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contributed to the preparation of this document and should not
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DOE/OR/07-1985&D0
Primary Document

Record of Decision for Remedial Action for the Groundwater Operable Unit Upper Continental Recharge System Source Zones near C-720, C-747-C, and C-746-D, Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—November 2001

Prepared for the
U.S. Department of Energy
Office of Environmental Management

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
managed by
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for the
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under contract DE-AC05-98OR22700

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PREFACE

This *Record of Decision for Remedial Action for the Groundwater Operable Unit Upper Continental Recharge System Source Zones near C-720, C-747-C, and C-746-D, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1985&D0, was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act, Resource Conservation and Recovery Act, and K.R.S. 224.46-530 for documenting the selection of a preferred remedial action, or corrective measure, for a solid waste management unit. Publication of this document will meet a primary document deliverable for the U.S. Department of Energy, pursuant to the Paducah Gaseous Diffusion Plant's *Federal Facility Agreement*.

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ACRONYMS AND ABBREVIATIONS

ACO	Administrative Order by Consent
ALARA	As Low as Reasonably Achievable
AOC	Area of Concern
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
ATD123	Analytical Transient 1-, 2-, 3- Dimensional Model
BERA	baseline ecological risk assessment
BGOU	Burial Grounds Operable Unit
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CAB	Citizens Advisory Board
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COC	contaminant of concern
CPT	cone penetrometer technology
DCE	*trans*-1,1-dichloroethene
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DPE	Dual Phase Extraction
DPT	direct push technology
DWRC	Dual Wall Reverse Circulation
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
FS	feasibility study
GWOU	Ground Water Operable Unit
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
IRIS	Integrated Risk Information System
KAR	Kentucky Administrative Regulations
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
K.R.S.	Kentucky Revised Statutes
LUC	land use control
MEPAS	Multimedia Environmental Pollutant Assessment System (software)
MW	monitoring well
mcl	Maximum Contaminant Level
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
O&M	operation and maintenance

OREIS	Oak Ridge Environmental Information System
OU	operable unit
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
Ppb	Parts Per Billion
PRAP	proposed remedial action plan
POE	Point of Exposure
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
RAOs	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactivity Computer Code
RfD	reference dose
RGA	Regional Gravel Aquifer
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SESOIL	Seasonal Soil Compartment Model
SF	slope factor
SI	site investigation
SPH	Six-Phase Heating
SOU	Soils Operable Unit
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TBC	To Be Considered
^{99}Tc	technetium-99
T&E	threatened and endangered
TCE	trichloroethene
TCL	Target Compound Level
Trans-1,2-DCE	trans-1,2-Dichloroethene
TSCA	Toxic Substances Control Act
UCRS	Upper Continental Recharge System
VC	vinyl chloride
U.S.C.	United States Code
UST	underground storage tank
VOC	volatile organic compound
WAG	waste area group
WKWMA	West Kentucky Wildlife Management Area

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PART 1.

DECLARATION

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DECLARATION FOR THE RECORD OF DECISION FOR REMEDIAL ACTION FOR THE GROUNDWATER OPERABLE UNIT UPPER CONTINENTAL RECHARGE SYSTEM SOURCE ZONES NEAR C-720, C-747-C, AND C-746-D

SITE NAME AND LOCATION

Upper Continental Source Zones near C-720, C-747-C, and C-746-D
Groundwater Operable Unit
Paducah Gaseous Diffusion Plant
U.S. Department of Energy
Paducah, Kentucky

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Groundwater Operable Unit (GWOU) Upper Continental Recharge System (UCRS) source zones near C-720, C-747-C Oil Landfarm (SWMU 1) and C-746-D Scrap Yard (SWMU 99) at the Paducah Gaseous Diffusion Plant (PGDP) near Paducah, Kentucky. This remedial action was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision is based on the Administrative Record (AR) file for this site.

In addition, this decision document has been prepared in accordance with paragraph II E.2 of the *Secretarial Policy Statement on the National Environmental Policy Act* (NEPA) (DOE 1994) which states, "To facilitate meeting the environmental objectives of CERCLA and to respond to concerns of regulators, consistent with the procedures of most other Federal agencies, the DOE hereafter will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures as provided below...Department of Energy CERCLA documents will incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable."

A Feasibility Study (FS) for the GWOU was submitted to the U.S. Environmental Protection Agency (EPA) and Commonwealth of Kentucky on August 27, 2001 (DOE 2001). The FS provided an evaluation of alternatives for remediation of various UCRS sources for the GWOU. In addition, a Proposed Remedial Action Plan (PRAP) was submitted to the EPA and Commonwealth of Kentucky on November 2, 2001. The Commonwealth of Kentucky concurs with the U.S. Department of Energy (DOE) and the EPA on the selected remedial action. This action will serve as an incremental step toward comprehensively addressing problems within GWOU. Since the GWOU is extensive, multiple actions are planned. At a minimum, these multiple actions will focus on remediation of (a) on-site sources [including secondary sources such as dense nonaqeous-phase liquids (DNAPL)], (b) dissolved-phase groundwater plumes, (c) potential "fenceline" containment or treatment actions, and (d) institutional controls for groundwater. This Record of Decision (ROD) represents the first of five RODs currently planned for the GWOU and focuses on trichlorethene (TCE) source reduction within the UCRS at the C-720 Building and the Oil Landfarm (SWMU 1) and technetium 99 (^{99}Tc) source reduction at the C-746-D Scrap Yard (SWMU 99).

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ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the UCRS source zones near C-720, C-747-C (Oil Landfarm), and C-746-D Scrap Yard(SWMU 99), if not addressed by implementing the response action selected in this ROD for remedial action, will continue to present an endangerment to public health, welfare, or the environment.

DESCRIPTION OF SELECTED REMEDY

Source units and areas of contamination at the PGDP have been combined into four operable units (OUs) for evaluation of remedial actions. These OUs include the Surface Water OU (SWOU), Burial Grounds OU (BGOU), Soils OU (SOU) and GWOU. Each OU is designed to remediate an area and contaminated media associated with the PGDP. The UCRS source zones near C-720 Area, C-747-C Oil Landfarm, and C-746-D Scrap Yard (SWMU 99) are within the scope of the GWOU. This OU consists of units that primarily contain or cause groundwater contamination.

The primary objectives for the remedial action are to do the following:

- Reduce volatile organic compound (VOC) contamination in UCRS soil at SWMU 1 and the C-720 Building to levels that no longer would result in unacceptable contaminant levels in groundwater at the point of exposure based on the industrial use scenario;
- Excavate soil and concrete at SWMU 99 to an approximate depth of 3 ft to prevent ^{99}Tc within the excavated soil and concrete from migrating from this source and potentially impacting the groundwater treatment system for the Northeast Plume; and
- Reduce or eliminate migration of contaminants to groundwater to speed the return of groundwater resources to beneficial use.

The major components of the selected remedy include the following:

- Removal and treatment of VOC-contaminated UCRS groundwater from C-720 and C-747-C (Oil Landfarm) areas using Six-Phase Heating (SPH);
- Removal and treatment of vadose zone VOCs from C-720 and C-747-C areas using SPH;
- Excavation of contaminated concrete and soil from the C-746-D (SWMU 99);
- Implementation of Land Use Controls (LUCs) at C-720, C-747-C, and C-746-D; and
- Completion of five-year reviews for the areas, since residual contamination will remain in place following the remedial actions.

The EPA and Kentucky Department for Environmental Protection (KDEP) have participated in the development of this ROD, including review and comment on the content of the document.

STATUTORY DETERMINATIONS

This remedial action satisfies the mandates of CERCLA §121 and the requirements of the National Contingency Plan (NCP) (i.e., protective of human health and the environment, compliant with federal and state applicable or relevant and appropriate requirements for the scope of this limited action, and cost effective). In addition, this remedial action is consistent with Resource Conservation and Recovery Act corrective action requirements that otherwise would be obligated under the Hazardous and Solid Waste Amendments (HSWA) Permit for these SWMUs. This remedial action would directly address the statutory preference for treatment of principal threat wastes at C-747-C and C-720. Since this remedy will result in hazardous substances potentially remaining at the units, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after commencement of the remedial action. In addition, this remedial action requires implementation of long-term LUCs.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the AR file for this site.

- Chemicals of concern (COC) and their respective concentrations
- Baseline risk represented by the chemicals of concern
- Clean-up levels established for chemicals of concern and the basis for these levels
- How source materials constituting principal threats are addressed
- Current and reasonably anticipated future land use assumptions
- Estimated cost of the remedial action
- Key factors that led to selecting the remedy

____ Date____________________________

Rodney R. Nelson
Assistant Manager for Environmental Management
U.S. Department of Energy

____ Date____________________________

Dick Green
Regional Administrator
U.S. Environmental Protection Agency, Region 4

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PART 2.

DECISION SUMMARY

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DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The PGDP (site EPA ID KY8890008982) is located in McCracken County in western Kentucky, about 6.5 kilometers (4 miles) south of the Ohio River and approximately 16 kilometers (10 miles) west of the city of Paducah. This ROD addresses shallow soil and groundwater contamination at the C-747-C Oil Landfarm (SWMU 1), the C-746-D Scrap Yard (SWMU 99), and the C-720 Area. The C-747-C and C-720 Areas are located in the southwest portion of the PGDP within the plant security fence and C-746-D is located on the eastern side of the PGDP, also within the plant security fence.

The DOE is the owner and lead agency of the PGDP cleanup activities. Both the EPA and the Commonwealth of Kentucky are oversight agencies to environmental restoration of the PGDP under the Paducah *Federal Facility Agreement*. Funding for this cleanup at the PGDP is derived from federal appropriations for the DOE.

The PGDP is a uranium enrichment facility that has been in operation since 1952 to supply fuel for commercial nuclear reactors. Most industrial activities are sited in a 304 hectare (750 acre) security area and buffer zone that have restricted access to the general public. This secured area is located on 1,457 hectares (3,600 acres) controlled by DOE.

The C-747-C Oil Landfarm was used for the biodegradation of contaminated waste oils from 1975 to 1979 and later was designated as SWMU 1. The C-746-D Scrap Yard is the foundation of the former Kellogg Building Site, a steel and sheet metal fabrication building, built in 1951 and used as temporary support facilities during the construction of the PGDP. The building was demolished in 1955 and has been designated as SWMU 99. The remaining part of SWMU 99 is a septic tank and a leach field that received sanitary waste from the Kellogg Buildings and is located approximately 350 to 400 ft southeast of C-746-D. The C-720 Building has been used since the early 1950s for the fabrication, assembling, cleaning, and repairing of process equipment as well a supply warehouse.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

After the discovery of off-site groundwater contamination at the PGDP, the EPA entered into an Administrative Order by Consent (ACO) with the DOE on November 23, 1988, pursuant to the CERCLA (EPA 1988). The ACO required the DOE to monitor the residential wells, provide an alternate drinking water source to affected residents, identify the nature and extent of contamination, and take action to protect human health and the environment.

The DOE has undertaken several actions subsequent to the ACO to protect the neighboring population potentially affected by the groundwater contamination and to stop the off-site migration of high concentration cores of groundwater contamination. These actions have included two July 1993 documents, an Engineering Evaluation/Cost Analysis (EE/CA) for the Water Policy at the Paducah Gaseous Diffusion Plant (DOE 1993a) and a Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant (DOE 1993b), as well as a June 1995 document entitled Record of Decision for Interim Remedial Action at the Northeast Plume (DOE 1995a). The Water Policy provided municipal water service to all existing private residences and businesses within the projected migration area of contaminated groundwater.

