OU-9, Robinson Brick Company, Metals, Groundwater Contamination.

Sverdrup Corporation. May 1993. Groundwater Contamination Characterization Report for the Remedial Action at the Denver Radium Site, Operable Unit No. 9, Robinson Brick Company - Metals, Denver, Colorado.

RUST Geotech Inc. April 1994. Denver Radium Site Operable Unit M Close Out Report for the U.S. Environmental Protection Agency.

ERM-Rocky Mountain, Inc. June 9, 1995. Robinson Brick Company, Ground Water Monitoring Report for April 1995 Sampling.

ERM-Rocky Mountain, Inc. April 1996. Phased Remedial Action Closure Report, Phases 1, 2 and 3, Robinson Brick Company, 500 South Santa Fe Drive, Denver, Colorado.

United States Environmental Protection Agency. July 26, 1995. Agreement and Covenant not to Sue Re: Denver Radium Site Operable Units 4 and 9 between USEPA Region 8 and Home Depot USA, Inc. (Prospective Purchaser Agreement).

ERM-Rocky Mountain, Inc. May 30, 1997. Home Depot O&M Plan, 500 South Santa Fe Drive, Denver, Colorado.

Colorado Department of Public Health and Environment (CDPHE). November 6, 2000. Denver Radium OU9 Ground Water Monitoring Report.

Colorado Department of Public Health and Environment (CDPHE). March 2002. Denver Radium OU9 Ground Water Monitoring Report. March 8, 2002

Colorado Department of Public Health and Environment (CDPHE). May 5, 2003. Denver Radium OU9 Ground Water Monitoring Sampling and Analysis Plan.

ERM-Rocky Mountain, Inc. May 6, 2003. Home Depot O&M Plan - Amended, 500 South Santa Fe Drive, Denver, Colorado

OU 10

United States Environmental Protection Agency. June 1987. Superfund Record of Decision: Denver Radium/Card Property, Colorado.

RUST Geotech Inc. 1992. Denver Radium Site Operable Unit 10 Close Out Report for the U.S. Environmental Protection Agency.

This Page Intentionally Left Blank

Site Photographs



OU1 – B&C Metals – 1623 – 1625 West 12th Street



OU1 – Rudd Property – 1223 – 1229 Quivas Street



OU1 – Erickson Monuments – 121 – 1245 Quivas Street



OU1 – Materials Handling Inc. – 1740 West 13th Avenue



OU2 – Rocky Mountain Research Corporation – 1020 and 1030 Yuma Street



OU2 – Capital Management Realty – 1050 Yuma Street



OU2 – Flame Spray, Inc. – 1900 West 12th Avenue



OU2 – Atlas Metals (Formerly DuWald Steel) – 1100 Umatilla Street



OU2 – Denver Water Board – 1600 West 12th Avenue



OU2 – Jerome Maintenance Yard CDOT – 2300 West 11th Avenue



OU2 – Burlington Northern Railroad ROW – Between 10th and 11th Avenues



OU2 – Staab Property – 2121 West 10th Avenue



OU2 – G&K Services – 999 Vallejo Street



OU2 – Jenkins Property – 2191 West 10th Avenue



OU2 – Air Conditioning Inc. – 1001 South Tejon Street



OU2 – Alpha Omega Electronics – 1010 Yuma Street



OU3 - Packaging Corp of America – 1377 South Jason Street



OU3 – Various Offices – 1300 South Jason Street



OU3 – Kwan Sang Noodle Company (formerly Titan Labels) – 1140 West Louisiana St.



OU3 – Central and Sierra Rail Road ROW – Between West Louisiana and West Florida Streets.



OU3 – Creative Illumination Inc. – 1298 South Kalamath Street



OU3 – GT Car Shop – 1235 South Jason Street



OU4 – Robinson Brick Company – 500 South Santa Fe Drive



OU5 – Denver and Rio Grande Western Railroad ROW – East of OU4



OU6 – Ruby Hill Park



OU6 – Denver Water – 1190 Yuma Street (View from 1600 West 12th Avenue)



OU6 – Allied (formerly General Chemical) – 1721 West Bayaud



OU6 – Public Service Company – South Pecos Street and West Arizona Avenue

OU7

No Photographs Taken Streets - Remediated and Remain as Streets



OU8 – Shattuck Chemical – 1805 South Bannock Street



OU9A – International House of Pancakes and Larry's Trading Post – 2001, 2015, and 2017 East Colfax Street



OU9B – Robinson Brick Company – 500 South Santa Fe Drive



OU10 – Card Corp – 1314 West Evans Avenue



OU11 – Thomas Property – 1285 – 1295 South Santa Fe Drive

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
Hazardous Materials and Waste Management Division

INTEROFFICE COMMUNICATION

TO: Mark Rudolph

FROM: Wendy Naugle

DATE: September 10, 2008

SUBJECT: Technical Review of Shattuck Groundwater Data

As you requested, I have reviewed the groundwater data that you have provided from the Shattuck (Denver Radium Operable Unit 8) Superfund Site. I have summarized my conclusions below, with a more detailed explanation in the following sections. Tables and Figures are located at the back of this memo.

Summary of Recommendations:

- 1) Natural attenuation is occurring at the Shattuck Site, as evidenced by the decreasing uranium and molybdenum concentrations in some of the monitoring wells. A statistical trend evaluation was conducted (a Mann-Kendall test for trend) which confirms declining trends in some wells.
- 2) Although a declining trend is occurring, the rate of decline is very slow. Therefore, groundwater monitoring will need to continue for a long period of time. As such, less frequent monitoring (rather than quarterly sampling) is appropriate. It is recommended that semi-annual sampling be conducted for the next 5-years, targeting the high and low water table. Typically the high water levels correspond to the summer irrigation season, so semi-annual monitoring could be conducted during the summer months (June, July or August) with the second sampling round in the winter (December, January or February.)
- 3) Some of the analytes can be removed from the sampling plan, as indicated in the data analysis that follows: Gross Alpha, Gross Beta, isotopic analysis for U-234 and U-238, manganese, copper and zinc. (However, PZ-2 should still include copper and zinc.)
- 4) Monitoring of Well APM-5 should be discontinued as this well does not appear to be properly screened to capture alluvial groundwater.

Introduction

The purpose of this report is to evaluate and interpret groundwater monitoring data collected near the Shattuck (Denver Radium Operable Unit 8) Superfund Site in Denver, Colorado. Groundwater monitoring has been conducted at the Site under several different sampling programs since 1981. More recently, quarterly samples have been collected since 2006. This report evaluates both the long-term trends that can be evaluated for wells that have large data sets and a detailed analysis of the more recent, quarterly data.

The groundwater remedy for the Site is natural attenuation after source removal. This remedy is similar to the “natural flushing” remedy being applied at many of the Colorado Uranium Mill Tailings Remedial Action Sites (UMTRA) Sites. The objective of the groundwater monitoring program is to document that natural attenuation/flushing of Site related contaminants is occurring.

The Site is located in southwest Denver, northeast of the intersection of Evans Avenue and Santa Fe Drive. Overland Park Golf Course lies to the west of the Site. The South Platte River forms the western boundary of the golf course. The topography of the area surrounding the Site is relatively flat and generally slopes to the north and west toward the South Platte River.

The Shattuck Site is located within the drainage basin of the South Platte River, which is located approximately 3000 feet west of the Site. The Site is located on an alluvial terrace which is topographically higher than the modern floodplain of the South Platte River. A shallow, unconfined aquifer exists below the Site. The shallow aquifer is perched on bedrock and merges with the alluvial aquifer beneath the floodplain of the South Platte River. The shallow groundwater is not used as a drinking water source.

Groundwater in the area of the Site generally flows west across the Site and then northwest toward the South Platte River. Figure 1 shows the Site vicinity and the groundwater monitoring network. Four of the monitor wells (MW-1, MW-3, PZ-2 and VMW-06) are located on the terrace, while the remaining wells are in the floodplain. VMW-06 is located upgradient from the Site. The floodplain wells are located on or adjacent to the Overland Park Golf Course. High concentrations of Site-related contaminants occur in the terrace wells, with floodplain wells exhibiting better water quality. Previous investigations identified groundwater infiltrating a subsurface storm sewer line located along South Santa Fe Drive, west and downgradient of the Site. A portion of the sewer was lined with an epoxy-based liner in 1997. Infiltration of contaminated groundwater into the storm sewer resulted in elevated concentrations of Site related contaminants in the storm sewer discharge.

The groundwater samples from the recent, quarterly monitoring program have been analyzed for dissolved copper, manganese, molybdenum, uranium and zinc. Additionally, the samples were analyzed for Gross Alpha, Gross Beta, Uranium 234,

Uranium 238 and nitrate. Samples were collected from a total of 12 monitoring wells and one storm sewer outfall location to the South Platte River. Groundwater monitoring wells are located upgradient, downgradient, and cross gradient of the Shattuck Site.

Source removal for uranium occurred during the original remedial action in the 1990's. Later it was discovered that soils containing molybdenum still remained at the Site that had not been removed during the original cleanup. Source removal for the molybdenum-contaminated soils was completed in 2006. As such, the uranium plume has had a longer time-frame for natural flushing to take place. In addition, while uranium concentrations in groundwater are elevated, uranium concentrations only exceed the applicable groundwater standard (0.030 mg/l) by 4 to 5 times in the more recent sampling data. Molybdenum, on the other hand, occurs in groundwater in very high concentrations, up to 600 times the State of Colorado Basic Standards for groundwater concentration of 0.035 mg/l. Natural flushing for molybdenum is expected to take longer than uranium because of the higher concentrations and the more recent removal of the molybdenum source.

Results of the Monitoring Program

Water Level Data

Wells closest to the Site, VMW-06, PZ-2 and MW-1, show very little variation in water level throughout the year. Floodplain wells show more variation, with wells APM-5 and BH-3 showing the highest degree of variation in water level. BH-3 is located adjacent to both the Aqua Golf pond and the South Platte River, therefore, this well is more affected by changes in the surface water regime. Water levels in the terrace wells during the recent quarterly sampling are shown below in Figure 2. Water levels in the floodplain wells are shown in Figure 3.

Well APM-5 (see Figure 3) fluctuates up to 9 feet and is bailed dry during each sampling round. In addition, this well also contains much lower concentrations of uranium and, molybdenum than the remainder of the floodplain wells. It appears that some clean water source may be affecting this well. This well is most likely screened at too shallow of depth, and is not intersecting the alluvial aquifer. Instead, it is being recharged by surface water inflows after being bailed dry. Due to the fact that it provides anomalous results, sampling of this well should be discontinued. At a future date, it should be plugged and abandoned.

A comparison of the groundwater flow directions indicates that even though seasonal variations do occur in the water table, these variations do not cause a significant change in the groundwater flow directions. The most significant variation in the configuration of the potentiometric surface occurs as a result of the water level fluctuations in well APM-5.

Gross Alpha/Gross Beta Analysis

The Gross Alpha measurement is usually conducted as a screen for alpha emitters and if it exceeds the 15 pCi/l limit, then a more detailed analysis for specific alpha emitters (e.g.

uranium) is conducted. Since uranium is a known contaminant of concern and already included in the sampling program at Shattuck, monitoring for Gross Alpha can be discontinued.

Similarly, Gross Beta analysis is also a screening tool. Since the previous Site characterization activities have identified uranium as the primary radionuclide of concern, the gross alpha and gross beta analyses provide a secondary “data checking” mechanism, but are not used for any other purpose. Both of these analyses are unnecessary and can be eliminated in future monitoring.

Uranium

Since August 2006, analysis for uranium has been done using both an isotopic analysis, where Uranium-234 and Uranium-238 are reported separately in units of activity (pCi/l) and a mass-based method where total Uranium-238 is reported in units of mg/l. Theoretically, the comparison between the two methods should reveal the same or very similar U-238 concentrations in groundwater.

There is not good agreement between the U-238 data from the two different analytical methods. In 64% of the samples where both analyses were performed, the mass analysis resulted in a higher concentration than the isotopic method. The one notable exception is in well PZ-2, where for all sampling rounds, the isotopic method resulted in slightly higher U-238 concentrations than the mass method. However, it should be noted that the isotopic samples are not filtered, whereas the mass-based sample is filtered. This difference in sample preparation, could account for some of the differences between the methods. The remainder of the analysis that was conducted for this review utilized a combined data set of isotopic U-238 converted to mass when only the isotopic data were available. When both types of data were available, the mass-based data were used.

The regulatory limit from the Basic Standards for Groundwater for uranium is based on dissolved uranium measured in units of mass. In addition, because in most cases the mass method gave a higher result, future analysis should use the mass-based analytical method.

The uranium concentrations from the March 2008 sampling are shown in Figure 2. The extent of the uranium plume is now mainly on the golf course and appears to be dissipating, when compared against data from 1999.

Molybdenum

The aerial extent of the molybdenum plume has remained stable. The high levels of molybdenum in the terrace groundwater are generally absent in floodplain monitoring wells. Some of this may be due to interception of the molybdenum plume by the storm sewer line. Data for the recent quarterly monitoring program illustrates that infiltration into the storm sewer is still occurring and the storm sewer is still impacted by elevated concentrations of molybdenum. The molybdenum concentrations from the March 2008 sampling are shown in Figure 3.

Seasonal Trend Concentration Trends

A comparison between the water level data and the uranium/molybdenum concentrations was used to determine if seasonal trends are occurring in the groundwater. Hydrogeologic data (a comparison of water level fluctuations to concentration data) were used to determine seasonal trends, as there are not enough seasonal data to conduct statistical tests for seasonality. Using this method, seasonal trends are evident in some of the wells. In all cases where a seasonal trend was recognized, higher concentrations occur concurrent with rises in the water table. The highest water table elevations typically occur in the May through October timeframe, most likely in response to the summer irrigation season. These seasonal trends are more apparent in wells that are in the floodplain. The wells that are closer to the Site exhibit higher concentrations and do not have seasonal trends. Examples of wells with strong seasonality are exhibited in Figures 4 and 5 below. Table 1 summarizes the results of the seasonal trend analysis.

Mann-Kendall Test for Trends

One method to determine if natural attenuation is occurring at the Site is to check for declining concentration trends. A method for determining trends in monitoring data is the nonparametric Mann-Kendall test for trend. The test does not require any particular data distribution and will accommodate missing values. The test analyzes a series of data by comparing the values of data collected earlier from those collected at a later date. The method results in a test statistic that is a positive or negative value (meaning increasing or decreasing trend) and estimates the probability that the trend is real.

Because uranium and molybdenum are the primary contaminants of concern at the Shattuck Site, 11 wells were tested for trend for both the molybdenum and uranium. Nitrate was not tested for trend because nitrate can undergo geochemical transformation, which could invalidate the test results. Well APM-5 was not tested because of the very low concentrations of uranium and molybdenum in that well. All of the statistically significant trends were tested with an alpha value of 0.01, meaning there is a 1% probability of a false conclusion. A statistical program available from the USGS was used for the Mann-Kendall tests.

The results of the Mann-Kendall tests are included in Table 1. Statistically significant declining trends are evident for uranium in wells MW-3 and APM-3. The uranium trends in these wells are shown in Figures 6 and 7 below. For illustrative purposes, a linear regression line is shown to approximate the declining trend. Two additional wells, APM-3, MW-6, also exhibit downward trends, but the trends are not yet statistically significant. These trends will be re-tested at the next 5-Year Review.

The combined information from the aerial extent of the uranium plume, comparison to 1999 and the declining trends in some of the monitoring wells, all indicate that natural attenuation of the uranium plume is occurring. In addition, there has been concern expressed about the possible impact of remaining mill tailings deposits under the railroad tracks and Bannock Street. These remaining deposits do not appear to be impacting groundwater quality, or serving as a continuing source. A continuing source of uranium

should be impacting the two wells closest to the Site, MW-1 and PZ-2. As shown in Figure 4, these wells now have uranium concentrations below the standard.

With regard to molybdenum, several wells exhibit statistically significant declining trends, including VMW-06, MW-3, PZ-2, APM-3, APM-6 and MW-6. Examples of the declining molybdenum trends are shown in Figures 8 and 9 below. Technically, because wells MW-3 (uranium), APM-4 (uranium) and APM-3 (molybdenum) indicated both seasonal trends and concentration trends, a different configuration of the Mann-Kendall test, called a Seasonal Kendall should be used. However, use of the Seasonal Kendall test requires 10 or more years of data. Because the sampling program has had two significant periods of hiatus, 10 years of data are not available to run this test. The upward trend in Well VMW-06, which is located upgradient of the Site, is unexplained.

Other Contaminants

Table 1 also summarizes the occurrence of additional contaminants of concern in the monitoring wells. Well PZ-2 continues to be the well most impacted by the Site, with concentrations of nitrate, copper and zinc occurring above regulatory limits. Copper and zinc do not occur frequently in any of the other wells. Nitrate also occurs in relatively high concentrations in wells MW-1 and MW-3. While nitrate does occur in many of the other wells in lower concentrations, it is difficult to determine if this is plume related. Other sources of nitrate occur in the environment, most notably from fertilizer, leaking sewer lines and septic systems. The occurrence of manganese in well APM-5 does not appear to be Site related, because no other wells in the plume exhibit similar manganese concentrations.

Recommendations

The monitoring plan should be amended to change to semi-annual sampling, targeting the time of year when the water table is rising. The highest water table elevations typically occur in the May through October timeframe, most likely in response to the summer irrigation season. Thus it is recommended that sampling take place during the summer (June – August) with the second sampling round occurring in winter for the next 5 years.

Note that the State of Colorado's Basic Standards for Groundwater (Regulation 41) were modified in December 2007 to include a groundwater standard for molybdenum at 0.035 mg/l. This newer standard is the appropriate ARAR for molybdenum and as such, natural flushing will take a longer period of time to reach this lower concentration. Because of the long time-frame for natural flushing, less frequent monitoring is recommended.

Monitoring for copper and zinc no longer appears to be necessary in any of the wells except PZ-2. These constituents are consistently below the respective limits and do not appear to be contaminants of concern any longer. Manganese can also be dropped from the monitoring program, as manganese does not appear to be a contaminant of concern any longer. Similarly, Gross Alpha, Gross Beta, Uranium-234 and Uranium-238 analyses can also be removed from the sampling plan. Monitoring for nitrate is still

necessary because of the higher concentrations of nitrate in the terrace wells. Well APM-5 should no longer be monitored and when possible, this well should be plugged and abandoned. APM-5 does not appear to be screened properly to intersect the alluvial groundwater.

Table 1 – Summary of Shattuck Groundwater Monitoring Results

Well Number	Concentration Trends		Seasonal Trends	Other contaminants
	Uranium	Molybdenum		
APM-5	Not tested	Not tested	None	Contains manganese above secondary standards
VMW-06	Significant Upward	Significant downward	None	Contains some nitrate
MW-1	No trend detected	No trend detected	None	Contains nitrate above limit
MW-3	Significant downward	Significant downward	Uranium	Contains nitrate above limit
PZ-2	No trend detected	Significant downward	Uranium	Contains nitrate above limit, also copper and some zinc
APM-3	No trend detected	Significant downward	Molybdenum	Contains some nitrate that might be from fertilizer
APM-4	Significant downward	No trend detected	Uranium	Other metals usually below detection
APM-6	No trend detected	Significant downward	None	Contains some nitrate that might be from fertilizer
BH-3	No trend detected	No trend detected	Molybdenum & Uranium	Contains some nitrate that might be from fertilizer
MW-6	No trend detected	Significant downward	None	Contains some nitrate that might be from fertilizer
VMW-03	No trend detected	No trend detected	Molybdenum & Uranium	Other metals usually below detection
VMW-04	No trend detected	No trend detected	Molybdenum & Uranium	Other metals usually below detection

Figure 1
Ground Water, Surface Water and Storm Sewer Outfall
Sample Locations
Shattuck Denver Radium OU8



Figure 2 – Water Levels in Terrace Wells

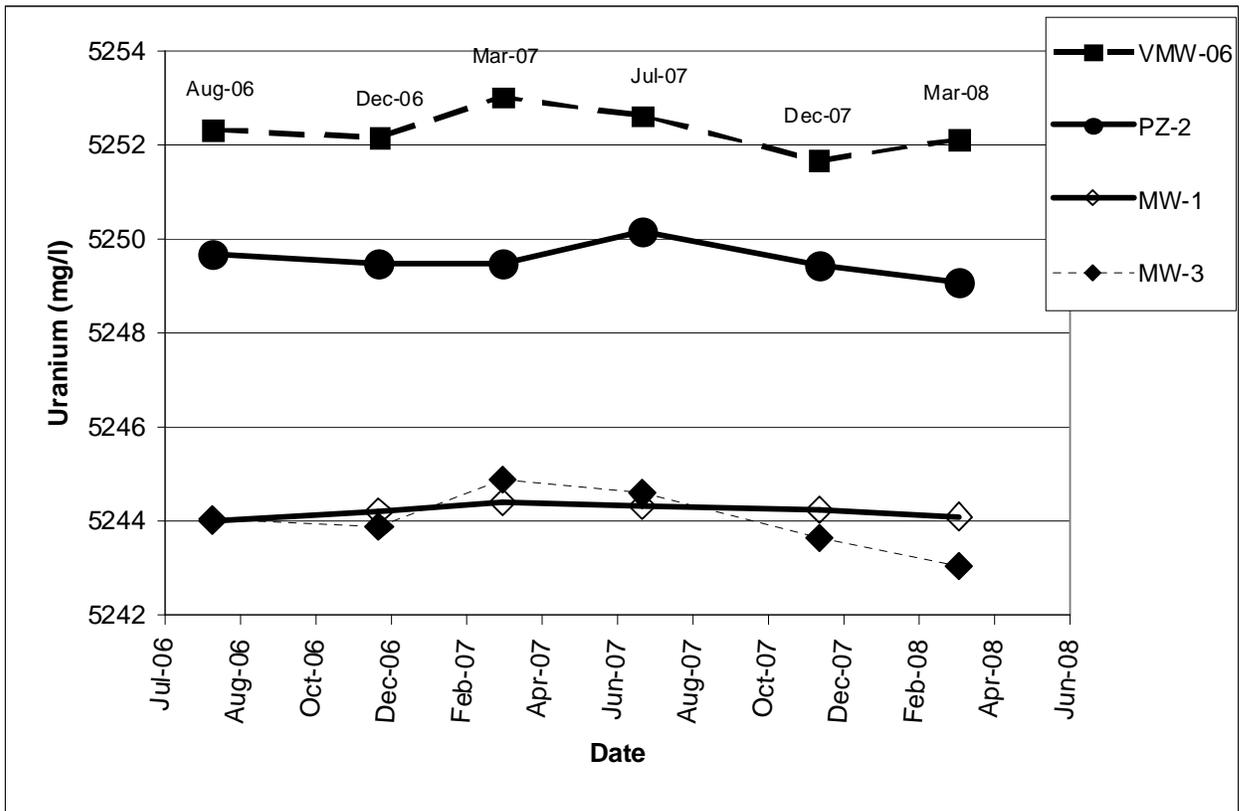


Figure 3 – Water Levels in Floodplain Wells

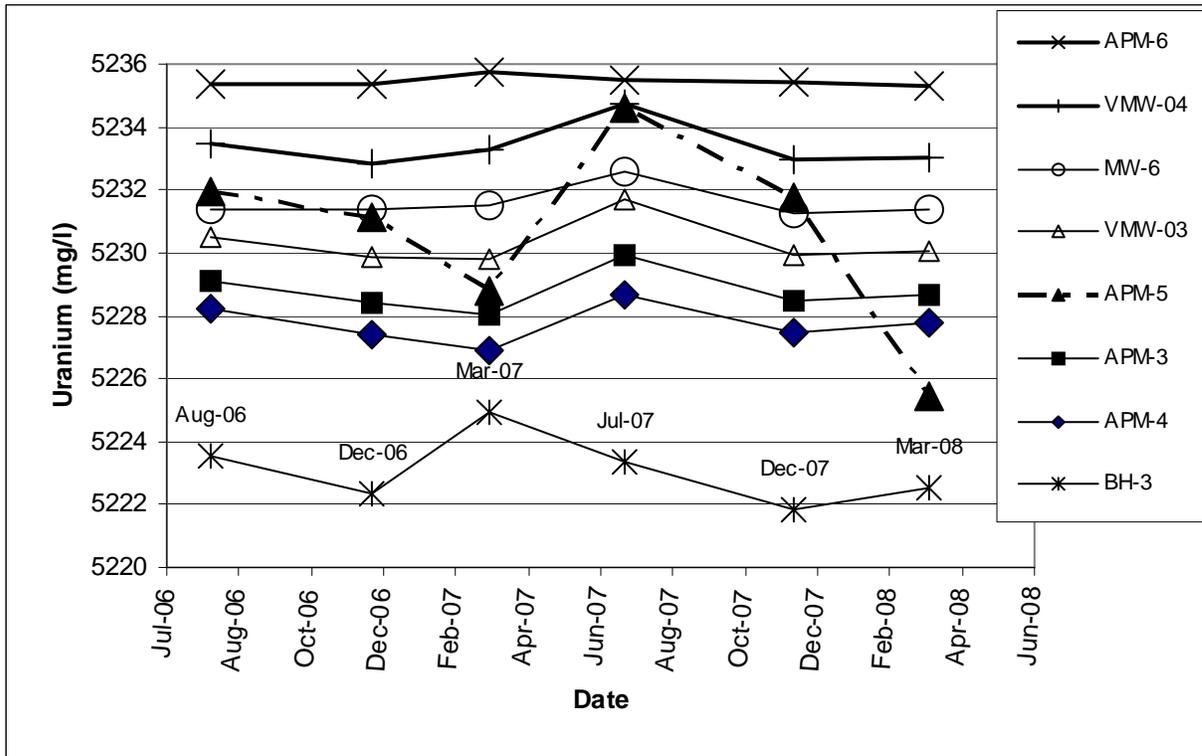


Figure 4
Uranium Concentration in Ground Water
March 2008 Sampling
Shattuck Denver Radium OU8



Figure 5
Molybdenum Concentration in Ground Water
March 2008 Sampling
Shattuck Denver Radium OU8