When in use, the C-747-C Oil Landfarm, was plowed to a depth of 0.3 to 0.6 m (1 to 2 ft), and then waste oils, contaminated with TCE were spread across the surface. It is estimated that approximately 19,000 L (5,000 gal) of waste oil were applied to the landfarm, with the oil being added to the plots at 3- to 4-month intervals (CH2M HILL 1992). Although sources of the waste oils are not reported, it is assumed that they were derived from virtually all areas of the plant. Periodically, lime and fertilizers were plowed into the soil to promote the biodegradation of contaminants. At one time, a layer of gravel was placed below the soil in the landfarm to improve drainage. After use of the landfarm was discontinued in 1979, a minimal cover [<30 cm (<12 inches)] was placed over the two disposal plots (DOE 1999a).

A CERCLA Site Investigation (SI) studied potential soil and groundwater contamination at C-747-C in 1991 and 1992 (CH2M HILL 1992). Additional sampling performed in March 1996, as part of the Waste Area Group (WAG) 23 project, resulted in the delineation of polychlorinated biphenyl (PCB) and dioxin contamination in surficial soils at the unit (DOE 1996). In January and February 1998, DOE conducted a non-time-critical removal action to excavate the PCB and dioxin contamination found above cleanup levels in surficial soils at C-747-C (DOE 1998). The subsurface soil and groundwater contamination found at the unit during the SI was delineated as part of the WAG 27 Remedial Investigation (RI) completed in 1998 (DOE 1999a). No actions have been taken to address groundwater contamination at C-747-C. The WAG 27 RI samples identified a source zone of VOCs in the shallow subsurface of C-747-C.

The C-746-D Scrap Yard orininally was the site of a steel and sheet metal fabrication building built in 1951 as temporary support facilities during the construction of the cascade facilities. A similar building was situated immediately to the east. Both buildings, sometimes referred to as the Kellogg Facility, were erected on concrete slabs with a gravel access road between them. No other information is available regarding the construction and design of the facility. The Kellogg Buildings were taken out of service and demolished in 1955, leaving only the concrete pads.

The eastern building pad is currently used as the C-745-E UF_6 Cylinder Storage Yard. The western pad, C-746-D, is used for the storage of equipment and aluminum ingots and often is referred to as the C-746-D Scrap Yard (SWMU 99).

No previous remedial actions have been taken at C-746-D. Soil and groundwater samples collected from the area as part of the Phase II SI (CH2M HILL 1992) did not identify sources of groundwater contamination. The area later was included in the WAG 28 RI (DOE 2000a). A single sample of backfill material from a storm sewer pipe located adjacent to C-746-D revealed ^{99}Tc contamination. This contamination is thought to be the source of increasing levels of ^{99}Tc in groundwater evidenced in the Northeast Plume downgradient of C-746-D.

The C-720 Building was constructed in the early 1950s. Various shops housed within the C-720 Building include the compressor shop, machine shop, paint shop, instrument shop, vacuum pump shop, welding shop, and valve shop. The building is also used as a warehouse for general plant supplies. The C-720 Building has not had any previous remedial actions.

The WAG 27 RI (DOE 1999a) included C-720 among the areas studied as potential sources to the PGDP's Southwest Plume. Soil and groundwater samples identified source zone areas of contamination by VOCs in the shallow subsurface. These appear to be associated with the connection points of the building drainage system to the plant storm sewer system and a discrete area north of the east end of the C-720 Building where cleaning of parts routinely was undertaken.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The FS and PRAP for GWOU at the PGDP in Paducah, Kentucky, were made available to the public on November 2, 2001. They can be found in the AR file and information repository maintained at the Region 4 EPA Docket Room in the Paducah Public Library. The notice of availability of these two documents was published in a regional newspaper, *The Paducah Sun*, November 2 2001. A public comment period was held from November 2, 2001 to December 17, 2001.

Specific groups that received individual copies of the PRAP include the Natural Resource Trustees and the PGDP Citizens Advisory Board (CAB). A public meeting will be held in XX, 2001 [dates to be determined] if requested.

2.4 SCOPE AND ROLE OF THE OPERABLE UNIT

The GWOU is one of four OUs at the PGDP being used to evaluate and implement remedial actions. The scope of this response action encompasses three areas containing surface and subsurface sources contributing to contamination of the GWOU. Its role is to achieve final remediation of the three UCRS source areas and, by so doing, to take an interim step towards the goal of eventual groundwater remediation.

As part of the GWOU evaluations, the DOE, EPA, and KDEP have agreed that multiple actions will be required to address contamination associated with the GWOU. The DOE, EPA, and KDEP, determined that, at a minimum, the actions should focus on remediation of (a) on-site sources [including secondary sources such as DNAPLs, (b) dissolved-phase groundwater plumes, and (c) potential "fenceline" containment or treatment actions. Consistent with this decision, DOE proposes treatment of the on-site VOC source areas at C-747-C and C-720 and the on-site ^{99}Tc source area at C-746-D as one of the actions required for the GWOU.

2.5 SUMMARY OF SITE CHARACTERISTICS

The shallow aquifer underlying the PGDP is the Regional Gravel Aquifer (RGA). Low-conductivity sediments overlie the RGA to a depth of approximately 18 m (60 ft). Groundwater flow in the overlying sediments is principally downward to recharge the RGA. This flow system is termed the UCRS.

Groundwater flow within the RGA is northward, to discharge into the Ohio River and adjacent streams. However, at the PGDP, the dominant east-to-west orientation of the sand and gravel units within the RGA, in combination with leakage from the plant water utilities, causes the groundwater flow to diverge. Three large plumes of dissolved contaminants have migrated beyond the secured fenced area. These are known as the Northeast Plume, the Northwest Plume, and the Southwest Plume. The Northeast and Southwest Plumes leave the security-fenced area on the east and west sides, respectively, and the Northwest Plume migrates from the PGDP plant near the northwest corner of the security fenced area. The three areas addressed in this ROD are similar in that the contaminant source zones are restricted to the UCRS and in that contaminants migrate from the source zones to the RGA.

C-747-C Oil Landfarm (SWMU 1). The C-747-C Oil Landfarm includes approximately 8,947 m^2 (96,300 ft^2) and encompasses two disposal plots covering approximately 104.5 m^2 (1,125 ft^2) each in the southwest portion of the fenced security area of the plant, south of the C-745-A Cylinder Yard.

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The ground surface at C-747-C is grass-covered and relatively flat, grading gently from 114 m (375 ft) amsl on the east to about 113 m (370 ft) amsl on the west. West-trending drainage ditches are present on the north and south sides of the unit, and a south-trending drainage ditch is present on the west. Storm water runoff from C-747-C flows to one of these perimeter ditches and discharges via Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 008 to Bayou Creek.

The conceptual model for the source of release is the landfarm that was used from 1975 to 1979 for the biodegradation of waste oils contaminated with TCE, 1,1,1-trichloroethane, uranium, and PCBs. It is estimated that at least 19,000 L (5,000 gal) of waste oil was applied to the landfarm over the 6-year period; oil was added at 3- to 4-month intervals. The sources of the waste oils were not reported, but it is assumed the oils were from virtually all areas of the plant. Contaminants in the surface soil have, in the past, percolated into subsurface soil, ultimately contaminating groundwater. Figure 1 illustrates the conceptual site models for the areas addressed by this ROD.

The following investigations and sampling activities have been conducted at SWMU 1.

- The two-phased CERCLA SI conducted in 1991 and 1992, which included the installation of four RGA soil borings, 10 shallow soil borings, and four groundwater monitoring wells (MWs) at the unit. In addition, two surface geophysical surveys, electromagnetic and magnetometer, were conducted during the Phase II SI (CH2M HILL 1992). Aquifer slug tests were conducted at two RGA wells (MW161 and MW188) and two UCRS wells (MW162 and MW189) in the vicinity of SWMU 1.

- Soil sampling activities at SWMU 1 focused on the delineation of the extent of PCB and dioxin contamination in surficial soils at the unit. These sampling activities were performed in support of the WAG 23 RI/FS.

- The Environmental Surveillance (Annual Monitoring) Program at the PGDP, which includes the collection of groundwater samples from upgradient and downgradient RGA MWs (MW188 and MW161, respectively). In addition, historical groundwater sampling data are available from two shallow (UCRS) MWs in the vicinity of the unit (MW162 and MW189).

- The WAG 27 RI activities at SWMU 1. These activities included a surface geophysical survey (EM-61 magnetometer), soil sampling from eight test pits dug to investigate geophysical anomalies, sediment sampling from seven locations in the ditches, and soil and groundwater sampling from 73 borings.

To investigate subsurface soils at SWMU 1, 198 soil samples were collected from 73 borings varying in depth from 1.5 to 15 m (5 to 50 ft) bgs during the WAG 27 RI. Two VOCs, TCE and vinyl chloride (VC), were detected in subsurface soil samples. The maximum TCE concentration was 439,000 µg/kg, detected at a depth of 4.6 m (15 ft) bgs from boring 001-165 in the north–central portion of SWMU 1. This concentration is above levels considered indicative of the presence of DNAPL. Four other soil borings at SWMU 1 contained soil samples with TCE concentrations greater than 10,000 µg/kg. In addition, the TCE breakdown product *cis*-1,2-DCE was detected at a concentration of 2,400,000 µg/kg at a location east of boring 001-165 during the WAG 23 soil sampling conducted in February 1996.