Figure 6 – Seasonal Variation of Molybdenum in Well BH-3

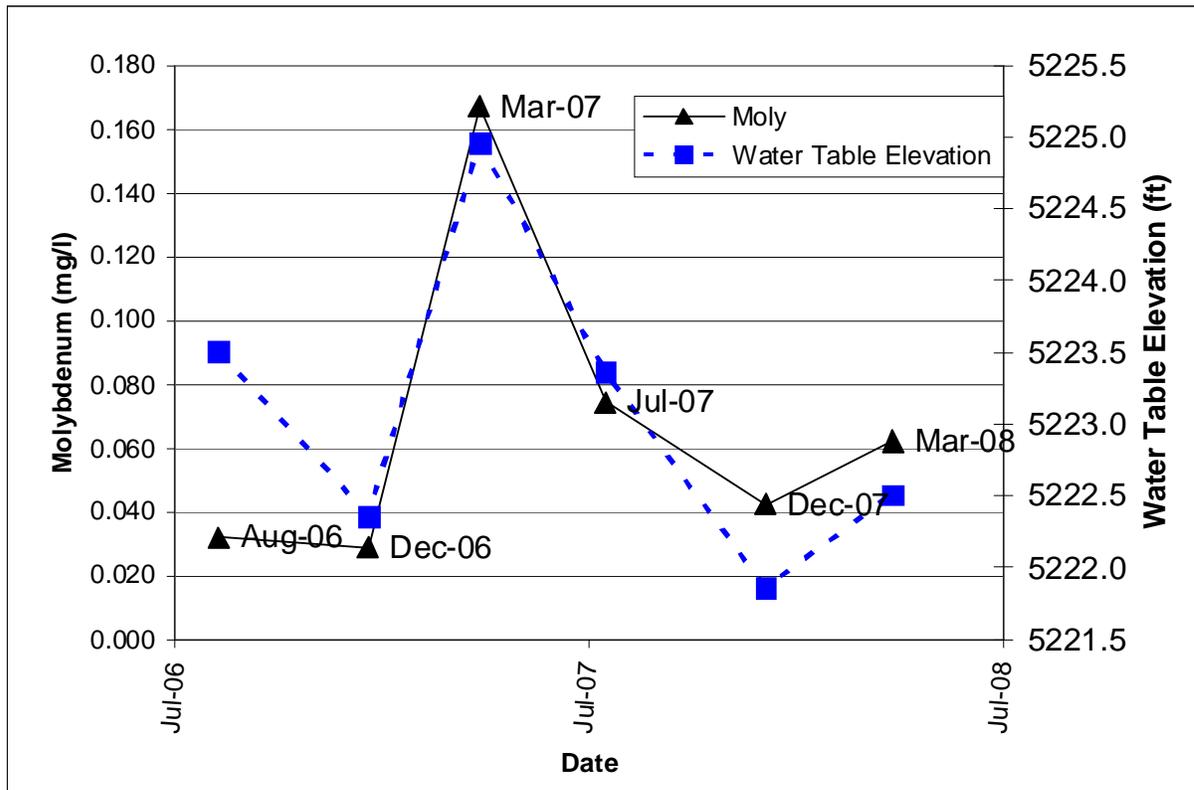


Figure 7 – Seasonal Variation of Uranium in Well APM-4

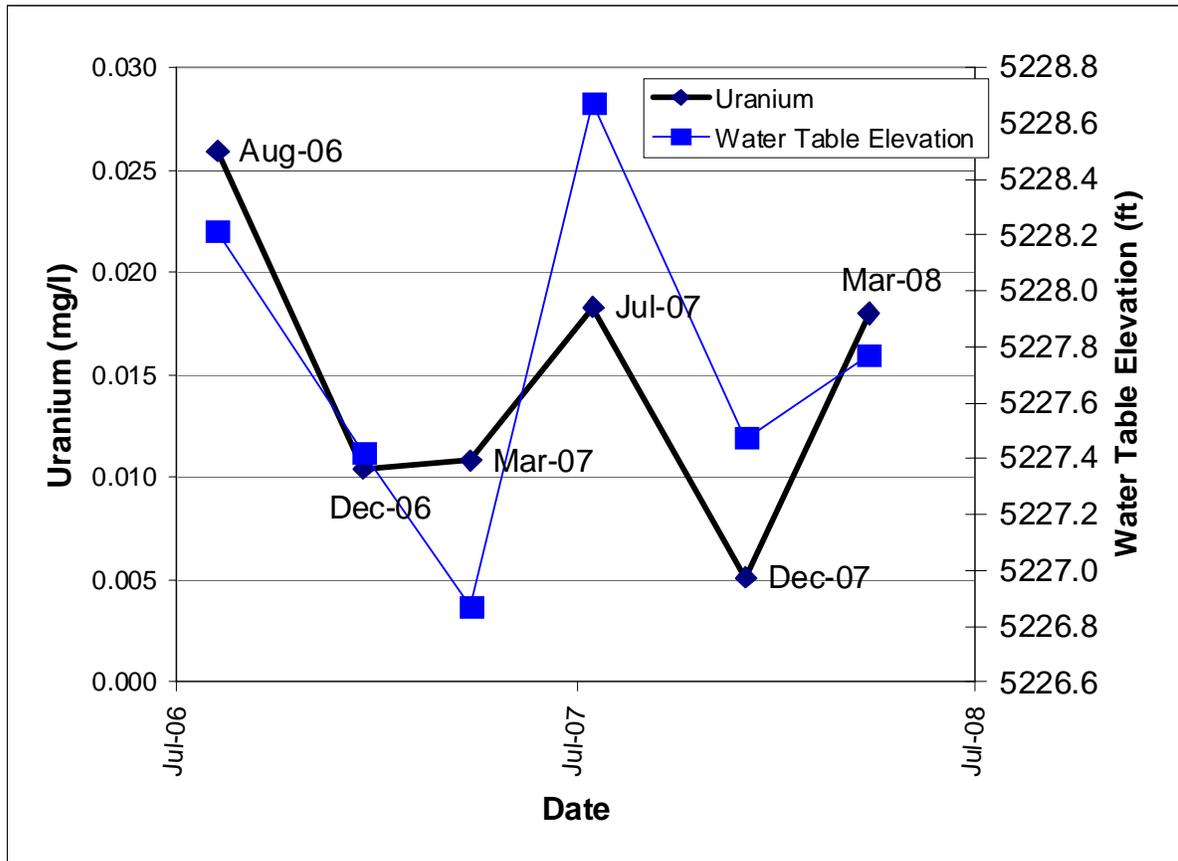


Figure 8 – Uranium in Well MW-3

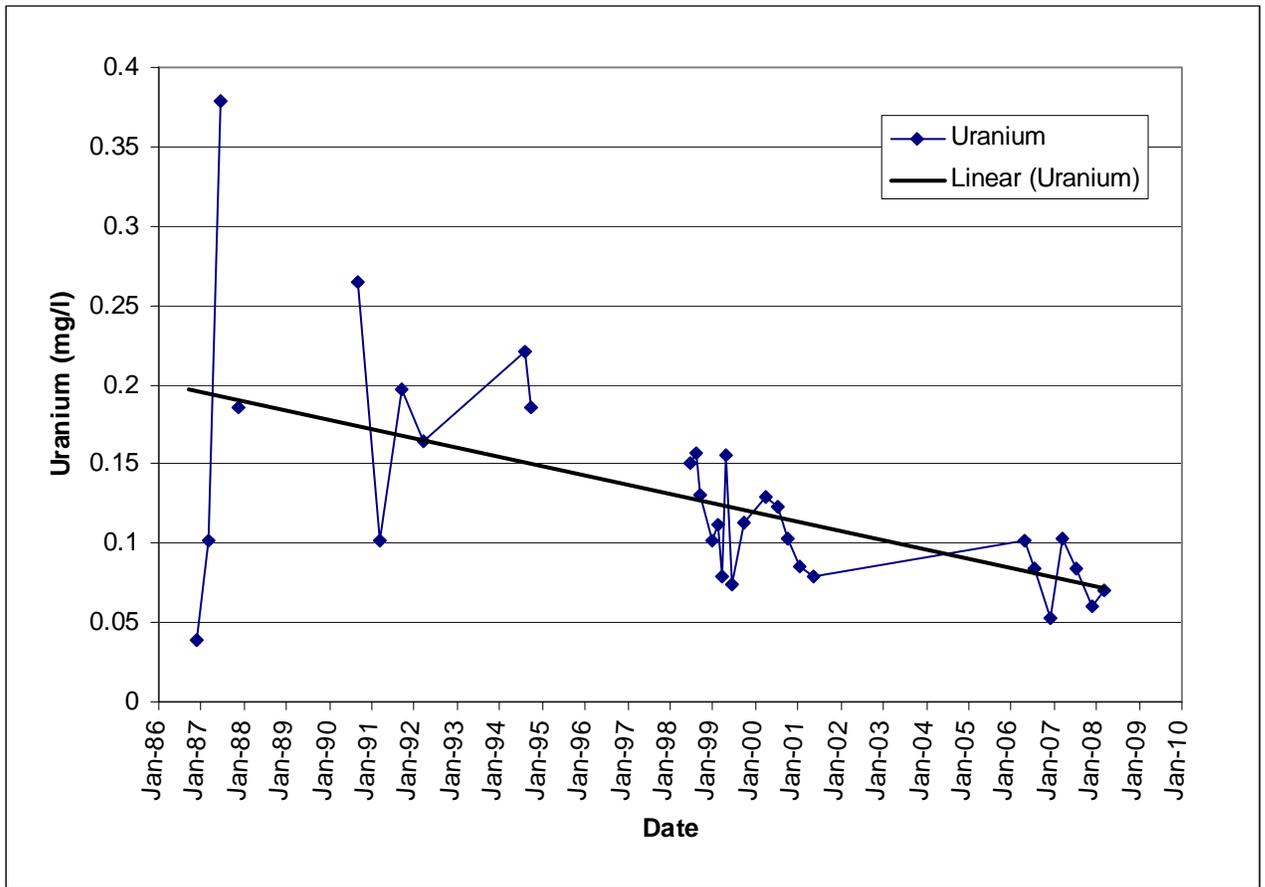


Figure 9 – Uranium in Well APM-3

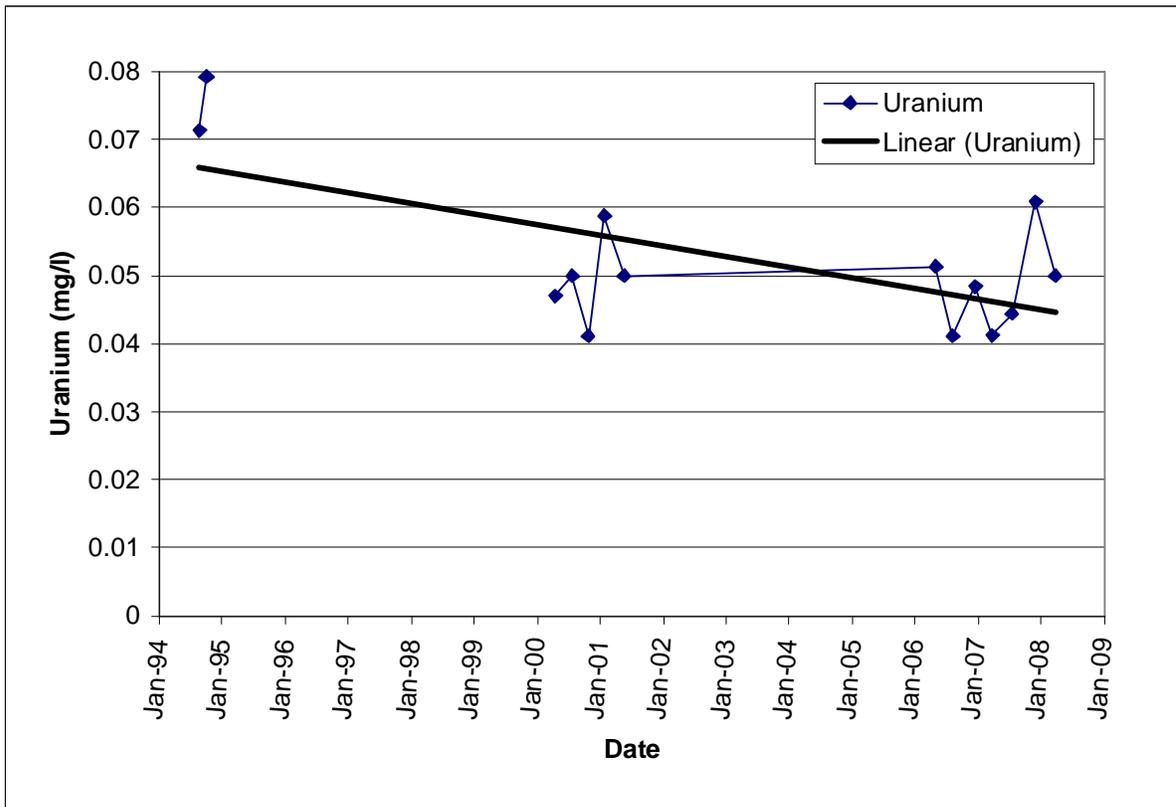


Figure 10 – Molybdenum in Well MW-3

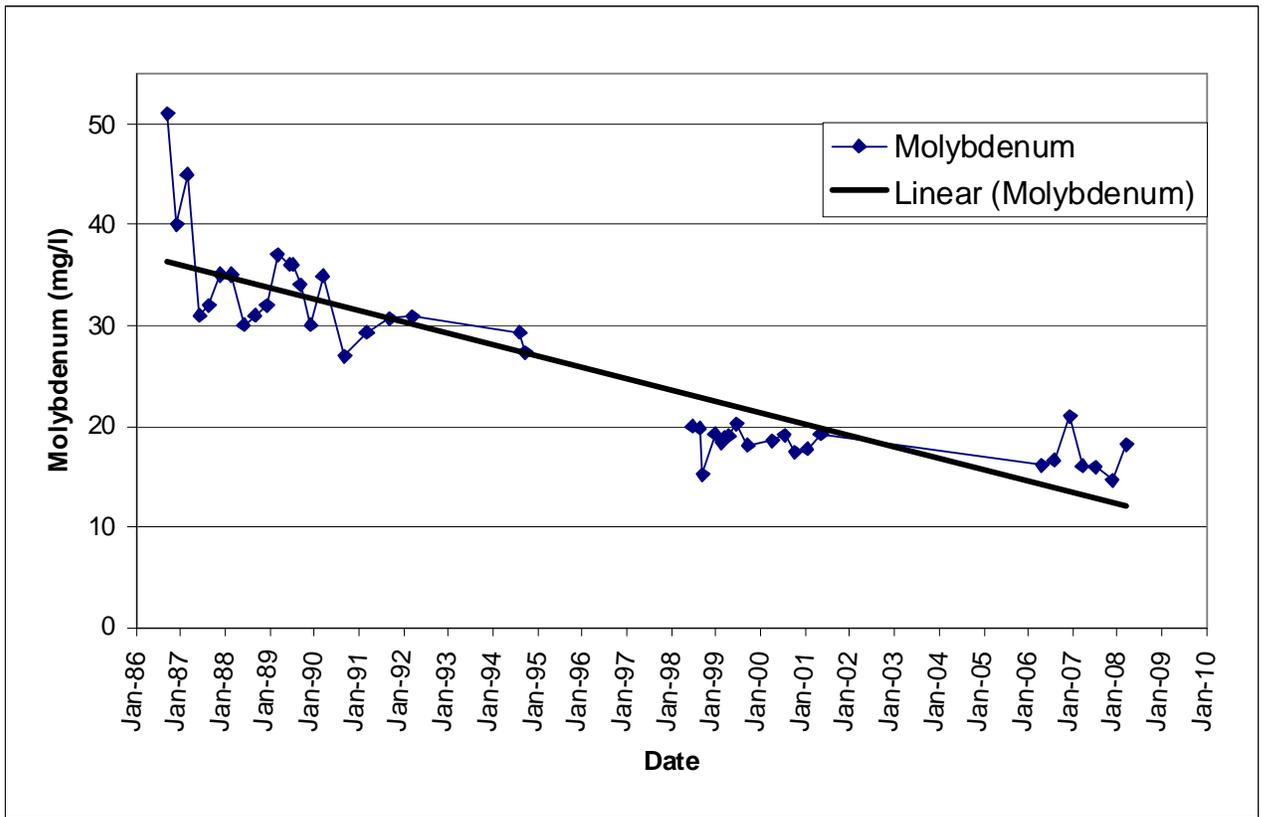
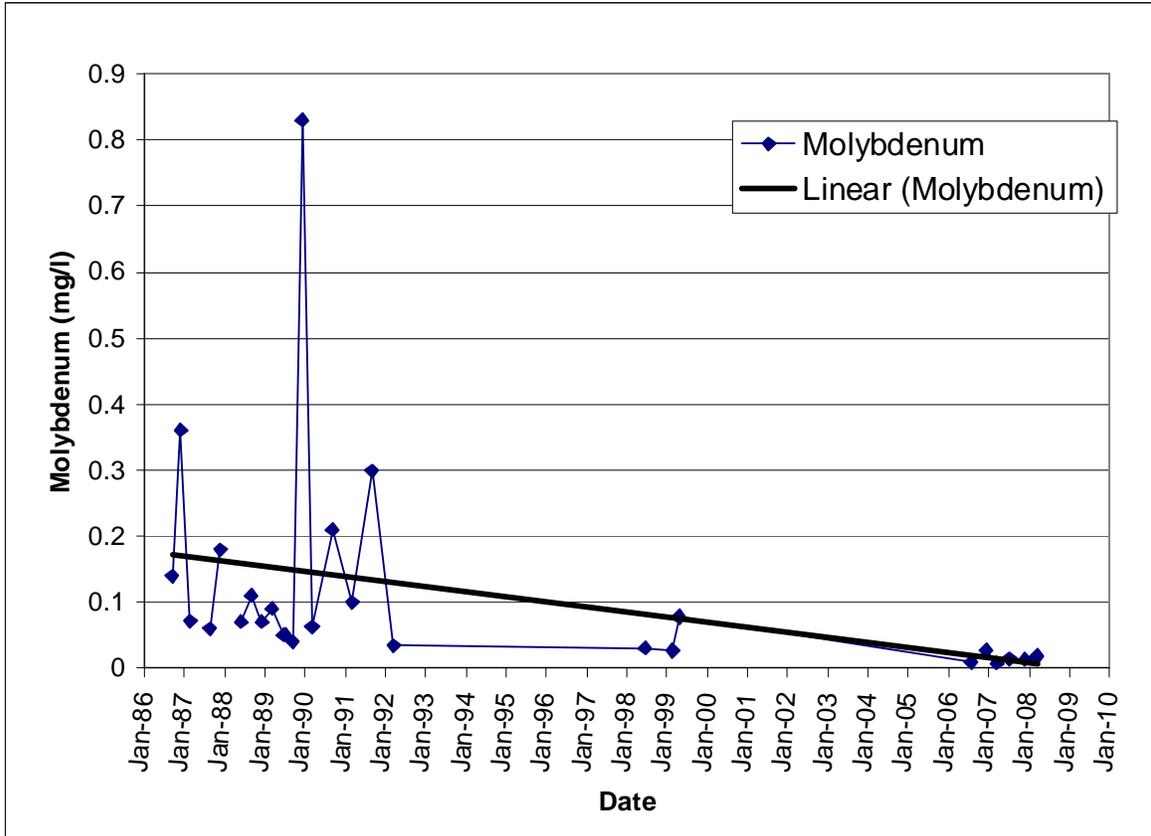