The elevated concentrations of TCE and its breakdown products detected in subsurface soils at SWMU 1 indicate a small DNAPL source area may exist within shallow (<10 m, 32 ft, bgs) UCRS soils. The potential DNAPL source is likely confined to the HU1 clays and HU2 sands and gravels in the immediate area surrounding soil boring 001-165. A water sample from boring 001-173 at 15 m (50 ft) bgs provides characterization of dissolved-phase TCE levels in the upper RGA immediately downgradient of the former Oil Landfarm. The TCE-in-water level is 312 µg/L, which compares favorably to inferred

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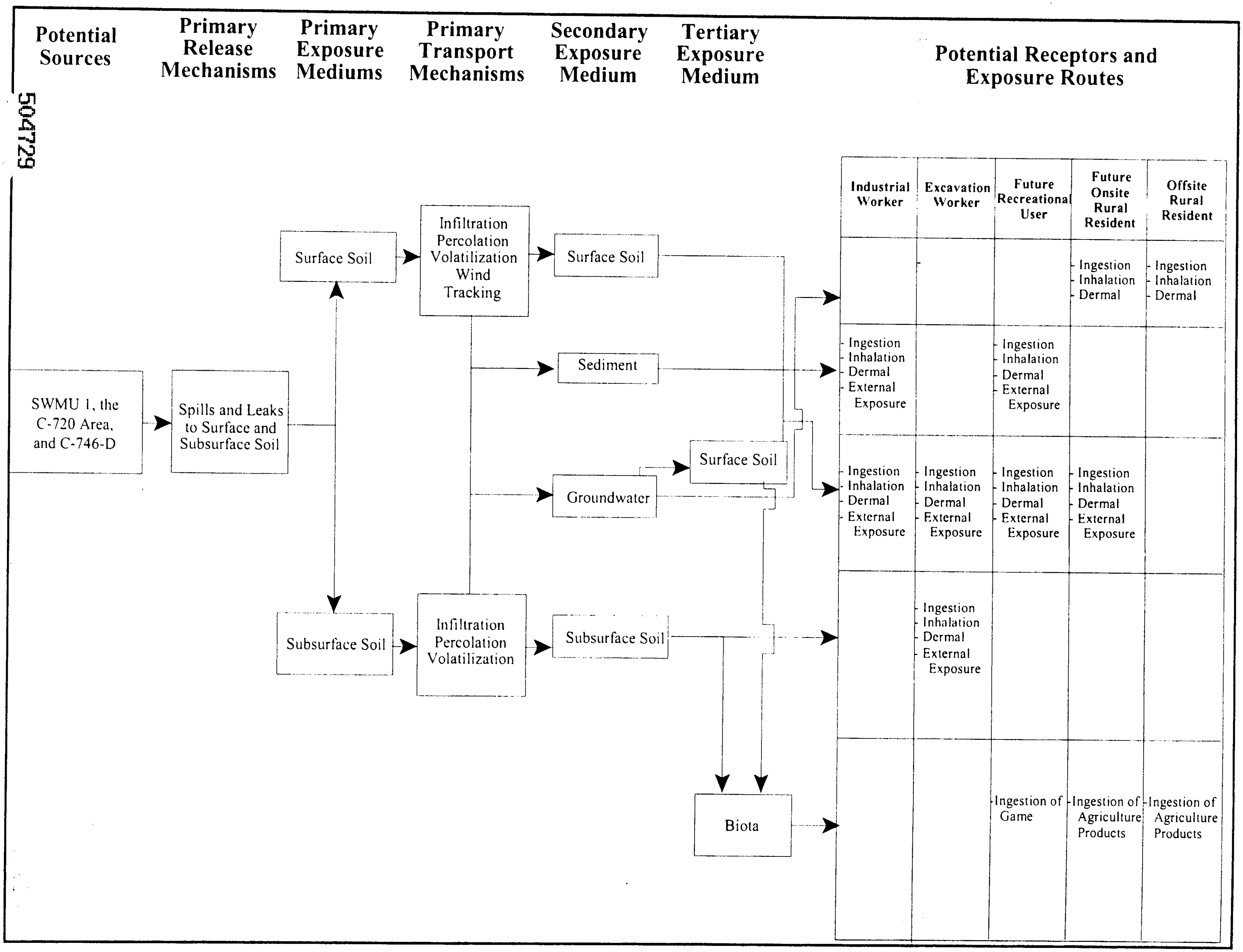

Fig. 1. Conceptual site model for human exposure to contaminated media at SWMUs 1 (Oil Landfarm) and 99 (C-746-D Scrap Yard) and the C-720 Maintenance Facility.

dissolved-phase levels in the area of concentration and suggests a deep UCRS or RGA DNAPL source does not occur (higher dissolved levels would be expected).

C-746-D Scrap Yard (SWMU 99). The C-746-D Scrap Yard (SWMU 99) is located on the eastern side of the PGDP, south of Building C-360, immediately north of Tennessee Avenue and west of Patrol Road 3. This originally was the site of a steel and sheet metal fabrication building built in 1951. This building and another located immediately to the east are sometimes referred to as the Kellogg Facility. Both buildings were taken out of service and demolished in 1955, leaving only the concrete pads. The C-746-D pad covers an area of approximately 5,518 m^2 (59,400 ft^2).

The eastern building pad currently is used as the C-745-E UF_6 Cylinder Storage Yard. The C-746-D pad currently is used for the storage of metal equipment and aluminum ingots. It will be necessary to move this equipment and aluminum ingots in order to perform remediation of the area. The removal of this equipment and ingots will be performed as part of the Scrap Metal Program [please see *Engineering Evaluation/Cost Analysis for Scrap Metal Disposition at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1880&D2*]. Only the western building pad is part of this remedial action. The associated septic field is located outside the security fence approximately 350 to 400 ft southeast of the C-746-D Scrap Yard. (The area containing the septic field was referred to as SWMU 99b in the WAG 28 remedial investigation.)

The topography in the vicinity of C-746-D is relatively flat, with drainage from the vicinity of the former buildings toward Outfall 010. Surface drainage is routed through surface swales and ditches to storm sewers, which discharge to the Outfall 010 effluent ditch and into Little Bayou Creek on the east side of the plant.

Information regarding the specific activities conducted within these buildings, other than pipe fabrication, is limited. The area was investigated during the WAG 28 RI. The WAG 28 investigation did not identify a source for metals, VOCs, or radionuclides in the soils at C-746-D.

During the WAG 28 investigation a collapsed drainpipe that extends beneath Tennessee Avenue was located at the southwest corner of C-746-D (SWMU 99). This pipe appears to carry surface runoff from the SWMU 99 to the drainage ditch leading to Outfall 010. The conceptual site model for a release from C-746-D (SWMU 99) is that runoff from the scrap contained high levels of ^{99}Tc that have impacted the surrounding soils. Contaminants are not present within the pipe at the break. Figure 1 is a graphical presentation of the assessment of release, transport, and exposure for C-746-D (SWMU 99).

The following summarizes previous investigations of C-746-D (SWMU 99).

- SWMU 99 was investigated during the CERCLA Phase II SI performed by CH2M-HILL (CH2M HILL 1992). Soil samples were collected and analyzed from two UCRS borings to depths of 12.2 m (40 ft). Drilling of nearby well MW163 allowed collection and analysis of RGA soil samples for comparison. The Phase II SI installed two groundwater MWs (MW163, screened in the RGA, and MW164, screened in the UCRS) northwest of SWMU 99 and conducted aquifer slug tests in the wells.

- The Groundwater Phase IV Investigation drilled and sampled groundwater from boring P4E6 to the southeast of the Kellogg Building Site(SWMU 99). This soil boring was completed as a lower RGA well (MW256). In addition, the Phase IV Investigation completed four soil borings to the east of SWMU 99, P4D9, P4D10 (completed as lower RGA well MW258), P4D11, and P4D12. Groundwater samples collected from these borings helped define the nature of the Northeast Plume. The results from this

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investigation are presented in the *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995b).

- The WAG 28 RI, conducted in 1999, evaluated releases from SWMU 99 to determine if the SWMU is a source of TCE contamination in the RGA in the Northeast Plume. The investigation included three cone penetrometer technology (CPT) logs to identify water-bearing units within the UCRS followed by 15 direct push technology (DPT) boreholes to sample surface and subsurface soil in the UCRS. Groundwater was sampled in the UCRS, where present, and in two RGA borings installed with a Dual Wall Reverse Circulation (DWRC) air rotary drill rig. In addition, two surface soil/sediment samples were collected from the drainage ditch parallel to the East Patrol Road 3 and two soil samples were collected from a collapsed drainpipe excavation in the southwest corner of SWMU 99.

Several metals were detected in soil samples that may represent small isolated spills or leaks. PCBs were found in one sample and low concentrations of several semi-volatile organic compounds were detected in multiple samples. TCE was present in two subsurface samples. Radioisotopes were detected in two surface samples. The WAG 28 investigation did not identify a source for metals, VOCs, or radionuclides in the soils at SWMU 99. Elevated levels of radioisotopes were detected in a soil sample collected from an excavation related to a collapsed drainpipe in the southwest corner of SWMU 99. The source of the radionuclides is believed to be runoff from the Scrap Yard at C-746-D (SWMU 99).

MW256, an RGA well located near the southeast corner of SWMU 99, monitored an increase of ^{99}Tc activity beginning in mid-1998. Previous ^{99}Tc activity had been approximately 20 pCi/L. ^{99}Tc levels rose to 80 pCi/L beginning in early 1999. Through the year 2000, the level has risen to 96 pCi/L. Although this activity of ^{99}Tc is below the risk action levels for human health and the environment, the rise in ^{99}Tc activity is a concern because it potentially impacts continued operation of the Northeast Plume pump-and-treat facility, which is downgradient of MW256. Operation of the Northeast Plume pump-and-treat facility is contingent upon the absence of detectable levels of ^{99}Tc in the groundwater being treated.

The ^{99}Tc-contaminated backfill around the underground piping at C-746-D is a likely source of the contamination that is present in MW256. Although the available data are insufficient to determine the activity of ^{99}Tc present or the mass or volume of the contaminated zone, the data suggest that the majority of the contamination is limited to the backfill surrounding the drains underlying the Kellogg Building Site.

C-720 Building: The C-720 Maintenance Building occupies 26,124 m^2 (281,200 ft^2) in the southwest portion of the fenced security area of the PGDP. Most of the area surrounding the C-720 Building is covered by concrete or asphalt. The topography is relatively flat, with elevations ranging from approximately 113 to 115 m (371 to 376 ft) amsl. Drainage from the C-720 Complex is via the PGDP storm drain system that eventually discharges through KPDES Outfalls 008 and 009 to Bayou Creek.

The C-720 Building drainage system discharges to the plant storm water system at eight major exit points. Storm sewers are constructed of either reinforced concrete piping or vitreous clay piping. The backfill areas in the vicinity of the building drainage system exit points, as they connect to the storm sewer system, are a primary release mechanism in the conceptual site model. The major releases from this system are leaks and/or discharges from the major exit points of the storm water system as it exits the building.

The north side of a paved lot on the east end of the C-720 Building is an area that was used in the past for routine equipment cleaning and rinsing. The release of contaminants in this open area is another potential release pathway in the conceptual site model. Contaminants in the subsurface soil percolate into

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deeper strata, ultimately contaminating groundwater. Figure 1 summarizes the potential exposure scenarios for the C-720 area.

Sources of data that define contaminant levels in the C-720 area include the following.

- A MW pair (MW203 and MW204) was installed to the northeast of the C-720 area during the CERCLA Phase II SI. MW204 was drilled to a depth of 16.8 m (55 ft) and was screened in the UCRS. MW203 was an RGA well screened to a depth of 23.2 m (76 ft). The most recent groundwater monitoring data for MW203 and MW204 were collected in August 1996 and December 1994, respectively.

- The Groundwater Phase IV Investigation installed soil boring P4H7 to the northeast of the C-720 area. Boring P4H7 yielded geophysical logs and three RGA water samples.

- MW217 and MW218, both UCRS wells, were installed to the south of the C-720 area in association with an underground storage tank (UST) investigation.

- The WAG 27 RI, conducted in 1998, evaluated releases from the C-720 Complex to determine if the area is a source of TCE contamination in the RGA in the southwestern part of the plant. The investigation included two CPT logs within the UCRS followed by 16 DPT boreholes for UCRS soil (total of 122) and groundwater (total of 5) samples. RGA and McNairy groundwater samples (83 from the RGA and 24 from the McNairy) were collected from 13 soil borings and piezometers were installed in 5 locations.

Only eight VOCs were detected in the subsurface soil samples in the C-720 area. TCE and its degradation products were the most common VOCs detected, but were present at very low frequencies of detection. The maximum TCE concentration (68,000 μg/kg) was detected from boring 720-002. Vinyl chloride (400 μg/kg) and *trans*-1,2-dichloroethene (DCE) (estimated at 450,000 μg/kg) also had maximum detections in this boring.

TCE was detected in four other borings located along the building drainage system (720-004, 720-005, 720-007, and 720-008) at depths of 3.0 to 11.6 m (10 to 38 ft). Appreciable TCE concentrations also were found in samples from boring 720-007 (500 to 8,100 μg/kg), which was drilled near the outside parts wash area north of the east end of the C-720 Building.

All of the borings sampled for metals in subsurface soils had several detects. The most common metals detected were beryllium, vanadium, sodium, and antimony. However, of the 38 samples collected for radiological isotopic analysis and 49 samples collected for ^{99}Tc analysis, no isotopes were detected at elevated concentrations.

Several sites were identified where significant releases may have occurred at the C-720 area. First, an area south of the east end of the C-720 building displayed the highest VOC concentrations in soil. The source of these contaminants may be the connection between the drain exit point and the storm drain at location 720-002. The depth of the storm drain was noted as 1.6 m (5.3 ft) below ground surface (bgs) on plant utility drawings. VOCs, primarily TCE, were found throughout the upper 15.2 m (50 ft) of soil at this location. This drain exit collected water from more than 20 drains located in the machine shop, compressor shop, vacuum pump shop, and valve shop. In these operations, solvents were routinely used for cleaning parts and machinery. Lead was the only other contaminant detected in this boring. Migration of TCE may have occurred along the storm water line to the west, given the TCE detection in shallow groundwater at location 720-003 and the slope of the line in this direction. However, the extent of soil

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contamination appears to be well defined by the absence of VOCs in soil at boring 720-003 to the west and 720-022 to the south and with only one detect of vinyl chloride in boring 720-001 to the east.

Another release site may have occurred along the drainage exit point at location 720-005. TCE was detected in this boring throughout the entire depth drilled (9.1m/30 ft bgs). The depth of the drain at this exit was noted as 2.4 m (7.8 ft) on plant utility drawings. The networks of drains directed to this exit were primarily from general storage and the welding shop. The storm drains east and west of this location slope toward this point and discharge water through a 0.9-m (36-in.) line extending south from this drain exit. No other significant contaminants were observed at this location.

On the northeast side of the C-720 Building at location 720-027, TCE and several metals were detected throughout the boring. The boring was installed to investigate the possibility that a release in this area contributed to high TCE concentrations found in borings P4H7 (Groundwater Phase IV Investigation) and 720-018. It was common practice in the past to rinse and clean parts with TCE in this area. The occurrence of TCE and metals in subsurface soil in this area suggests that this practice was followed, but an exact release point was not determined.

Types of Contamination and the Affected Media. The contaminants to be addressed by this ROD are VOCs at SWMU 1 and the C-720 area and ^{99}Tc at C-746-D. Table 1 summarizes the contaminated media and measured levels of contamination in the media to be addressed by this action.

Table 1. Contaminants of concern* and affected media

	VOC						Radionuclide	
	1,2-DCE		TCE		VC		^{99}Tc	
	UCRS soil	UCRS water	UCRS soil	UCRS water	UCRS soil	UCRS water	UCRS soil	UCRS water
SWMU 1			439,000	312	480			
SWMU 99							2,650	148
C-720 Area	2,400,000	113	68,000	149	400	46		

*Note numbers are maximum levels measured. For VOCs, soil values are in µg/kg and water values are in µg/L. For ^{99}Tc, soil values are in pCi/g and water values are in pCi/L.

1,2-DCE. 1,2-DCE exists in two isomeric forms, *cis*-1,2-DCE and *trans*-1,2-DCE, that are degradation products of TCE. These contaminants also are halogenated organic compounds, but they are not used extensively in industry and have not been used at the PGDP. Exposure to *cis*-1,2-DCE and *trans*-1,2-DCE has been associated with liver disorders, blood disorders, and lung and eye irritation. Neither chemical has been classified by EPA as to human carcincogenicity due to the lack of adequate studies.

TCE. TCE was detected in both subsurface soils and groundwater at the sites. This contaminant is a halogenated organic compound used by industry in the past for a variety of purposes. Exposure to this compound has been associated with deleterious health effects in humans, including anemia, skin rashes, liver conditions, and urinary tract disorders. Based on laboratory studies, TCE is considered a probable human carcinogen. Over time, TCE naturally degrades to other organic compounds. TCE currently is not used at the PGDP.

VC. VC is a degradation product of TCE. It is also a halogenated organic compound and is used in industry as an intermediary of polyvinyl chloride (PVC) and other chlorinated compounds. VC has not been used in the PGDP manufacturing processes. Exposure to VC has been associated with narcosis and anesthesia (at very high concentrations), liver damage, skin disorders, vascular and blood disorders, and abnormalities in central nervous system and lung function. Liver cancer is the most common type of cancer linked with vinyl chloride, a known human carcinogen. Other cancers related to exposure include that of the lung, brain, blood, and digestive tract.

^{99}Tc. ^{99}Tc is a radioactive element with a half-life of 212,000 years. All ^{99}Tc found in the environment is assumed to be from human activities. The ^{99}Tc at the PGDP was brought onsite as a fission byproduct in spent nuclear reactor fuel that was recycled in the PGDP's diffusion cascade. ^{99}Tc is an emitter of beta particles of low specific activity. Exposure to ^{99}Tc, like all radionuclides, is associated with the development of cancer.

Location of contamination and routes of migration. Investigations at the PGDP have determined the general boundaries of contamination sufficiently, such that remedial actions can proceed at the UCRS DNAPL sites at the C-747-C Oil Landfarm (SWMU 1) and UCRS source zones near the C-720 Complex and the UCRS ^{99}Tc source at C-746-D Scrap Yard (SWMU 99). Figure 2 shows the location of the contaminant source zones to be addressed in this ROD. The vertical limits of contamination are presented in the previous text.

At all three locations, the primary migration route of concern is as follows:

1. dissolution of contaminants into UCRS groundwater;
2. downward migration into the RGA; and
3. lateral migration offsite through the RGA to potential exposure points via well withdrawal or via discharge to Little Bayou Creek or the Ohio River.

The much lower hydraulic conductivity of the McNairy Formation, underlying the RGA, limits vertical migration of dissolved contamination below approximately 30.5 m (100 ft).

Monitored contaminant levels in RGA groundwater associated with each of these source zones provides empirical evidence of contaminant mobility. Groundwater from the C-720 and C-747-C areas flows with the PGDP's Southwest Plume. The Southwest Plume extends approximately 0.2 km (0.1 miles) west of the PGDP security fence and is completely contained within the PGDP property. Potentiometric trends of the RGA indicate that the Southwest Plume likely will travel northward over time and join with the PGDP's Northwest Plume. The PGDP's Northwest Plume reaches 4.6 km (2.8 miles) beyond the PGDP security-fenced area to Little Bayou Creek in the Ohio River floodplain. Both human recreators and the riparian ecology in Little Bayou Creek are exposed to the Northwest Plume contaminants.

The C-746-D area overlies the PGDP's Northeast Plume. The Northeast Plume extends approximately 3.5 km (2.2 miles) from the east side of the PGDP northward to near residences along Metropolis Lake Road. Contamination within the Northeast Plume does not reach to any natural discharge points of the RGA. DOE's provision of municipal water supplies to residences and businesses in the affected area (known as the Water Policy) limits human exposure to contaminants in the Northeast, Northwest, and Southwest Plumes.

2.6 CURRENT AND POTENTIAL FUTURE LAND USE

The units for this remedial action are located within the PGDP security fence. Figure 3.3 of the Site Management Plan for the PGDP (DOE 2000b) contains a "reasonably anticipated future land use" map.

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That map indicates that the area inside the PGDP security fence will continue to be industrial, and the area outside of the PGDP security fence generally will continue to be used for recreational purposes. Although unlikely, these land uses could change when a final ROD and Land Use Control Implementation Plan for the entire PGDP/DOE property are issued.

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates the risks that a site poses to human and ecological receptors if no action is taken. It provides the basis for action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the methods used to complete and the pertinent results of the baseline risk assessments for the UCRS source area contamination at SWMU 1 (the C-747-C Oil Landfarm) and the C-720 Building. Results presented here were taken from *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1777&D2.

Throughout this discussion it is important to remember that only risk assessment results pertinent to the action being proposed to SWMUs 1 and the C-720 area are presented here. Additional risk assessment results that may be useful in determining if other actions are needed in the future can be found in the aforementioned RI Reports. Also, note that because the action at SWMU 99 is a maintenance activity to protect the Northeast Plume treatment system, risks are not presented for exposure to contaminants at or migrating from this unit.

2.7.1 Summary of Baseline Human Health Risk Assessment

This section summarizes the steps of the baseline human health risk assessment (BHHRA) and presents significant results used in making the current decisions for SWMU 1 and the C-720 area. As noted above, the information presented here is a relevant subset of the information presented in the BHHRAs contained in the aforementioned RI Reports and is not meant to completely describe the baseline risks estimated for all receptors and media assessed. Generally, the information presented is meant to support the current remedy selection process and to familiarize the reader with the basis for undertaking remedial action at SWMU 1 and the C-720 area.

2.7.1.1 Identification of contaminants of concern

This section presents the COCs for the UCRS source area contamination at SWMU 1 and the C-720 area. In this section, the COCs are presented in tables by area. In the tables, the following information is presented:

- exposure point (i.e., the location where the receptor may actually or potentially contact the contaminated media);
- COC (i.e., a chemical present at a risk or hazard greater than the *de minimis* risk levels used at the PGDP) *(Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1506&D1)*;
- minimum and maximum detected concentration;
- units of measure for the detected concentration;

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- frequency of detection;
- exposure point concentration (i.e., the concentration of the chemical used in deriving the risk estimate);
- percent of total risk posed by the individual chemical of concern; and
- statistical measure (i.e., the summary statistic used to represent the chemical's average exposure point concentration).

The medium to be addressed by the current action at SWMU 1 and the C-720 Building is subsurface soil contributing contamination to groundwater; therefore, only COCs for subsurface soil are summarized here. Additionally, risk at SWMU 99 is not considered because the action selected for the site is a maintenance activity to protect the Northeast Plume Treatment facility and is not a risk-based action. Table 2 presents COCs in soil for direct exposure to constituents migrating to groundwater. The point of exposure used in Table 2 is at a point along the PGDP fence line closest to the sources at SWMU 1 and the C-720 area.

The COCs presented in Tables 2 were selected following guidance presented in Section 5 of the baseline risk assessment contained in the aforementioned RI Reports. This guidance is consistent with that in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1(DOE 2000c). Specifically, COCs are defined as chemicals detected at a site that significantly contribute to a pathway in a use scenario for a receptor that either (a) exceeds a cumulative excessive lifetime cancer risk (ELCR) of 1×10^{-6}; or (b) exceeds a cumulative non-carcinogenic hazard index (HI) of 1. Chemicals are considered to be significant contributors to risk if their individual carcinogenic risk contribution is greater than 1×10^{-6} or their non-carcinogenic hazard quotient (HQ) is greater than 0.1. (See Sect. 2.7.1.4 for additional information about risk estimates.)

Table 2 indicates that the most common classes of COCs found in the soil and contributing to groundwater contamination at SWMU 1 and C-720 area are inorganic chemicals and TCE and its degradation products.