Figure 11 – Molybdenum in Well MW-6



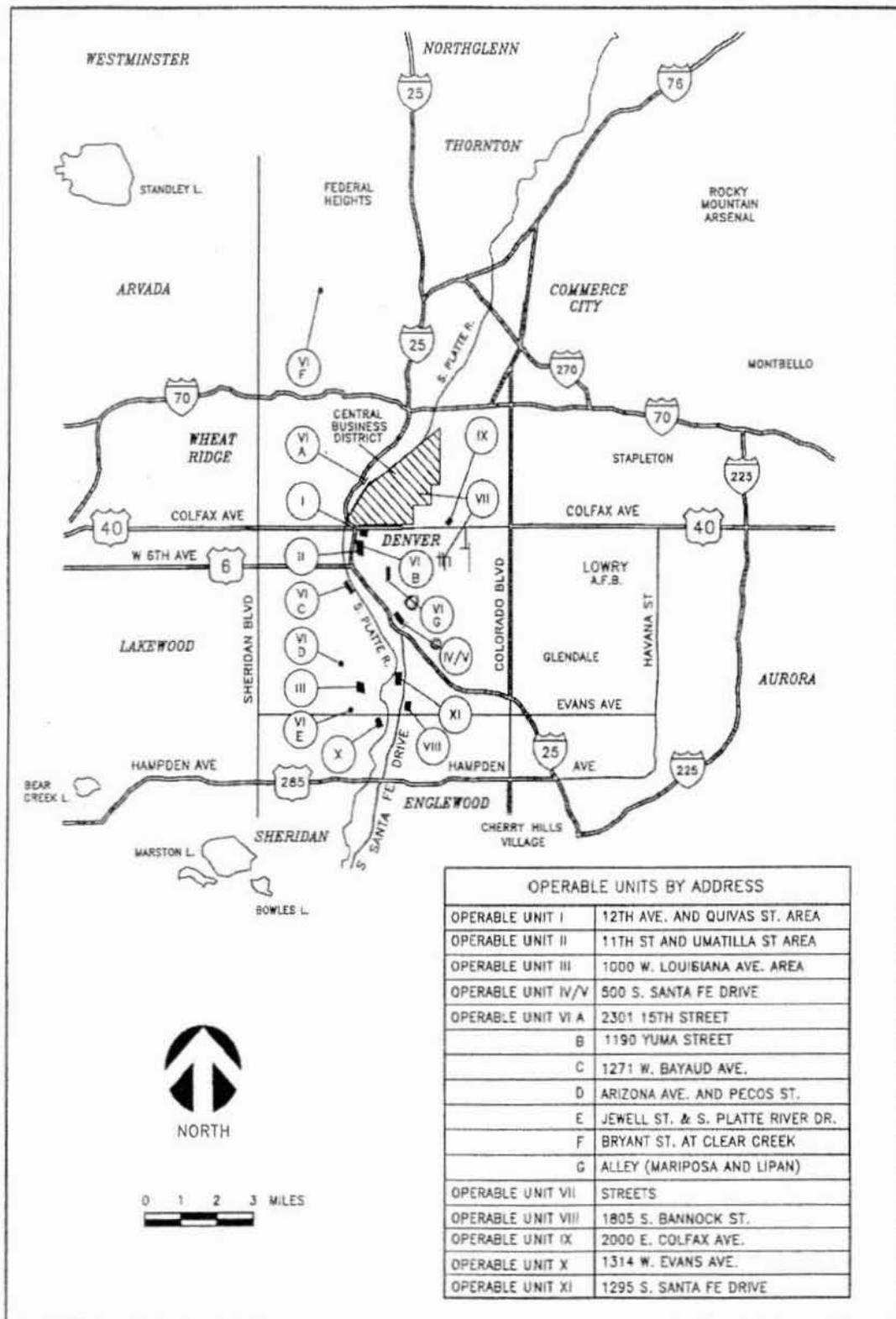


Figure 1- Denver Radium Sites
 Source: Interim Closeout Report OU3 1994

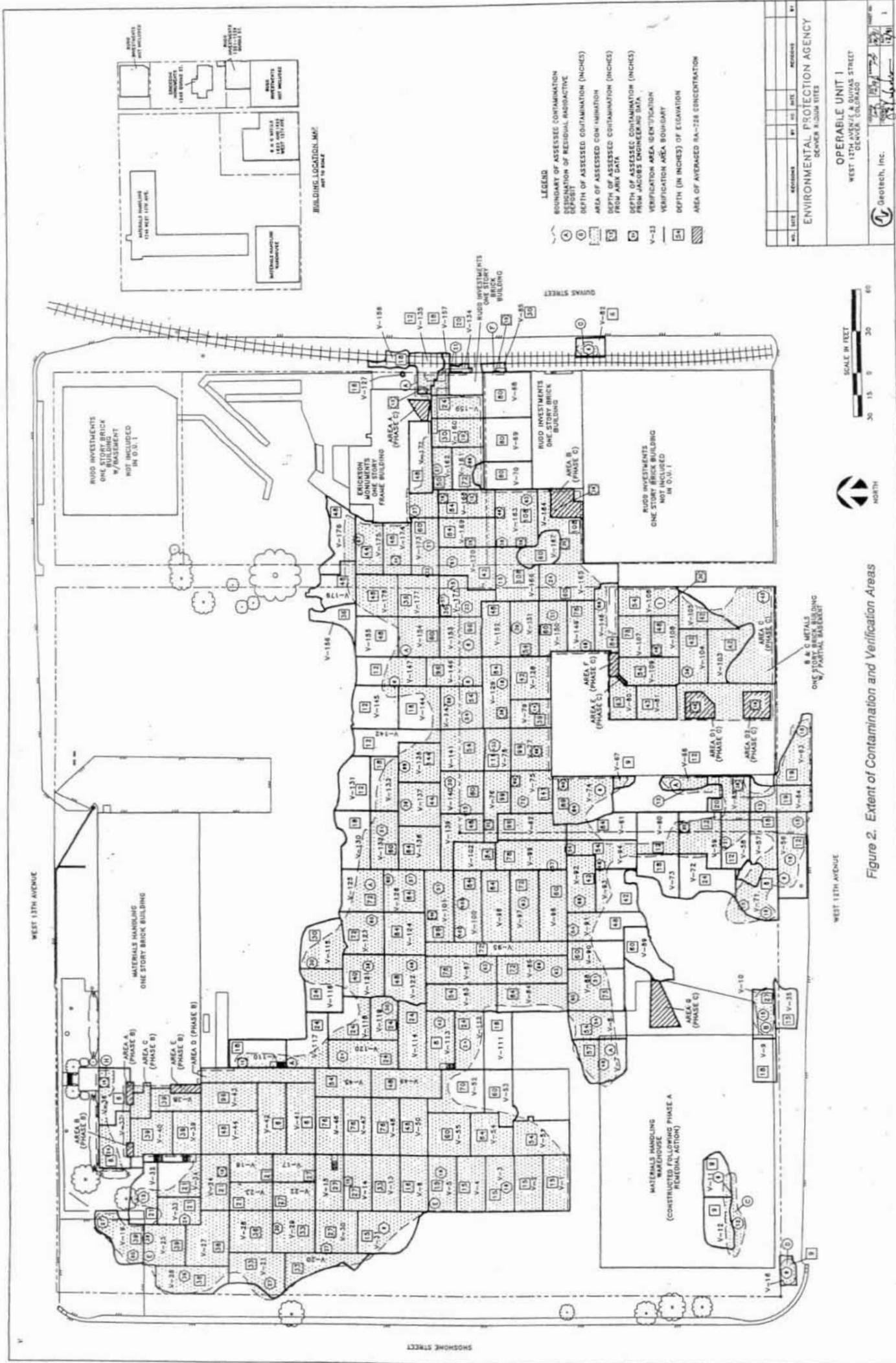


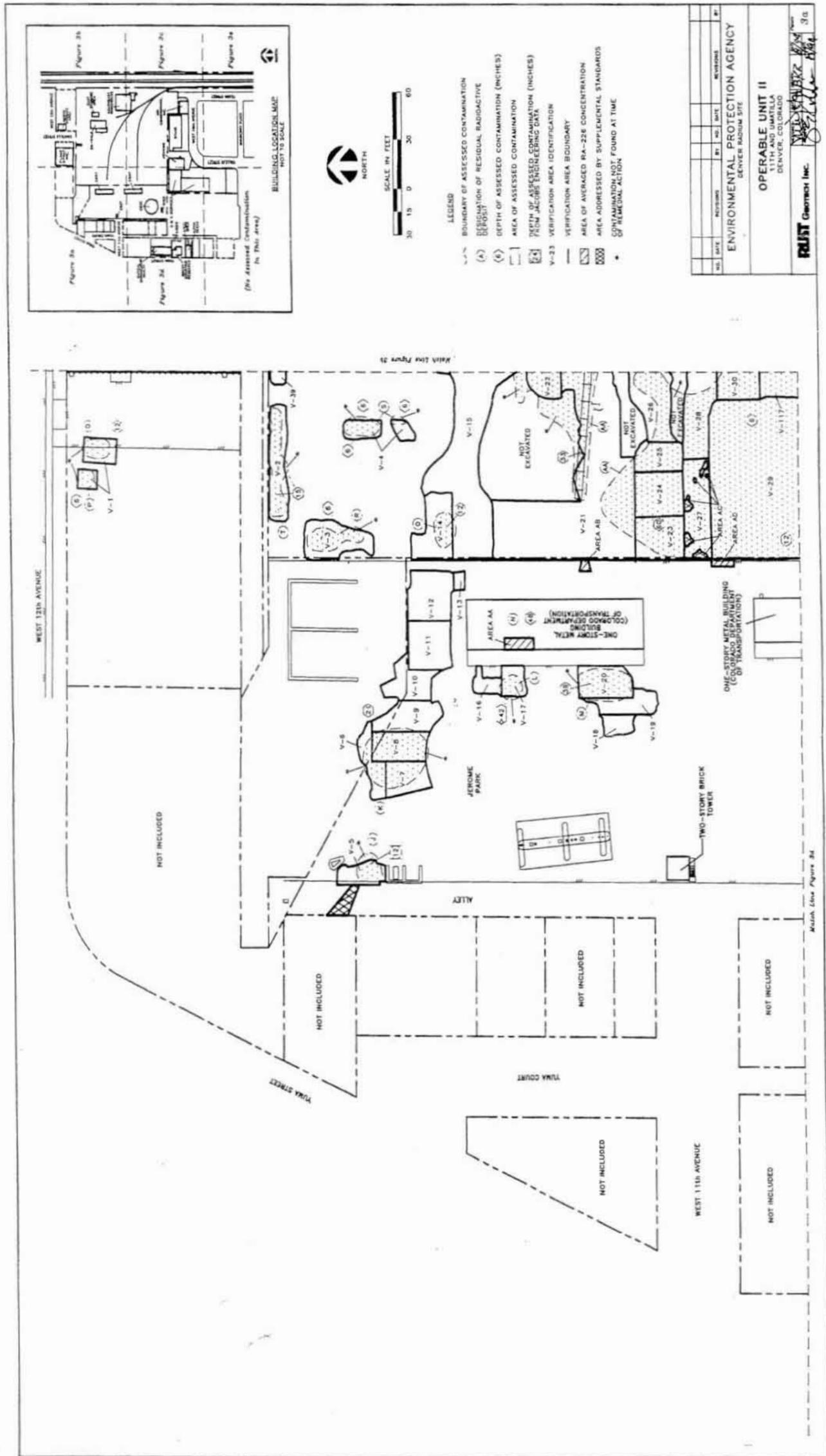
Figure 2. Extent of Contamination and Verification Areas

Source: Closocont Report 1992

Figure 2
Denver Radium Site - OUI

Waste left in place under
Area Averaging





Source: OU2 Interim Closeout Report 1994

Figure 3
Denver Radium Site - OU2

 Waste left in place under Supplemental Standards

 Waste left in place under Area Averaging

NO. DATE	DESCRIPTION	BY	DATE	REVISIONS

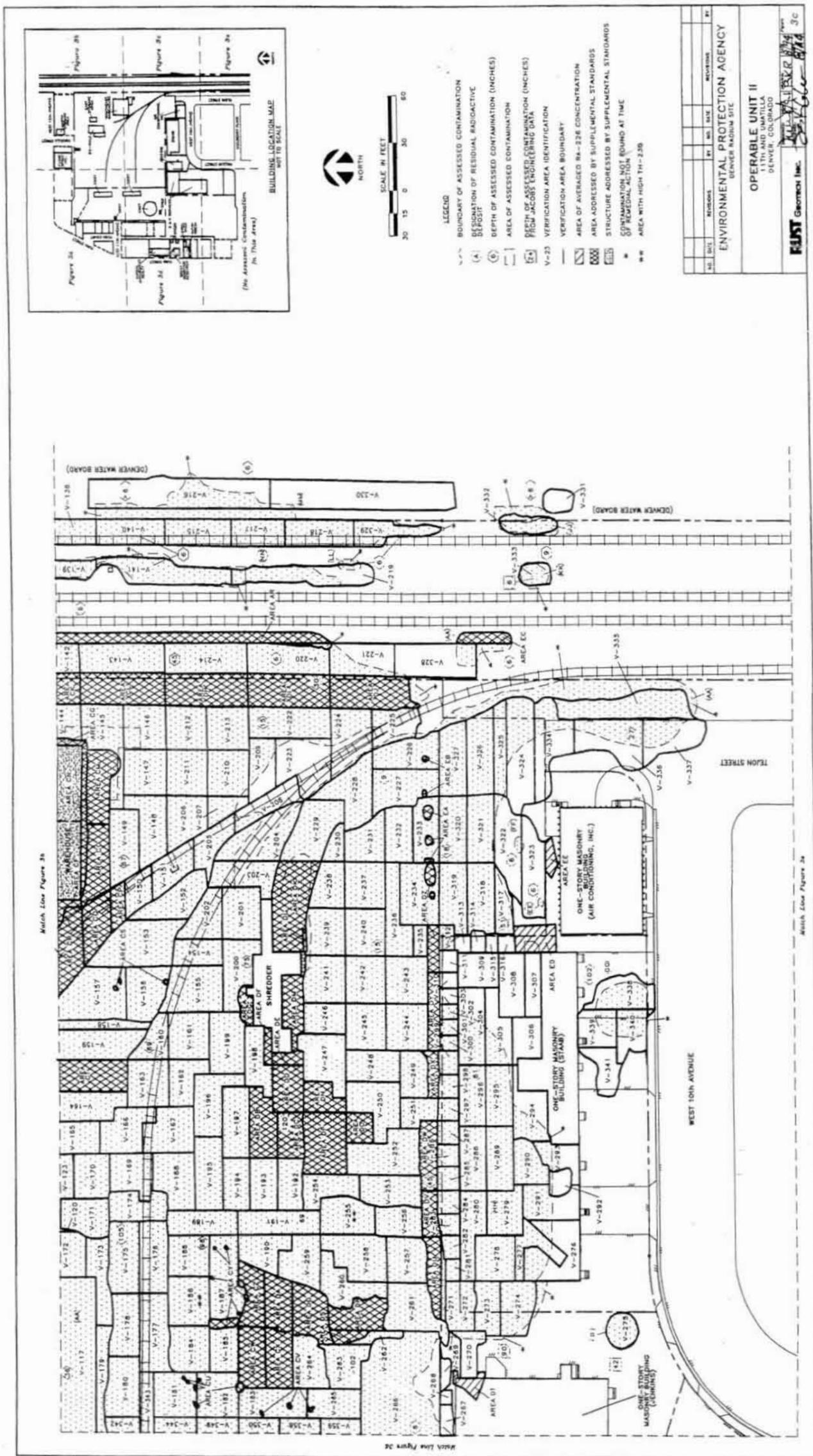
OPERABLE UNIT II
11TH AND UMATILLA
DENVER, COLORADO

ENVIRONMENTAL PROTECTION AGENCY
DENVER RADIUM SITE

RAST Geomark Inc.

- LEGEND**
- V-25 BOUNDARY OF ASSESSED CONTAMINATION
 - (A) BOUNDARY OF RESIDUAL RADIONUCLIDE
 - (B) DEPTH OF ASSESSED CONTAMINATION (INCHES)
 - (C) AREA OF ASSESSED CONTAMINATION
 - (D) AREA OF ASSESSED CONTAMINATION FROM ALIQUOT SAMPLING DATA
 - V-23 VERIFICATION AREA IDENTIFICATION
 - VERIFICATION AREA BOUNDARY
 - AREA OF AVERAGED RA-226 CONCENTRATION
 - AREA ADDRESSED BY SUPPLEMENTAL STANDARDS
 - CONTAMINATION FOUND AT TIME

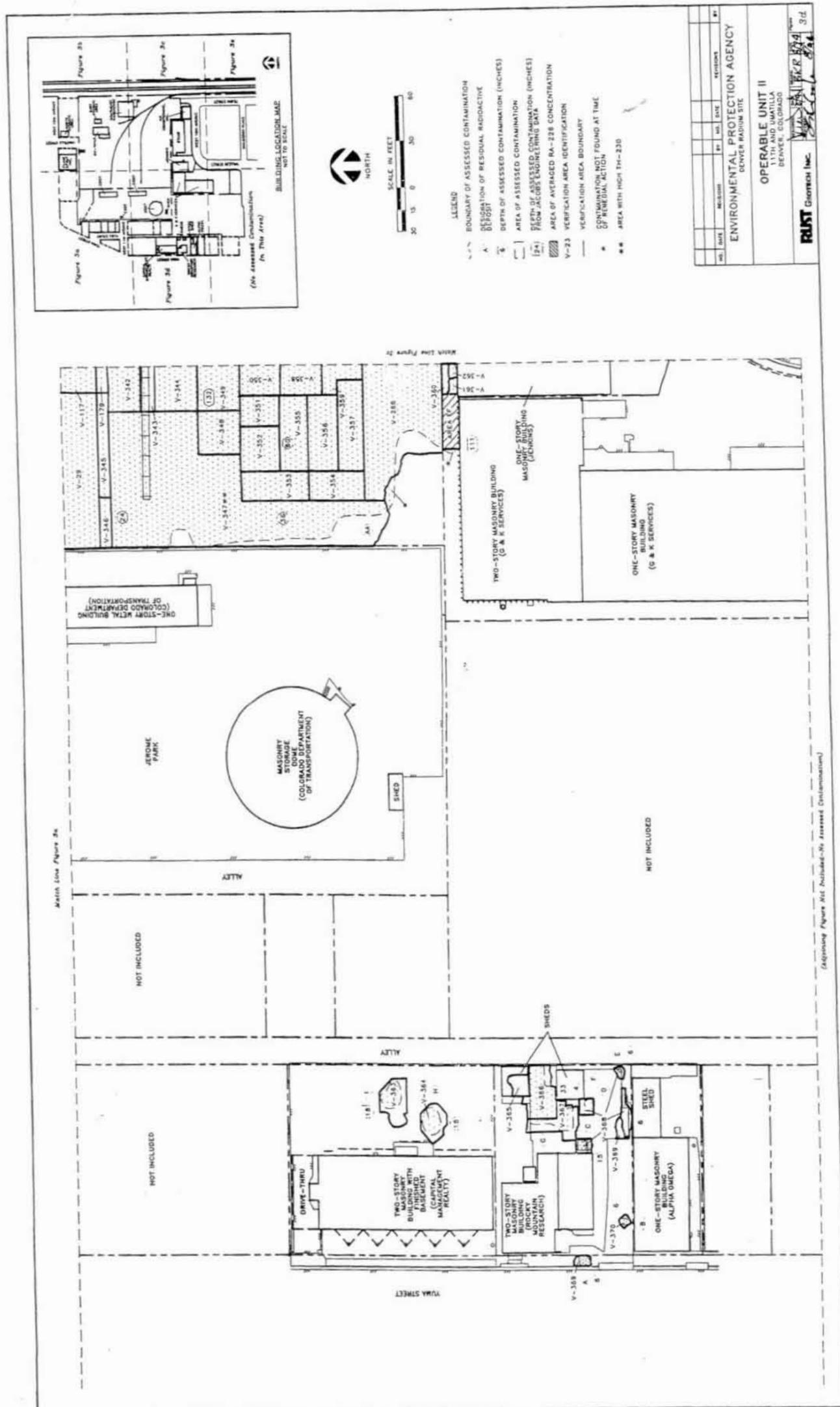




Source: OU2 Interim Closeout Report 1994

Figure 5
Denver Radium Site - OU2

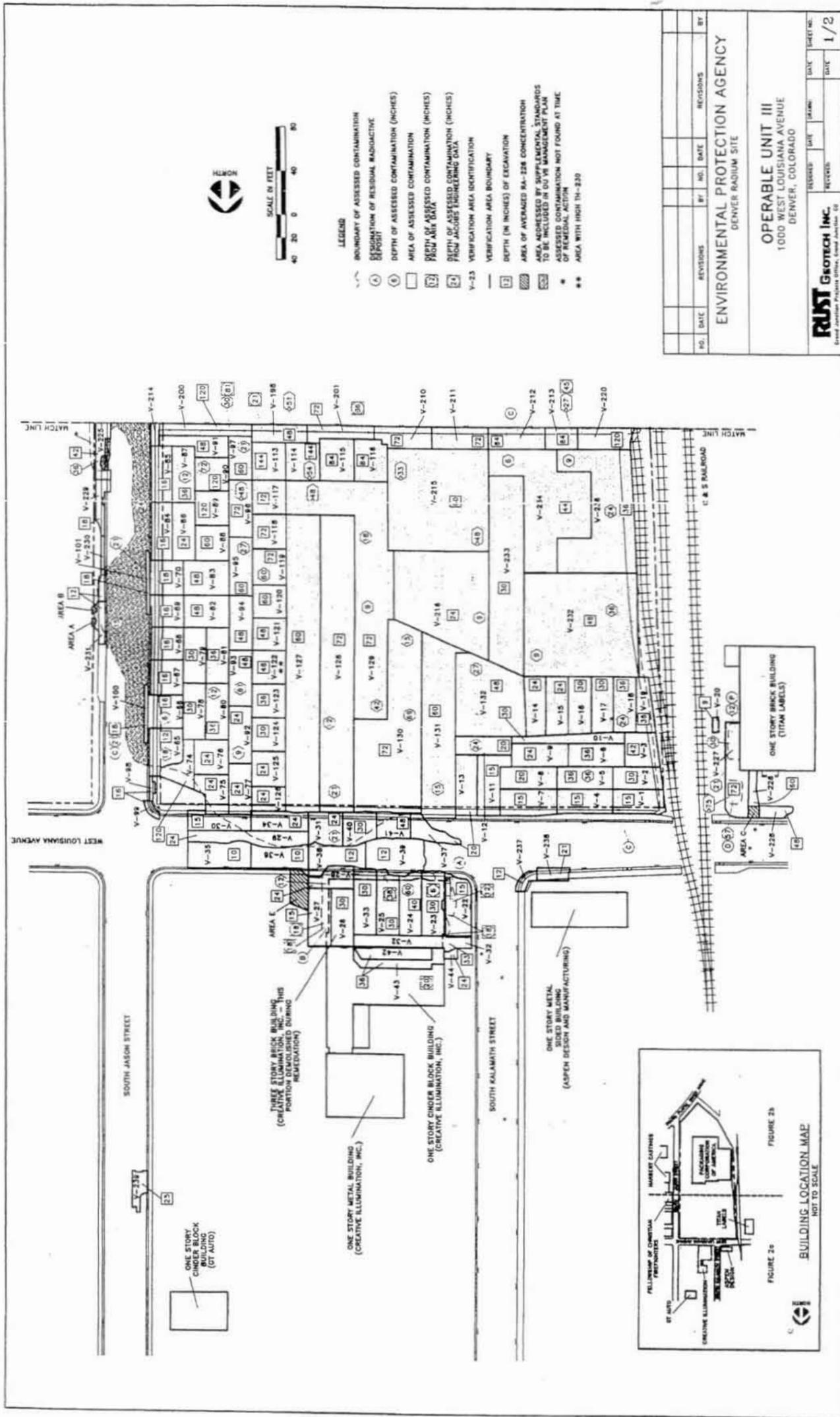
-  Waste left in place under Supplemental Standards
-  Waste left in place under Area Averaging