2.7.1.2 Exposure assessment

This section summarizes the results of the exposure assessment that was performed as part of the BHHRA for SWMU 1 and the C-720 area, with specific attention to the exposure routes that were quantitatively evaluated and that are relevant to the selected action. SWMU 99 is not discussed because the action at SWMU 99 is a maintenance activity to protect the Northeast Plume Treatment facility and is not a risk based action. Generally, exposure assessment is a procedure in which pathway analysis is used to identify significant pathways of human exposure and exposure equations are used to quantify doses to or intakes of receptors. Throughout the exposure assessment the guiding principal is that, in order to be quantified, the exposure pathway has to be complete either now or in the future. A complete pathway is one that includes a source of contamination and mechanism of release, a method of transport or retention, an exposure point, and a route of exposure. If any of these parts are absent, then the exposure pathway is deemed incomplete and is not quantified in the risk assessment.

Pathway analysis in the BHHRA identified four human health exposure scenarios to be evaluated for SWMU 1 and the C-720 area. These were the industrial worker exposure scenario, the excavation worker exposure scenario, the recreational exposure scenario, and the rural residential exposure scenario (onsite and offsite) (Fig. 1). Of these scenarios, only the rural residential exposure scenario (offsite) is being

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Table 2. Summary of COCs from baseline risk assessment and exposure point concentrations for contact with groundwater contaminated by constituents migrating from source zone soils at SWMUs 1 and C-720 Maintenance Facility

Scenario Timeframe: Future
Medium: Soil (Includes Surface and UCRS Soil)
Exposure Medium: Groundwater

Exposure Point	COC	Concentration Detected Min	Concentration Detected Max	Units	Frequency of Detection	Exposure Point Conc.	Units	% Total Risk	Statistical Measure
At Fence Line; Sources at SWMU 1	Antimony	0.013	12.9	mg/kg	58/225	0.0643	mg/l	NC	MAX
	Manganese	3.04	2,160	mg/kg	220/220	0.173	mg/l	NC	MAX
	Trichloroethene	0.0006	439	mg/kg	37/162	0.715	mg/l	9.6	MAX
	Vinyl chloride	0.0120	4.80	mg/kg	9/160	0.0819	mg/l	90.5	MAX
At Fence Line; Sources at C-720 Building	Antimony	0.527	87.2	mg/kg	25/238	0.0643	mg/l	NC	MAX
	Silver	0.229	94.8	mg/kg	14/128	0.0630	mg/l	NC	MAX
	Vanadium	7.83	128	mg/kg	124/128	0.0239	mg/l	NC	MAX
	trans-1,2-Dichloroethene	0.400	450	mg/kg	4/304	7.22	mg/l	NC	MAX
	Trichloroethene	0.001	68.0	mg/kg	91/321	1.27	mg/l	82.7	MAX
	Vinyl chloride	0.200	0.400	mg/kg	6/321	0.00363	mg/l	19.1	MAX

Min = Minimum detected concentration
Max = Maximum detected concentration
% Total Risk = Excess lifetime cancer risk due to exposure to the single analyte divided by risk from exposure to all contaminants in soil. Note that the sum of all percentages for an area may not equal 100% due to rounding error.
NC = COC is not cancer causing.
MAX = The EPC was derived from modeling based upon the maximum detected concentration within the source.

This table presents the chemicals of concern (COCs), range of detected concentrations in source zone soil, and exposure point concentrations (EPCs) in groundwater for each of the COCs detected in soil. Selection of COCs for soil was based upon EPC in groundwater. The point of exposure used was the PGDP fence line. The table includes the range of concentrations detected for each COC, as well as the frequency of detection in source zone soil, (i.e., the number of times the chemical was detected in samples collected at the site), the EPC in groundwater derived using modeling, and the value in source zone soil used to derive the EPC in groundwater (Statistical Measure).

The table indicates that the most common classes of COCs found at SWMU 1 and C-720 Maintenance Facility were inorganic chemicals and TCE and its degradation products.

addressed by the selected action; therefore, only this scenario is described in detail. The residential scenario included the assessment of both on-site and off-site conditions. Of these, only the result of the offsite scenario is relevant to the selected action. The off-site residential scenario in the risk assessment assumed that a homestead would be located along the PGDP fence line and that water would be withdrawn from the RGA at that location and used in the home. Exposure to water in this location was assumed to occur over a lifetime.

Contaminant concentrations in groundwater at this location were estimated from soil concentrations using a transport model (i.e., Multimedia Environmental Pollutant Assessment System, *Multimedia Environmental Pollutant Assessment System*). Only direct routes of exposure were considered for the off-site residential scenario. These included ingestion of groundwater, dermal contact with groundwater during showering, and inhalation of vapors emitted by groundwater during showering and during household use.

Exposure parameters used in all exposure equations were those used to derive chronic dose estimates. (A chronic dose estimate is one derived assuming repeated daily exposure to a contaminated medium over several years.) Therefore, the use of these parameters yielded dose estimates that allowed for the estimation of dose over a lifetime of exposure (i.e., 40 years for the resident) under frequent use (i.e., 350 days/year for the resident.) Also, in keeping with current agreements, doses used to calculate residential risk estimates included exposure durations as both a child (6 years) and an adult (34 years). The values used for all other exposure parameter were taken from those approved by decision makers. Use of these parameters and the EPCs presented in Table 2 yielded reasonable maximum exposure (RME) estimates of dose.

2.7.1.3 Toxicity assessment

This section summarizes the salient points of the toxicity assessment contained in the baseline human health risk assessment for SWMU 1 and the C-720 area. As with the earlier discussion of COCs, most information is contained in the tables presented in this section.

In order to characterize risk from the RME dose estimates calculated during the exposure assessment, toxicity values for cancer effects and noncancer effects (i.e., systemic toxicity or hazard) were gathered from approved sources. Primary among these sources were EPA's Integrated Risk Information System (IRIS), the EPA Superfund Technical Support Center in Cincinnati, and EPA Health Effects Assessment Summary Tables (HEAST). Toxicity values for the COCs taken from these and other sources are in Tables 3 and 4. Table 3 presents toxicity values used to estimate cancer risks, and Table 4 presents toxicity values used to estimate the potential for systemic toxicity. As shown in Tables 3 and 4 toxicity values were lacking for some chemical/endpoint combinations.

2.7.1.4 Risk characterization

This section describes how the outputs from the exposure assessment (i.e., RME doses) and toxicity assessment (toxicity values) were combined to characterize the baseline risks. As with the earlier sections, most information is presented in tables. This section concludes with a short discussion of the uncertainties affecting the results of the BHHRA.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime because of exposure to the carcinogen. Excess lifetime cancer risk (ELCR) is calculated from the following equation:

$$Risk = CDI \times SF\ ,$$

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual's developing cancer,
CDI = chronic daily intake averaged over 70 years (mg/kg-day),
SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6} or 1E-6). An ELCR of 1×10^{-6} indicates that an individual experiencing the RME estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other

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Table 3. Cancer toxicity data summary for the baseline human health risk assessment for SWMUs 1 and the C-720 Maintenance Facility

Route: Ingestion and Dermal Contact						
Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Type of Cancers	Source	Date Accessed
Antimony	—	—	—	—	—	—
Manganese	—	—	—	D	IRIS	1998
Silver	—	—	—	D	IRIS	1998
Vanadium	—	—	—	—	—	—
Trichloroethene	1.10E-02	7.33E-02	$mg/(kg \times day)^{-1}$	C/Liver, lung	Superfund	1998
Vinyl chloride	1.90E+00	1.90E+00	$mg/(kg \times day)^{-1}$	A/Liver, lung, digestive tract, brain	HEAST	1998
trans-1,2-Dichloroethene	—	—	—	D	HEAST	1998

Route: Inhalation							
Chemical of Concern	Unit Risk	Unit Risk Units	Inhalation Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Type of Cancers	Source	Date Accessed
Antimony	—	—	—	—	—	—	—
Manganese	—	—	—	—	D	IRIS	1998
Silver	—	—	—	—	D	IRIS	1998
Vanadium	—	—	—	—	—	—	—
Trichloroethene	—	—	6.00E-03	$mg/(kg \times day)^{-1}$	C/Liver, lung	Superfund	1998
Vinyl chloride	8.40E-05	m^3/g	3.00E-01	$mg/(kg \times day)^{-1}$	A/Liver, lung, digestive tract, brain	HEAST	1998
trans-1,2-Dichloroethene	—	—	—	—	D	HEAST	1998

- = No information available
NA = Route not applicable to chemical of concern

EPA Weight of Evidence Group:
A = Human carcinogen
B1 = Probable human carcinogen – limited human information available
B2 = Probable human carcinogen – sufficient evidence for animals but inadequate or no evidence from humans
C = Possible human carcinogen
D = Not classifiable as a human carcinogen
E = Evidence of noncarcinogenicity

Source:
IRIS = Integrated Risk Information System, US EPA
Superfund = Superfund Health Risk Technical Support Center, US EPA

This table provides carcinogenic risk information that is relevant to the chemicals of concern in water listed in Table 2. In this table, the slope factors for dermal contact were extrapolated from oral values using adjustment factors based upon the absorption that occurs in the gut.

Slope factors for radionuclides tagged with a "+D" are for the toxicity from both the radionuclide and its short-lived decay products.

Table 4. Noncancer toxicity data summary for the baseline human health risk assessment for SWMUs 1 and the C-720 Maintenance Facility

Route: Ingestion, Dermal								
Contaminant of Concern	**Chronic Oral RfD**	**Oral RfD Units**	**Chronic Dermal RfD**	**Dermal RfD Units**	**Primary Target Organ**	**Combined Uncertainty/ Modifying Factors**	**Source**	**Date Accessed**
Antimony	4.00E-04	mg/(mg × day)	8.00E-06	mg/(mg × day)	Liver, heart, developmental	1000	IRIS	1998
Manganese (water)	4.6E-02	mg/(mg × day)	1.84E-03	mg/(mg × day)	Central nervous system, lungs	1	IRIS	1998
Silver	5.00E-03	mg/(mg × day)	9.00E-04	mg/(mg × day)	Skin	3	IRIS	1998
Vanadium	7.00E-03	mg/(mg × day)	7.00E-05	mg/(mg × day)	Kidney, blood	100	HEAST	1998
Trichloroethene	6.00E-03	mg/(mg × day)	9.00E-04	mg/(mg × day)	Liver	—	Superfund	1998
Vinyl chloride	—	—	—	—	—	—	—	—
trans-1,2-Dichloroethene	2.00E-02	mg/(mg × day)	2.00E-02	mg/(mg × day)	Blood	1000	IRIS	1998
Route: Inhalation								
Contaminant of Concern	**Chronic Inhalation RfC**	**RfC Units**	**Chronic Inhalation RfD**	**RfD Units**	**Primary Target Organ**	**Combined Uncertainty/ Modifying Factors**	**Source**	**Date Accessed**
Antimony	—	—	—	—	—	—	—	—
Manganese (water)	1.43E-05	m^3/day	5.00E-05	mg/(mg × day)	Central nervous system, lungs	1000	IRIS	1998
Silver	—	—	—	—	—	—	—	—
Vanadium	—	—	—	—	—	—	—	—
Trichloroethene	—	—	6.00E-03	mg/(mg × day)	Liver	—	PRG	1998
Vinyl chloride	—	—	—	—	—	—	—	—
trans-1,2-Dichloroethene	—	—	2.00E-02	mg/(mg × day)	Blood	—	PRG	1998

RfD = reference dose
\- = No information available

Source:
IRIS = Integrated Risk Information System, US EPA
Superfund = Superfund Health Risk Technical Support Center, US EPA
PRG = Taken from EPA Region 9 PRG Tables

This table provides noncarcinogenic risk information that is relevant to the chemicals of concern in soil and water listed in Table 2. As with carcinogenic data, dermal RfDs were extrapolated from oral RfDs applying an adjustment factor based upon absorption from the gut.