Source: OU2 Interim Closeout Report 1994

Figure 6
Denver Radium Site - OU2

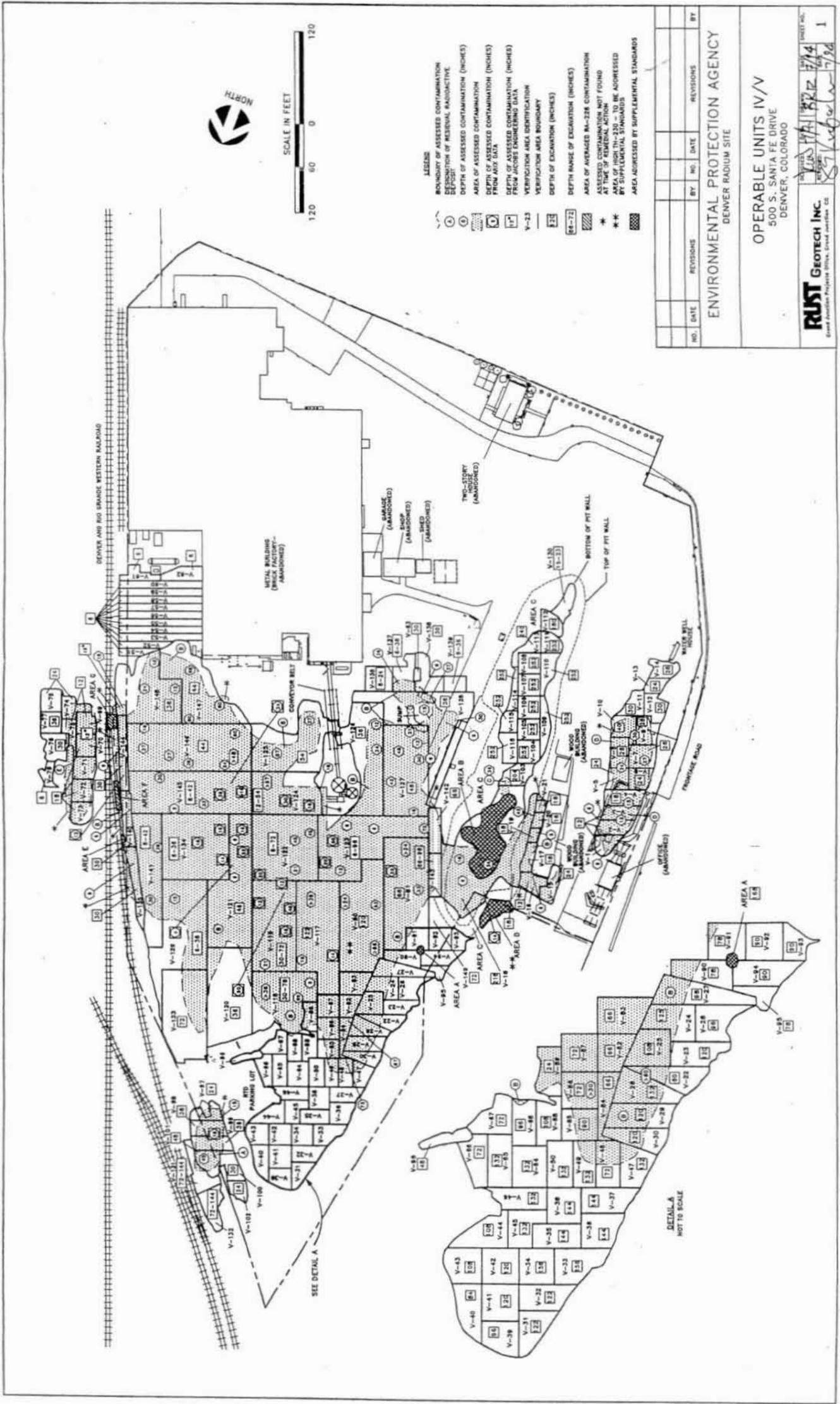
Waste left in place under Area Averaging



Source: OUI3 Interim Closeout Report 1994

Figure 8
Denver Radium Site - OUI3

Waste left in place under Area Averaging



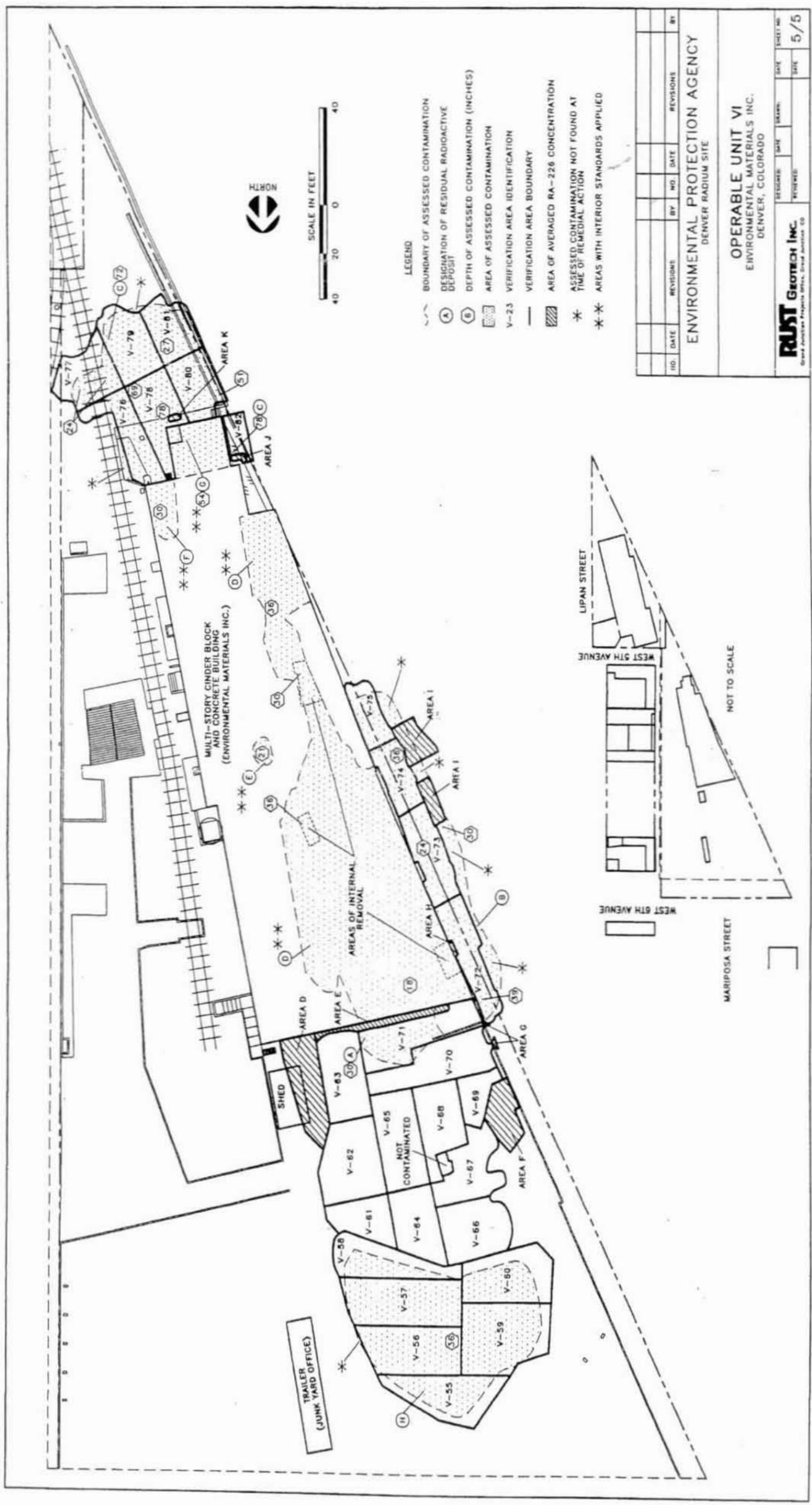
Source : Interim Closeout Report 1994

Figure 10
Denver Radium Site – OU4 and OU5

Waste left in place under Supplemental Standards

Waste left in place under Area Averaging

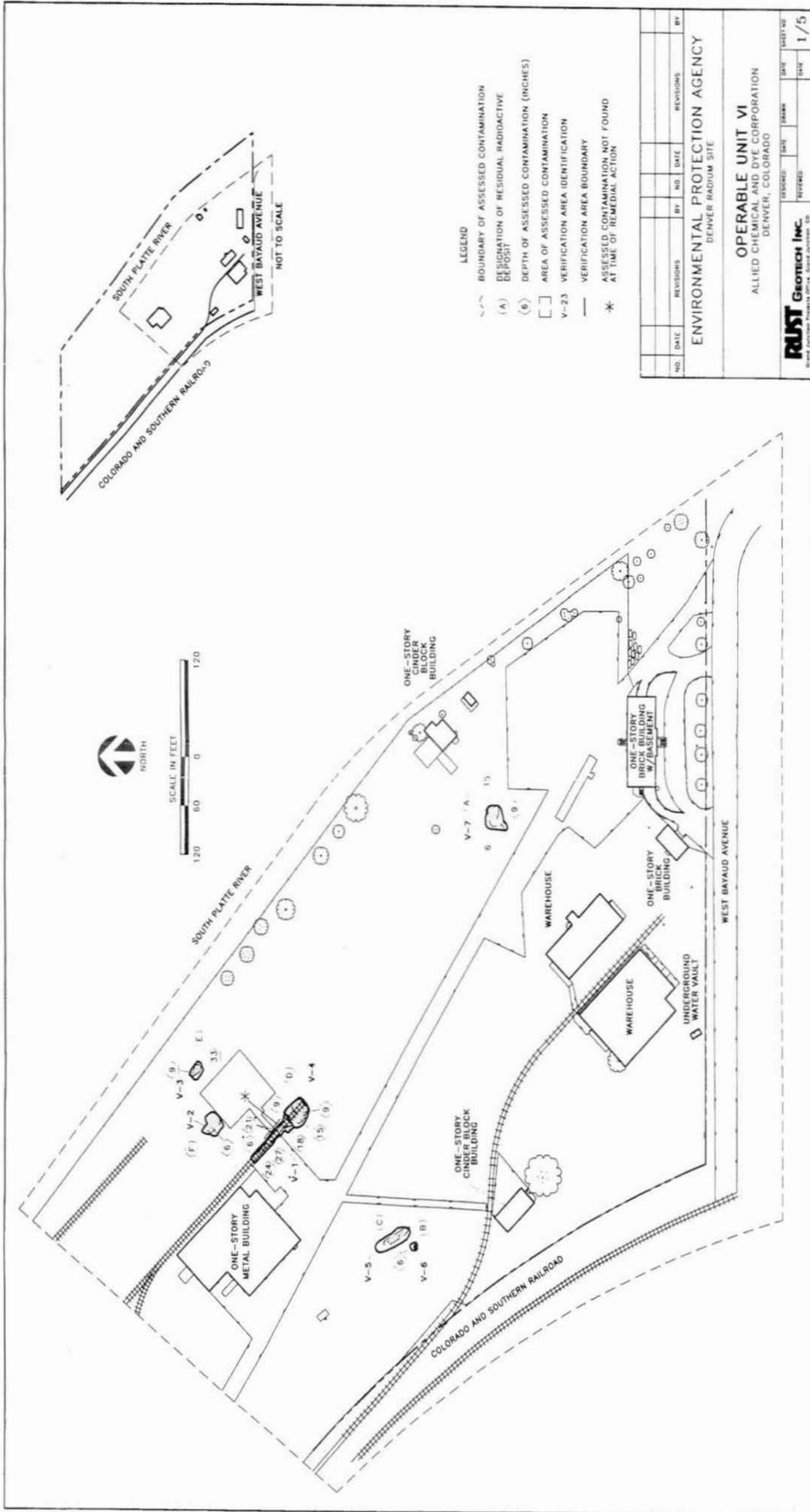




Waste left in place under Area Averaging

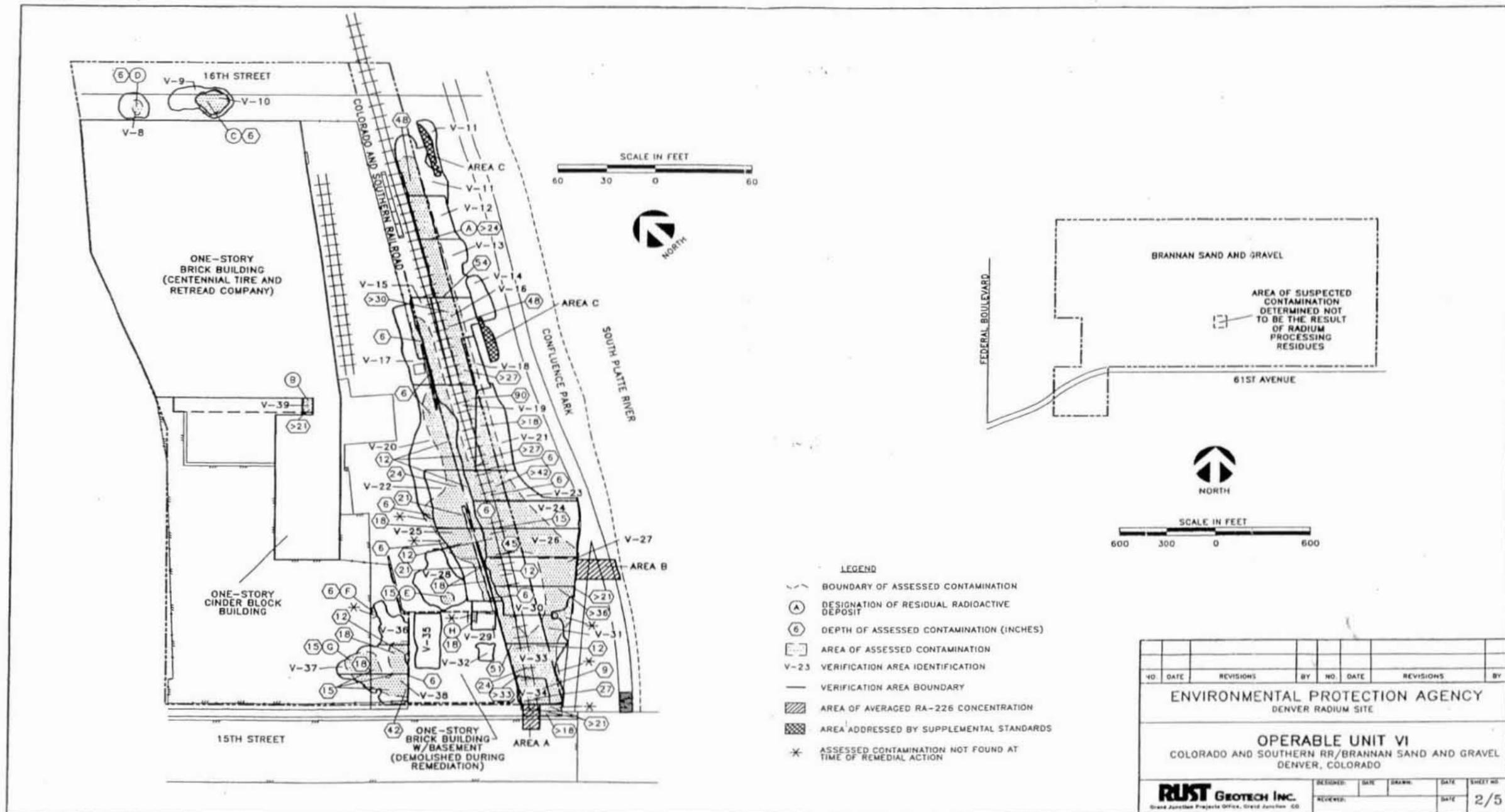
Figure 11
Denver Radium Site - OU6

Source: OU6 Interim Closeout Report 1994



Source:OU6 Interim Closeout Report 1994

Figure 12
Denver Radium Site – OU6



- Waste left in place under Supplemental Standards
- Waste left in place under Area Averaging