In keeping with EPA guidance, two values for manganese toxicity were used. The values for Manganese (water) were used to characterize the toxicity for exposure to manganese in environmental media.

causes has been estimated to be as high as one in three (i.e., approximately 3×10^{-1}). EPA's target risk range for site-related exposures is 1×10^{-4} to 1×10^{-6}. The PGDP *de minimis* risk level is 1×10^{-6} (*Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1506&D1*).

The potential for noncarcinogenic effects (i.e., systemic toxicity or hazard) is evaluated by comparing an exposure level over a specific time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effects. The ratio of the dose estimate to the RfD is called an HQ. An HQ < 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from the chemical are unlikely. The HI is generated by adding the HQs for all chemicals of concern that effect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may be reasonably exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than 1 does not mean that a toxic effect is certain in the exposed individual. An HI>1 indicates that site-related exposures <u>may</u> present a risk to human health.

The HQ is calculated as follows:

$$Non\text{-}cancer\ HQ = CDI \div RfD$$

where: CDI = chronic daily intake or dose,
RfD = reference dose.

The CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term). EPA does not have a target range for hazard; however, cumulative values less than 1 are deemed to be unimportant. The PGDP *de minimis* hazard level is a sum less than 1 (*Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1506&D1*).

Tables 5 and 6 present the results of risk characterization for SWMUs 1 and the C-720 area used in developing the current action for these sites. Other results are in the RI Reports. Table 5 presents the cancer risk results, and Table 6 presents the systemic toxicity results.

For SWMU 1, both cancer risk and hazard exceed the PGDP *de minimis* benchmarks, and cancer risk exceeds the EPA target risk range. Therefore, both the ELCR and hazard posed to the receptor under the scenario used to determine if action is needed at SWMU 1 have been deemed unacceptable. The primary contaminants driving cancer risk are TCE and VC (a degradation product of TCE). The primary contaminant driving hazard (over all target organs) is TCE; however, antimony also contributes significantly to hazard.

For the C-720 area, both cancer risk and hazard exceed the PGDP *de minimis* benchmarks, and cancer risk exceeds the EPA target risk range. Therefore, both the ELCR and hazard posed to the receptor under the scenario used to determine if action is needed at the C-720 area have been deemed unacceptable. The primary contaminants driving cancer risk are TCE and VC. The primary contaminants driving hazard (over all target organs) are TCE and *trans*-1,2-DCE (another degradation product of TCE); however, antimony also contributes significantly to hazard.

Table 5. Cancer risk characterization summary for chemicals of concern at SWMUs 1 and the C-720 Maintenance Facility

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Excess Lifetime Cancer Risk: Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Scenario Timeframe: Future **Receptor Population: Off Site Rural resident** **Receptor Age: Child and Adult (Lifetime)**								
SWMU 1								
Soil	Groundwater	Fence line	Antimony	NC	NC	NC	NA	NC
			Manganese	NC	NC	NC	NA	NC
			Trichloroethene	NV	NV	NV	NA	5.1E-04
			Vinyl chloride	NV	NV	NV	NA	4.8E-03
Total								**5.3E-03**
C-720 Building								
Soil	Groundwater	Fence line	Antimony	NC	NC	NC	NA	NC
			Silver	NC	NC	NC	NA	NC
			Vanadium	NC	NC	NC	NA	NC
			trans-1,2-Dichloroethene	NC	NC	NC	NA	NC
			Trichloroethene	NV	NV	NV	NA	9.1E-04
			Vinyl chloride	NV	NV	NV	NA	2.1E-04
Total								**1.1E-03**

NA – Route of exposure is not relevant for the COC.

NC – Chemical is not a carcinogen.

NV – No value available. Values were not available because risk was characterized using screening values that considered ingestion, inhalation, and dermal exposure (chemicals) or ingestion, inhalation, and external exposure (radionuclides).

This table provides cancer risk estimates for the scenarios utilized to determine that action is needed at SWMUs 1 and the C-720 Maintenance Facility. Cancer risk estimates for other scenarios and media are available in the Remedial Investigation Report but are not presented here because they are not relevant to the current action.

The risk estimates presented here were based upon a reasonable maximum exposure and were developed by taking into account various assumptions about frequency and duration of exposure to soil and groundwater, as well as the toxicity of the COCs listed. Generally, exposure parameters used in the derivation of the risk estimates were chosen to ensure that risk was not underestimated (i.e., conservative assumptions were used when choosing the exposure parameters).

The total cancer risk levels presented above indicate that if no clean-up action is taken, then a resident would have increased probabilities of 5 in 1,000; and 1 in 1,000 at SWMU 1 and the C-720 Maintenance Facility, respectively, of developing cancer from exposure to groundwater contaminated by constituents migrating from soil.

As discussed in the RI Reports, the summation of risks across chemicals potentially migrating from soil at SWMU 1 and the C-720 Maintenance Facility is a very conservative assumption because transit times for contaminants may vary. In addition, the values shown here are based upon the maximum concentration expected to be seen in groundwater.

Table 6. Hazard characterization summary for chemicals of concern at SWMUs 1 and the C-720 Maintenance Facility

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Excess Lifetime Cancer Risk			Exposure Routes Total
					Ingestion	Inhalation	Dermal	
Scenario Timeframe: Future **Receptor Population: Rural resident** **Receptor Age: Child**								
SWMU 1								
Soil	Groundwater	Fence line	Antimony	Liver	NV	NV	NV	11.5
			Manganese	CNS	NV	NV	NV	0.3
			Trichloroethene	Liver	NV	NV	NV	59.6
			Vinyl chloride	NA	NH	NH	NH	NH
Scenario Total								**71.4**
Liver Total								**71.1**
Other Target Total								**0.3**
C-720 Building								
Soil	Groundwater	Fence line	Antimony	Liver	NV	NV	NV	45.5
			Silver	Skin	NV	NV	NV	0.8
			Vanadium	Kidney	NV	NV	NV	0.3
			trans-1,2-Dichloroethene	Blood	NV	NV	NV	181
			Trichloroethene	Liver	NV	NV	NV	106
			Vinyl chloride	NA	NH	NH	NH	NH
Scenario Total								**333.6**
Liver Total								**151.5**
Blood Total								**181**
Other Target Total								**1.1**

CNS -- Central nervous system

NA – Chemical is not listed as a systemic toxicant. Therefore, a primary target organ is not available.

NH -- Chemical does not have an RfD.

NV – No value available. Values were not available because hazard was characterized using screening values that considered ingestion, inhalation, and dermal.

This table provides hazard quotients for the scenarios utilized to determine that action is needed at SWMU 1 and the C-720 Maintenance Facility. Hazard estimates for other scenarios and media are available in the RI Reports but are not presented here because they are not relevant to the current action.

The hazard estimates presented here were based upon a reasonable maximum exposure and were developed by taking into account various assumptions about frequency and duration of exposure to soil and groundwater, as well as the toxicity of the COCs listed. Generally, exposure parameters used in the derivation of the hazard estimates were chosen to ensure that hazard was not underestimated (i.e., conservative assumptions were used when choosing the exposure parameters).

The total hazard levels presented above indicate that if no clean-up action is taken, then an exposed individual may experience adverse effects from exposure to groundwater contaminated by COCs migrating from soil at SWMUs 1 and the C-720 Maintenance Facility. The information also indicates that the liver is the most likely target organ to be affected at SWMU 1, and liver and blood are the most likely target organs to be affected at the C-720 Maintenance Facility, respectively.

As discussed in the R I Reports, the summation of hazards across chemicals potentially migrating from soil at SWMU1 and the C-720 Maintenance Facility is a very conservative assumption because transit times for contaminants may vary. In addition, the values shown here are based upon the maximum concentration expected to be seen in groundwater.

Although the BHHRA was completed using the best site information available and following approved methods, the risk assessment cautions that several uncertainties should be considered when using the risk assessment results in decision-making. These uncertainties are listed in Table 7 along with their estimated effect (i.e., small, moderate, or large) upon the risk characterization results contained in the RI Reports.

Of the uncertainties listed in Table 7, the only uncertainties estimated to have a large impact on the risk results were those in the risk characterization for lead, in selecting the dermal absorption value when deriving risk from direct contact via dermal exposure, in the exposure parameters used for the excavation worker. As discussed in the footnote to Table 7, none of these uncertainties is important for the current action because neither affects the risk results used to guide this action.

2.7.2 Summary of Ecological Risk Assessment

This section summarizes the baseline ecological risk assessment (BERA) and presents significant results used in making the current decisions for SWMU 1 and the C-720 area. As noted above, the information presented here is a relevant subset of the information presented in the BERAs contained in the aforementioned RI Reports and is not meant to completely describe the baseline risks estimated for all receptors and media assessed. Generally, the information presented is meant to support the current remedy selection process and to familiarize the reader with the basis for undertaking remedial action at SWMU 1 and the C-720 area.

The BERAs for the C-720 area and for the drainage ditches in the vicinity of SWMU 1 appear in RI Report for WAG 27. No evaluation of data for ecological risk was conducted for the C-720 Area because this building is surrounded by cement and provides no suitable habitat for ecological receptors. Therefore, the C-720 area is not discussed further in this section. The drainage ditches in the vicinity of SWMU 1 are not addressed by the remedial actions addressed in this ROD and are not discussed further. Surface soil at SWMU 1 was treated under a separate action and is not discussed here.

The BERA for SWMU 99 appears in RI Report for WAG 28. However, because the action at SWMU 99 is being performed as a maintenance activity to protect the Northeast Plume Treatment Facility, the results of this BERA will not be summarized here.

2.7.3 Conclusions From Risk Assessment

This section presents the overall conclusions reached in the baseline risk assessment for SWMU 1 and the C-720 area that drive the need for action. These conclusions are used to develop the basis for action statement for these three areas.

2.7.3.1 Risks associated with SWMU 1

Risks to Human Health. For SWMU 1, the risk to human health considered in making the current decision was the potential for contaminants in the soil source area to migrate to groundwater, for this contaminated groundwater to migrate to a point along the PGDP fence line, and for a rural resident to use the contaminated groundwater in the home. The total risks for this scenario were 5.3×10^{-3} and 71.4 for ELCR and systemic toxicity, respectively. These values indicate that the total ELCR to a hypothetical resident could be as high as 5 in 1,000 and that a systemic toxic effect is possible. Both values exceed their respective PGDP *de minimis* risk levels (i.e., 1×10^{-6} and 1, respectively) (*Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1), and the cancer risk value exceeds the upper limit of the

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Table 7. Sources of uncertainty in the human health risk assessment for SWMU 1 and the C-720 Building

Description of uncertainty	Estimated effect		
	Small	Moderate	Large
Uncertainties related to data and data evaluation			
Inclusion of infrequently detected analytes in the data set	X		
Inclusion of infrequently analyzed for analytes in the data set	X		
Lack of consideration of temporal patterns in detection of analytes	X		
Quantitation limits for some analytes exceeding their respective human health risk-based screening criteria	X	X	
Inclusion of common laboratory contaminants in data	X		
Lack of analyte comparison to concentrations of these analytes in associated blanks	X		
Removal of analytes from the COPC list on the basis of a toxicity screen	X		
Removal of inorganic analytes in soil from the COPC list on the basis of a comparison to background concentrations	X		
Lack of approved groundwater background concentrations for comparison for the COPC list	X		
Characterization of exposure point concentrations for environmental media under current conditions	X		
Characterization of exposure point concentrations for environmental media under future conditions	X		
Use of groundwater data from samples collected from boreholes versus monitoring wells	X	X	
Migration of groundwater to off-site receptors underestimating risk		X	
Use of total water samples versus filtered in developing dose estimates		X	
Uncertainties related to exposure assessment			
Incorporation of biota fate and transport modeling into risk estimates	X	X	
Use of reasonable maximum exposure parameters versus average exposure parameters for all exposure routes and pathways	X		
Evaluation of groundwater separately from soil in future land use scenarios	X		
Lack of consideration of livestock scenarios	X		
Lack of consideration of an intruder/infrequent recreator land use scenario	X		
Summation of risk across areas and across scenarios	X		
Use of KDEP default values instead of EPA default values when estimating dermal absorbed dose for the HI and ELCR for exposure to soil	X	X	
Use of site-specific exposure values on systemic toxicity and ELCR for the excavation worker	X	X	X
Use of site-specific exposure values on systemic toxicity and ELCR for the current industrial worker	X	X	
Use of chronic toxicity values for the excavation worker use scenario	X		
Uncertainties related to toxicity assessment			
Use of provisional toxicity values for the systemic toxicity of lead			X
Use of provisional or withdrawn toxicity values for systemic toxicity and ELCR	X	X	
Use of KDEP default values for calculating the dermal absorbed dose of systemic toxicants			X
Route to route extrapolation in the derivation of toxicity values	X		
Derivation of toxicity values			
Chemicals		X	
Radionuclides	X		
Selection of toxicity values for PCBs	X		
Calculation of absorbed dose toxicity values from administered dose toxicity values	X		

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Table 7. (continued)

Description of uncertainty	Estimated effect: Small	Moderate	Large
Uncertainties related to risk characterization			
Combination of chemical-specific risk values and pathway risk value	X		
Excluding "hot-spot" soil samples from the risk characterization of SWMU 99a	X	X	
Combination of risk from chemical exposure with those from radionuclide exposure	X	X	

Small = Uncertainty should not cause the risk estimate to vary by more than one order of magnitude.
Moderate = Uncertainty should cause the risk estimate to vary between one and two orders of magnitude.
Large = Uncertainty may cause the risk estimate to vary by more than two orders of magnitude.

This table presents a summary of the effects various uncertainties are reported to have had on the risk characterization results contained in the baseline risk assessments for SWMU 1 and the C-720 Building. Please see the RI Reports for a complete explanation of these uncertainties and their effects.

Uncertainties characterized as having a large effect are of greatest importance when using the results of a baseline risk assessment to guide action. The uncertainties characterized as having a large effect on the risk results for SWMUs 1 and the C-720 Building contained in the RI Reports are the use of exposure parameters for the excavation worker that may exceed site-specific values, the use of default dermal absorption values for contact with soil that may be too conservative (i.e., lead to an overestimation of risk), and use of a provisional toxicity value to derive a risk estimate for lead. Therefore, these uncertainties may cause the final risk values reported in the RI Reports to vary from the reported value by up to two orders of magnitude. However, the effects of these uncertainties upon the risk results pertinent to the current decision are of little importance because none impacts the risk results used to make the decision for SWMU 1 and the C-720 Building (i.e., lead is not a COC at either location and risk from direct contact with soil is not being considered for this action).

EPA risk range deemed acceptable for site related exposures (i.e., 1×10^{-4}). The COCs in the soil source area are TCE, VC, antimony, and manganese. Of these, the contaminant of posing the greatest ELCR and hazard is TCE and its degradation product VC.

Risks to Ecological Receptors. For SWMU 1, the risks to ecological receptors resulting from contamination in the soil source area were determined to be insignificant. This decision was based upon the current and expected future industrial use of the SWMU 1 area and upon the subsurface location of the contaminated soil. (Note: The surface soils at SWMU 1 are being addressed under a separate action.)

2.7.3.2 Risks associated with C-720 Area

Risks to Human Health. For the C-720 area, the risk to human health considered in making the current decision was the potential for contaminants in the soil source area to migrate to groundwater, for this contaminated groundwater to migrate to a point along the PGDP fence line, and for a rural resident to use this groundwater in the home. The total risks for this scenario were 1.1×10^{-3} and 334 for ELCR and systemic toxicity, respectively. These values indicate that the total ELCR to a hypothetical resident could be as high as 1 in 1,000 and that a systemic toxic effect is possible. Both values exceed their respective PGDP *de minimis* risk levels (i.e., 1×10^{-6} and 1, respectively), *(Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1*)* and the cancer value exceeds the upper limit of range deemed acceptable by EPA (i.e., 1×10^{-4}). The COCs in the soil source area are TCE, VC, *trans*-1,2-DCE, antimony, silver, and

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vanadium. Of these, the contaminant of posing the greatest ELCR and hazard is TCE and its degradation products, VC and *trans*-1,2-DCE.

Risks to Ecological Receptors. For the C-720 area, the risks to ecological receptors resulting from contamination in the soil source area were determined to be insignificant. This decision was based upon the current and expected future industrial use of the C-720 area and upon the subsurface location of the contaminated soil. (Note, the surface at the C-720 Building is completely covered by pads and building infrastructure.)

2.7.4 Summary of Radiation Dose Assessment

The RI Report for WAG 27 did not contain a radiation dose assessment; therefore, a screening-level assessment was prepared for this document. Table 8 presents the results of this assessment. In that table, a summary of the radiation doses that could be expected by an off-site rural resident using groundwater contaminated by the constituents migrating from SWMU 1 and the C-720 area is presented. This table was developed using the contaminant concentrations reported in the aforementioned RI Reports and screening values for the relevant receptor listed in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1506&D1. The radiation dose estimate for exposure to groundwater by the rural resident for both sides is below the PGDP *de minimis* level (1mrem/yr, *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1506&D1 and the EPA and Nuclear Regulatory Commission (NRC) limits.

2.7.5 Basis for Action Statement

A response action is generally warranted if one or more of the following conditions exist at a site: (1) the cumulative ELCR to an individual exceeds 1×10^{-4} (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (2) the systemic toxicity hazard index is greater than one (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (3) site contaminants cause adverse environmental impacts; or (4) chemical-specific standards or other measures that define acceptable risk levels are exceeded and exposure to contaminants above these levels is predicted under current or reasonably anticipated future land use. Because the first, second, and fourth conditions exist at SWMU 1 and the C-720 area, a response action for these areas is appropriate.

These findings mean that the response action selected for SWMU 1 and the C-720 area in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants from these areas that may present an imminent and substantial endangerment to public health and welfare.

The action at SWMU 99 is being performed to prevent future ^{99}Tc migration from this source and potentially impacting the groundwater treatment system at the Northeast Plume. This action will promote protection of human health and welfare and the environment and reduce or eliminate migration of contaminants to groundwater to speed the return of groundwater resources to beneficial use by ensuring the continued operation of that treatment system.

Table 8. Radiation dose assessment summary for SWMU 1 and the C-720 Maintenance Facility

Medium	Exposure Medium	Exposure Point	Radionuclide of Concern	Exposure Point Concentration	Screening Value	Dose Estimate (mrem/yr)
Scenario Timeframe: Future **Receptor Population: Off Site Rural resident** **Receptor Age: Adult**						
SWMU 1						
Soil	Groundwater	Fence line	None			
C-720 Maintenance Facility						
Soil	Groundwater	Fence line	None			

This table provides radiation dose estimates for exposure to radionuclides in groundwater at the fence line. The groundwater EPC for SWMU 1 and the C-720 Maintenance Facility is the fence line point of exposure. The screening value isbased on a target value of 1 mrem/yr as discussed in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1506&D1) and include consideration of dose from short-lived decay products.

The radiation doses for exposure to groundwater for both SWMU 1 and the C-720 area are below the PGDP *de minimis* level and the EPA and NRC limits because neither area was identified as a source of radionuclide contamination to groundwater. (The adult is used as the receptor for groundwater because the screening value for the adult is smaller than that for the child.)

2.8 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are medium-specific or OU-specific goals for protecting human health and the environment (EPA 1988). The RAOs are developed by taking into account the results of the screening-level risk assessment and applicable or relevant and appropriate requirements (ARARs).

The RAOs for the three sites are as follows:

- Reduce VOC contamination in UCRS soil at SWMU 1 and the C-720 Building to levels that no longer would result in unacceptable contaminant levels in groundwater at the point of exposure based on the industrial use scenario;
- Excavate soil and concrete at SWMU 99 to an approximate depth of 3 ft to prevent ^{99}Tc within the excavated soil and concrete from migrating from this source and potentially impacting the groundwater treatment system for the Northeast Plume; and
- Reduce or eliminate migration of contaminants to groundwater to speed the return of groundwater resources to beneficial use.

2.9 DESCRIPTION OF ALTERNATIVES

The GWOU FS evaluated 12 technology-based alternatives for responding to the groundwater contamination and subsurface soil contamination present in the contaminant source areas. From these technology based alternatives, three alternatives were compiled and included in a PRAP for responding to the source areas of C-720 area, C-747-C Oil Landfarm, and C-746-D Scrap Yard. The three alternatives proposed consisted of the following:

- No Action at any of the three sites;

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- Dual Phase Extraction (DPE) at the C-720 and C-747-C areas, along with contaminated concrete removal and soil excavation at C-746-D and LUCs; and

- SPH at the C-720 and C-747-C areas, along with contaminated concrete removal and soil excavation at C-746-D and LUCs.

A description of each alternative evaluated for the sites is included below.

Alternative 1: No Action

Under the No Action alternative, active mass removal, treatment, or containment would not be performed. Pursuant to Section 300.430(e)(6) of the National Contingency Plan (NCP), DOE is required to consider a no action alternative. This remedial alternative provides a basis for assessing the effects of taking no action and provides a baseline against which the other alternatives may be compared. Because no action would be taken at any of the three sites, the risks associated with the present condition of the sites would remain. There would be no risk reduction. No additional monitoring or site restrictions would be included as part of this remedy. However, since contaminants would remain in place, the five-year reviews mandated by CERCLA would be required under this alternative.

Alternative 2: DPE and Excavation and LUCs

Alternative 2 consists of the following activities:

- Removal and treatment of VOCs contaminated UCRS groundwater from C-720, C-747-C areas using DPE;

- Removal and treatment of vadose zone VOCs from C-720, and C-747-C areas using DPE;

- Excavation of ^{99}Tccontaminated concrete and soil from the C-746-D;

- Implementation of LUCs on the C-720, C-747-C and C-746-D areas; and

- Completion of five-year reviews for the areas since contamination will remain in place following the remedial actions.