Figure 13
Denver Radium Site - OU6

Source: OU6 Interim Closeout Report 1994

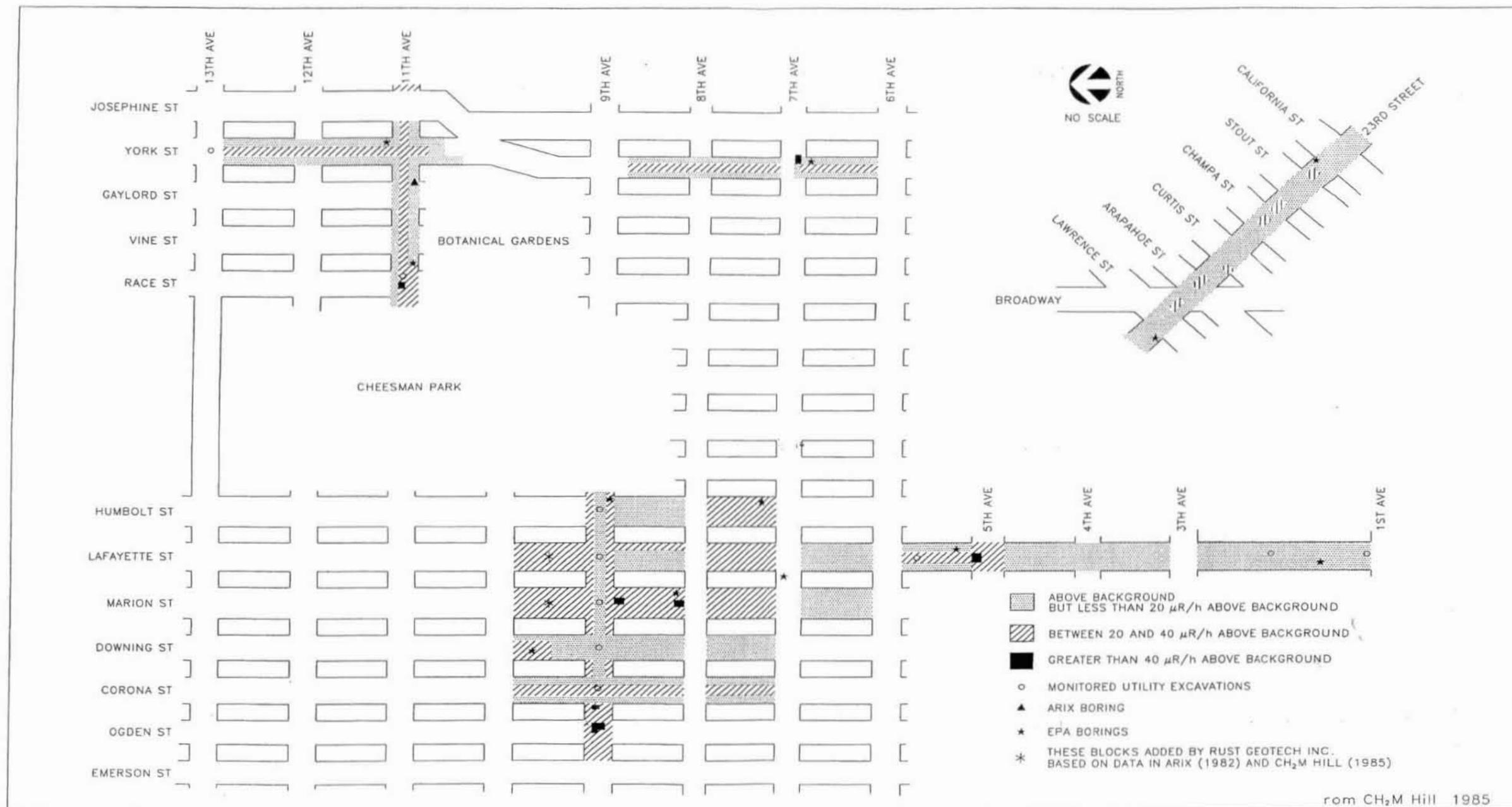


Figure 16
Denver Radium Site – OU7 - Denver Streets

Source: Interim Closeout Report OU7 1994

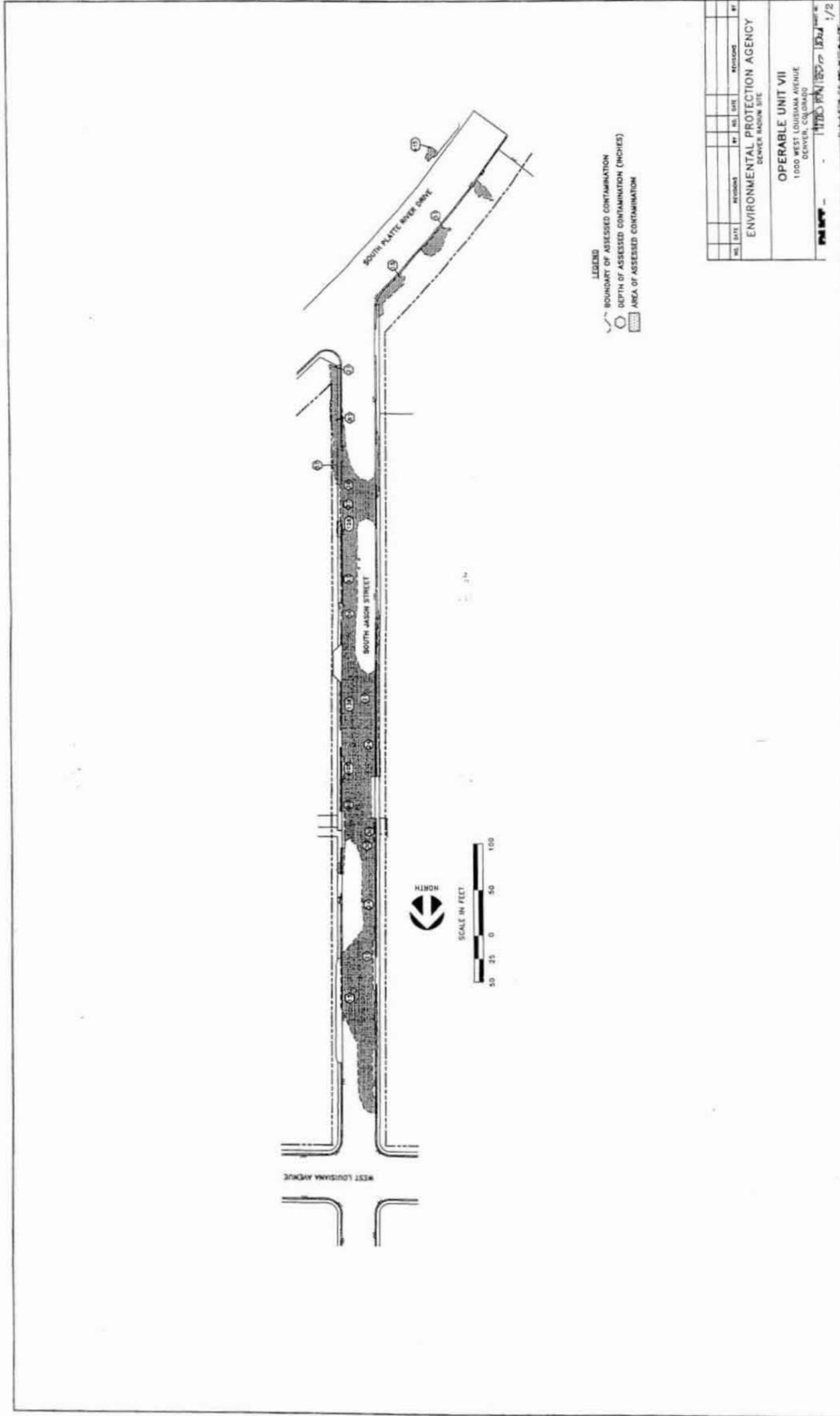


Figure 17 *Source: Interim Closeout Report OU7 1994*
Denver Radium Site – OU7 – Denver Streets



LEGEND

- DSE-1 APPROXIMATE MONITORING WELL LOCATION
- BANNOCK STREET SITE BOUNDARY
- CELL OUTLINE
- VICINITY PROPERTIES

SCALE
FEET
0 100 200

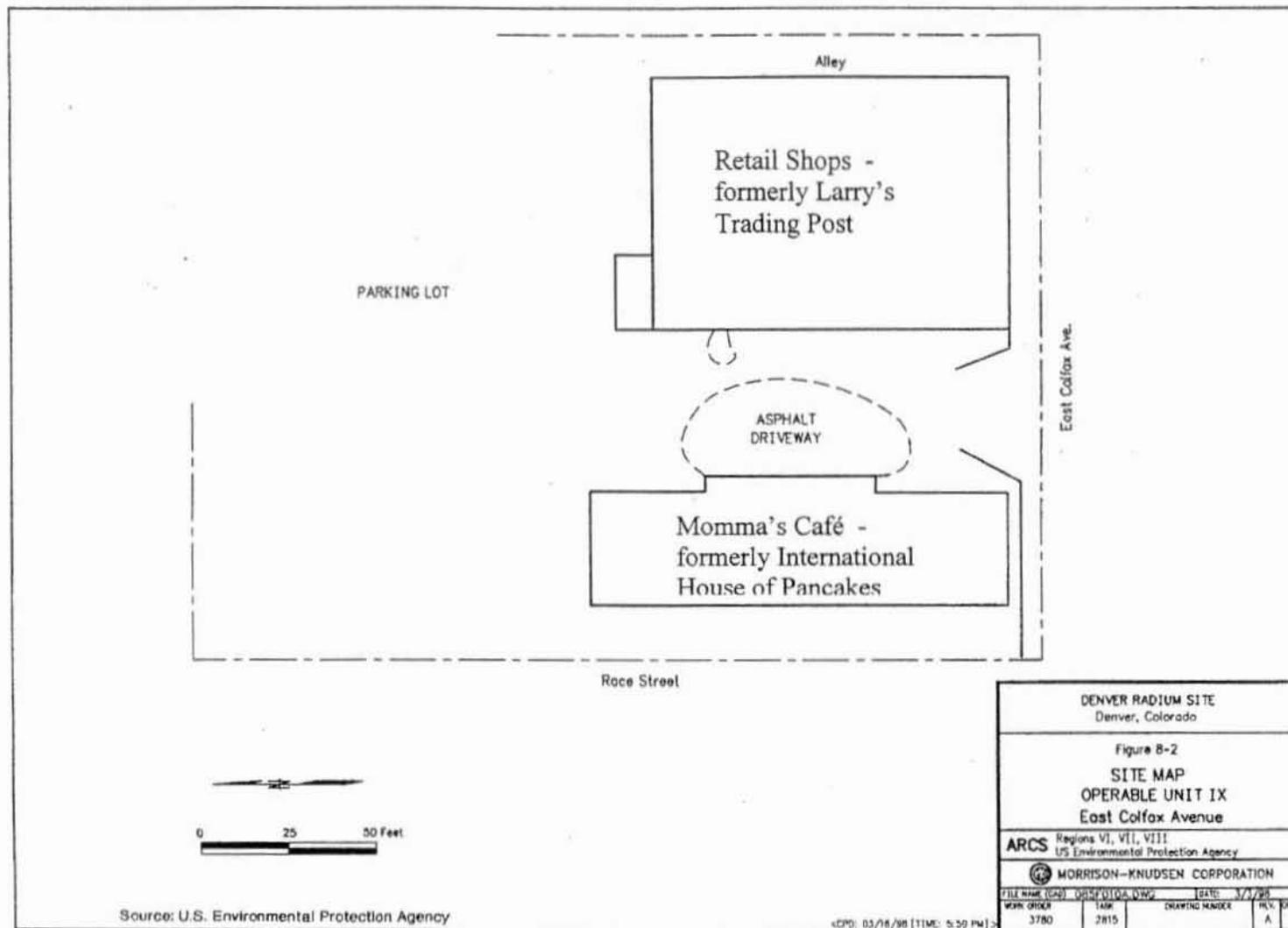
DENVER RADIUM SITE
Denver, Colorado

Figure 10-1
SITE MAP
OPERABLE UNIT VIII
1805 South Bannock Street
Region VI, VII, VIII
ARCS
US Environmental Protection Agency

MORRISON-KNUDSEN CORPORATION
DATE: 10/20/98 TIME: 11:00 AM

Source: Draft Five Year Review 1998

Figure 18
Denver Radium Site – OU8



Source: U.S. Environmental Protection Agency

<CP>: 03/16/98 [TIME: 5:59 PM]

Figure 20
Denver Radium Site – OU9a

Source: Denver Radium 5-Year Review 1998



KEY MAP

LEGEND

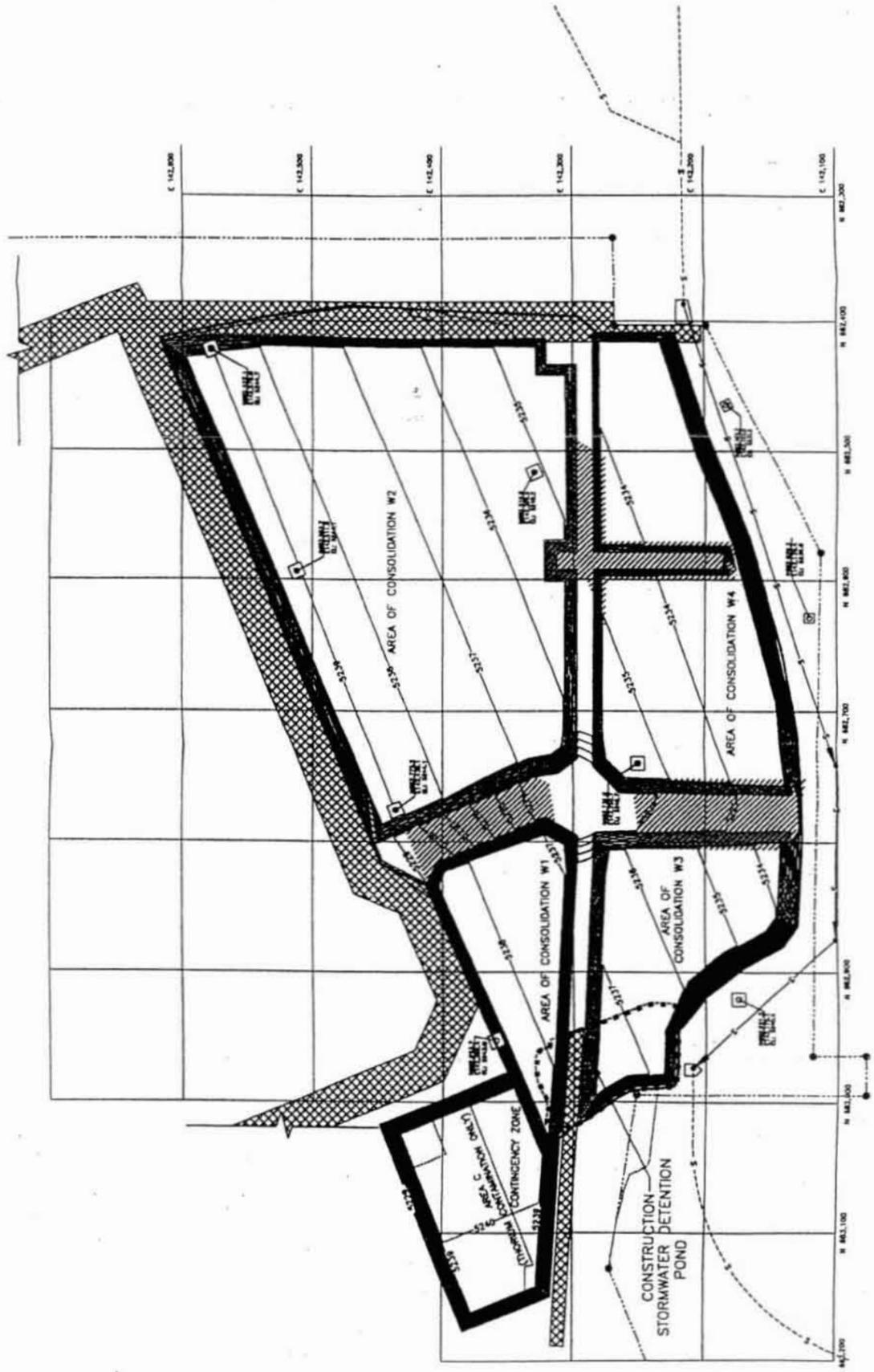
- UTILITY TRENCH BY OTHERS
- TOP OF SOIL EXCEEDING SITE SPECIFIC CRITERIA WHERE CUT IS REQUIRED.
- EXISTING 48" TERRACOTTA SANITARY SEWER (TO BE DEMOLISHED/CLOSED IN PLACE)
- NEW 36" RCP SANITARY SEWER
- TOP OF PROPOSED UTILITY TRENCH
- BOTTOM OF PROPOSED UTILITY TRENCH
- PROPERTY LINE
- TOP OF SOIL CAP (END OF PHASE 4)

- LIGHT POLE BASE (TO BE INSTALLED PRIOR TO PLACEMENT OF STRUCTURAL FILL)
- LIGHT POLE BASE (TO BE INSTALLED AFTER PLACEMENT OF STRUCTURAL FILL)

MEANS: LOCATION OF CENTER OF LIGHT POLE BASE. ELEVATION AT TOP OF CONCRETE PEA

NOTES

- 1) CONSOLIDATION CONTINGENCY ZONE TO BE CONSTRUCTED AT END OF PHASE 4/BEFORE OF PHASE 5. BY PHASE 5 CONTRACTOR (IF CONTINGENCY CAPACITY IS REQUIRED).
- 2) TOTAL SURFACE AREA OF CAP FOR AREA OF CONSOLIDATION IS 25,800 SQUARE YARDS (INCLUDING CONTINGENCY ZONE)



SCALE IN FEET
0 30 60

Source: ERM-Rocky Mountain, Inc.

DATE: 03/09/98 (TIME: 5:14 PM)

DENVER RADIUM SITE Denver, Colorado	
Figure 11-2	
AREAS OF CONSOLIDATION OPERABLE UNIT IX	
500 South Santa Fe Drive Regina VI, VI, VIII	
ARCS US Environmental Protection Agency	
FILE NAME: 030998.DWG	DATE: 03/09/98
USER: MORRISON-KNUDSEN CORPORATION	WORK NUMBER: 3780
DATE PLOTTED: 03/09/98	SCALE: 1"=30'
PLT: 3780	REV: A

Figure 21
Denver Radium Site – OU9B

Source: Denver Radium 5-Year Review 1998

LEGEND

PLAN VIEW OF AREA OF CONTAMINATION (A.O.C.) TO BE EXCAVATED AND MOVED TO AREA OF CONSOLIDATION

PLAN VIEW OF AREA OF CONSOLIDATION

PLAN VIEW OF AREA OF CONSOLIDATION CONTINGENCY ZONE TO BE CONSTRUCTED AT END OF PHASE I/ BEGINNING OF PHASE II, BY PHASE II CONTRACTOR (IF CONTINGENCY CAPACITY IS REQUIRED)

EXISTING 48" TERRAZCOTA SANITARY SEWER (TO BE DEMOLISHED/CLOSED IN PLACE)

NEW 36" RCP SANITARY SEWER

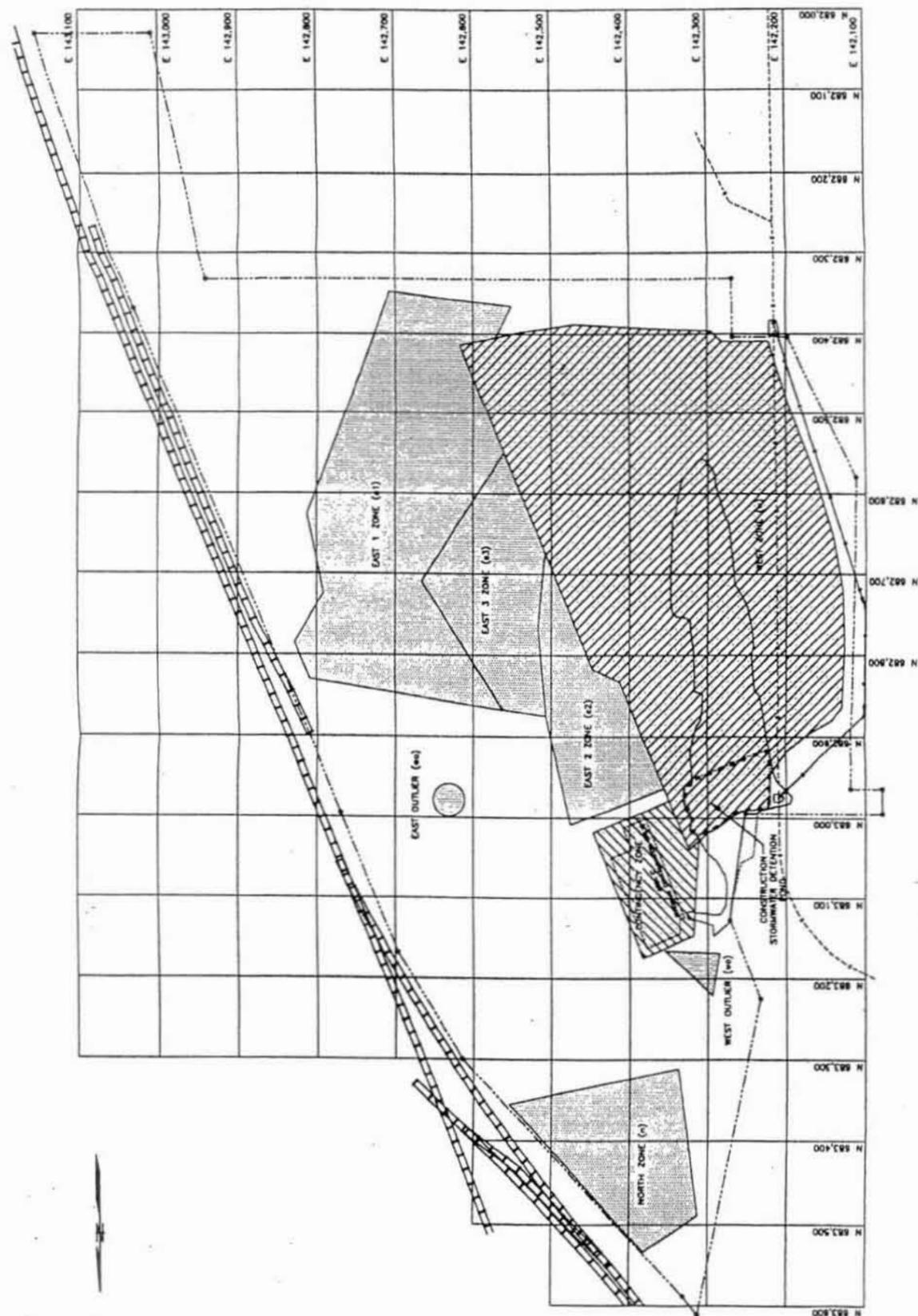
NOTES

ESTIMATED VOLUMES OF SOIL EXCEEDING SITE SCREENING CRITERIA IN:

NORTH ZONE	-	8,285	Y0-3
EAST OUTLIER	-	43	Y0-3
WEST OUTLIER	-	83	Y0-3
EAST 1 ZONE	-	8,302	Y0-3
EAST 2 ZONE	-	7,283	Y0-3
EAST 3 ZONE	-	765	Y0-3
WEST ZONE	-	24,827	Y0-3

ESTIMATED CAPACITY OF AREA OF CONSOLIDATION FOR A.O.C. TO BE EXCAVATED AND MOVED:

WEST ZONE	-	20,755	Y0-3
CONTINGENCY ZONE	-	4,270	Y0-3



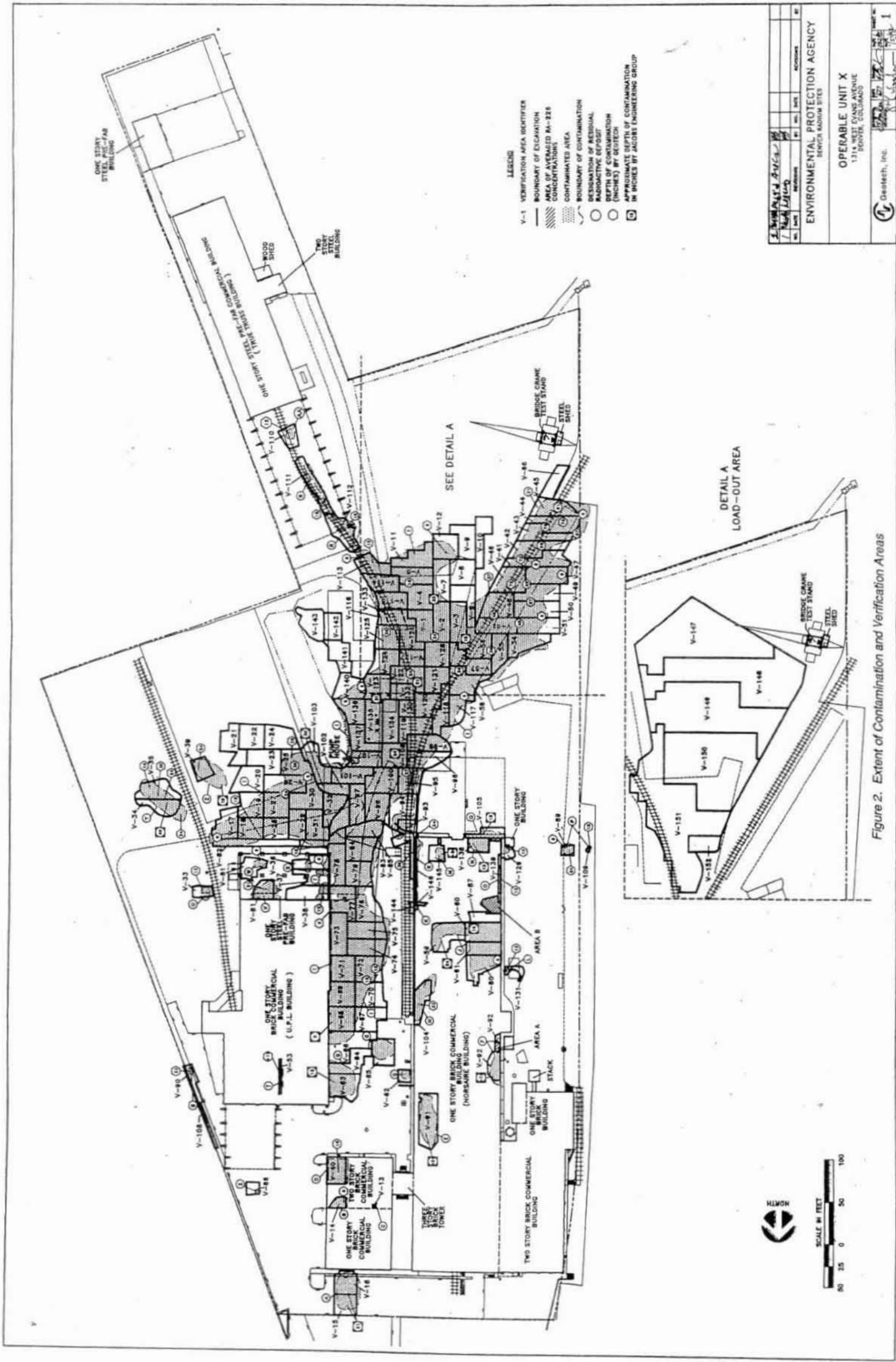
Source: ERM-Rocky Mountain, Inc.

CDP: 03/09/98 [TIME: 5:14 PM]

DENVER RADIUM SITE Denver, Colorado	
Figure 11-1 SITE MAP OPERABLE UNIT IX 500 S. Santa Fe Drive Regions VI, VII, VIII US Environmental Protection Agency	
ARCIS	MORRISON-KNUDSEN CORPORATION
FILE NAME (CAD): 08A5F002A.DWG	DATE: 3/1/98
WORK NUMBER: 3780	DATE: 2815
REV: 001/0	DATE: A

Figure 22
Denver Radium Site - OU9B

Source: Denver Radium 5-Year Review 1998



Source : Closeout Report 1992

Figure 23
Denver Radium Site – OU10

Waste left in place under
Area Averaging