A DPE system will be used to remove the contaminated groundwater and soil vapor from C-747-C and C-720 areas. DPE, also known as multi-phase extraction or vacuum-enhanced extraction, uses a high vacuum system to remove various combinations of contaminated groundwater, separate-phase nonaqeous-phase liquids, and VOC contaminant vapors from the subsurface. In DPE systems for liquid/vapor treatment, a high vacuum system is utilized to remove liquid and gas from low permeability or heterogeneous formations. The vacuum extraction includes a well screened in the target zone of contaminated soils and groundwater. It removes contaminants from above and below the water table. The pumping system lowers the water table around the well, dewatering the formation. Contaminants in the vadose zone then are accessible to vapor extraction by volatilizing in air that is now moving through the dewatered zones. Once above ground, the extracted vapors, liquid-phase organics and groundwater are separated and treated. The DPE system will not remediate groundwater contaminants located in the deeper RGA due to the high volume of groundwater and thus will not be applied to the RGA in this action. The DPE portion of Alternative 2 includes the following components:

- Installation of recovery wells at each of the two sites (C-720 and C-747-C);

- Withdrawal of UCRS groundwater by pumping;
- Withdrawal of VOCs from the vadose zone by high vacuum (approximately 20-25 inches of mercury) extraction;
- Treatment of contaminants in groundwater and soil vapor;
- Monitoring of contaminants in groundwater and air;
- Discharge of treated groundwater through a National Pollutant Discharge Elimination System (NPDES) permitted outfall; and
- Discharge of treated vapors to the atmosphere.

Also, included in the Alternative 2 remedial action will include the breakup and removal of the western pad of SWMU 99 (C-746-D). This portion of Alternative 2 will include the following components:

- Breakup and excavation of 180 x 330 ft. concrete pad and associated subsurface piping (2,200 yd^3 *in situ*);
- Excavation of ^{99}Tc contaminated soil located beneath the concrete pad to an estimated depth of 3 ft (4,400 yd^3 *in situ*);
- Excavation of ^{99}Tc contaminated soil in a 10 ft band adjacent to the concrete pad to an estimated depth of 3 ft (1,178 yd^3 *in situ*);
- Disposal of excavated concrete and soils at an disposal facility; and
- Backfilling, grading, seeding and mulching of excavation.

Note: Scrap metal that is currently located on the concrete pad will be and removed and disposed in a separate CERCLA action (Scrap Metal EE/CA).

LUCs will be included in Alternative 2 and will consist of the following activities:

- Placement of Property Record Notices to alert anyone searching property records to the important information about contamination and response actions on the property;
- Administrative Controls in the form of "excavation/penetration permit program" that will require a worker to obtain formal authorization prior to excavating or performing other intrusive activities in the area; and
- Access controls in the form of fences, gates and security measures necessary to ensure protectiveness following the remedial response.

Five-year reviews mandated by CERCLA would be required for this alternative, since untreated wastes would remain onsite.

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Alternative 3: SPH, Excavation, and LUCs

Alternative 3 consists of the following activities:

- Removal and treatment of VOCs contaminated UCRS groundwater from C-720 and C-747-C areas using SPH;
- Removal and treatment of vadose zone VOCs from C-720 and C-747-C areas using SPH;
- Excavation of contaminated concrete and soil from C-746-D;
- Implementation of LUCs on the C-720, C-747-C, and C-746-D areas; and
- Completion of five-year reviews for the areas since contamination will remain in place following the remedial actions.

SPH typically utilizes six electrodes located in a hexagonal shape with a neutral electrode located in the center of the hexagon serving as a vapor extraction well. A typical array diameter is 25–35 ft, with the heated zone being approximately 40% larger than the array diameter (i.e., approximate volume of 2,325 yd^3, assuming 50 ft depth). The technology uses electric current to apply *in situ* heating to raise the temperature of the soil to a level where the target contaminant(s) is/are volatilized. The technology can be deployed in the vadose and saturated zones, and may be used in low-permeability or highly heterogeneous soils. Common power sources (60Hz) may be used to heat the ground (typical subsurface applied voltages range from 150–600 volts), producing *in situ* steam to liberate the contaminants, which are removed by way of a vapor recovery system. The SPH will not be applied to the deeper RGA under this action. The SPH portion of Alternative 3 includes the following components: (1) Installation of electrodes and vapor extraction wells at each of the two sites (C-720 and C-747-C); (2) Heating of subsurface soil, contaminants, and groundwater via application of electrical current to the UCRS soils;

- Withdrawal of volatilized VOCs from the vadose zone by high vacuum (approximately 20-25 inches of mercury) extraction;
- Treatment of contaminated soil vapor;
- Monitoring of contaminants in groundwater and air;
- Discharge of treated groundwater through a NPDES permitted outfall; and
- Discharge of treated vapors to the atmosphere.

Alternative 3 also includes the excavation of contaminated soil and concrete at C-746-D, the application of LUCs, and CERCLA mandated five-year reviews. For specifics of these actions refer to previous description of Alternative 2.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

This section provides the basis for determining which alternative does the following: (1) meets the threshold criteria of overall protection of human health and the environment, and compliance with ARARs; (2) provides the best balance between effectiveness and reduction of toxicity, mobility, or

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volume through treatment, implementability, and cost; (3) satisfies state and community acceptance; and (4) is consistent with the Kentucky Hazardous Waste Permit.

Nine criteria are required by CERCLA for evaluating the expected performance of remedial actions. The nine criteria are identified below and the action has been evaluated on the basis of these criteria.

1. **Overall protection of human health and the environment.** This threshold criterion requires that the remedial alternative adequately protects human health and the environment, in both the short and long term. Protection must be demonstrated by the elimination, reduction, or control of unacceptable risks.

2. **Compliance with ARARs.** This threshold criterion requires that the alternatives be assessed to determine if they attain compliance with ARARs of both state and federal law.

3. **Long-term effectiveness and permanence.** This primary balancing criterion focuses on the magnitude and nature of the risks associated with untreated waste and/or treatment residuals remaining at the conclusion of remedial activities. This criterion includes consideration of the adequacy and reliability of any associated containment systems and institutional controls, such as monitoring and maintenance requirements, necessary to manage treatment residuals and untreated waste.

4. **Reduction of contaminant toxicity, mobility, or volume through treatment.** This primary balancing criterion is used to evaluate the degree to which the alternative employs recycling or treatment to reduce the toxicity, mobility, or volume of the contamination.

5. **Short-term effectiveness.** This primary balancing criterion is used to evaluate the effect of implementing the alternative relative to the potential risks to the general public, potential threat to workers, potential environmental impacts, and the time required until protection is achieved.

6. **Implementability.** This primary balancing criterion is used to evaluate potential difficulties associated with implementing the alternative. This may include technical feasibility, administrative feasibility, and the availability of services and materials.

7. **Cost.** This primary balancing criterion is used to evaluate the estimated costs of the alternatives. Expenditures include the capital cost, annual operation and maintenance (O&M), and the combined net present value of capital and O&M costs.

8. **State acceptance.**

9. **Community Acceptance.** This modifying criterion provides for consideration of any formal comments from the community on the PRAP.

2.10.1 Overall Protection of Human Health and the Environment

Under this threshold criterion, alternatives are evaluated to determine the ability to reduce risk to human health and the environment. Since Alternative 1 is a No Action alternative, it does not provide overall protection to human health or the environment. Alternatives 2 and 3 provide overall protection to human health and the environment by meeting RAOs at the point of exposure for source unit and target compounds. Alternatives 2 and 3 generally provide positive long-term impacts that would result from the removal and treatment of the contamination.

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2.10.2 Compliance with ARARs

Under this threshold criterion, alternatives are evaluated to ensure compliance with applicable or relevant and appropriate regulatory requirements that must be met during implementation of the alternative(s). Although CERCLA waives administrative requirements for activities conducted within an AOC or CERCLA unit, the substantive requirements, or ARARs, must be met or waived.

Alternative 1, the No Action Alternative, does not meet this threshold criteria since contaminant source areas would remain in place. The continued introduction of contaminants into groundwater from source areas would result in continued exceedances of contaminants at the Point of Compliance and the Point of Exposure.

Implementation of Alternatives 2 or 3 can be conducted in a manner that achieves the applicable requirements for the soil sources. As such these actions are considered final for volatile contamination at C-720 and SWMU 1 and for ^{99}Tc contamination at SWMU 99. These alternatives would result in the reduction or removal or source areas, but they would not immediately achieve compliance with the MCL for TCE in groundwater. In accordance with the NCP at 40 CFR 300.430(f)(1)(ii)©(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action. Therefore Alternative 2 and 3 are interim actions with respect to groundwater contamination. Attainment of ARARs for groundwater will be addressed in the multiple actions for the GWOU as described in the Scope and Role of the Operable Unit section.

2.10.3 Long-Term Effectiveness and Permanence

Under this balancing criterion, long-term effectiveness and permanence are evaluated based upon the magnitude of residual risk and the adequacy and reliability of controls used to manage remaining waste (untreated waste and treatment residuals) over the long term (i.e., after remedial objectives are met).

Alternative 1, the No Action alternative, does not meet this balancing criterion since residual risks would remain in place. No reduction of contaminant concentrations will occur except through limited natural attenuation and migration into the groundwater via flushing during precipitation events. The migration of the contaminants would impact groundwater resulting in the continued presence of off-site groundwater contaminant plumes and continued risk.

Alternatives 2 and 3 meet the criterion for long-term effectiveness and permanence. Both alternatives are expected to reduce the magnitude of residual risk by removal of the VOCs from the UCRS soils and groundwater from the C-720 and C-747-C source areas. It is expected that both of the alternatives will leave residual quantities in place following completion of the action. However, it is expected that these quantities will be insufficient to result in an unacceptable risk at the point of compliance. Alternative 3, SPH, is expected to be the most efficient at reduction of the volatile contaminants in the UCRS source zone. This is expected since Alternative 3 heats the soil and contaminants which results in volatilization of the contaminants and increased removal. SPH also may increase soil permeabilities through dessication of the clays in the low permeability areas that may also result in increased contaminant removal. Alternative 2, DPE, will encounter more difficulties in removing the similar quantities of volatile contaminants since it relies on diffusion of the DNAPL contaminants into the air stream that is passing through the area. Dual Phase also will be more susceptible to reduced contaminant recoveries due to by-passing of the contaminant contained in zones of insufficient permeability to allow the passage of air.

Neither Alternative 2 or 3 will result in any major reductions of ^{99}Tc at C-720 or C-747-C. The reductions in technetium will be limited to the recoveries made from extracted UCRS groundwater. Both alternatives, however, are expected to be successful at removing technetium from the C-746-D area

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through the use of the soil and concrete excavation. The technetium reductions at C-746-D are expected to prevent the migration of the contaminant to groundwater and then subsequent spread to off-site locations.

Potential long-term impacts to resources and mitigative measures to offset any potential impacts are described in the text below. The depth of impact analysis and mitigative measures is correlated to the degree to which a resource may be impacted.

No long-term environmental impacts on land use, air quality and noise, geology and soils, wetlands and floodplains, cultural resources, socioeconomics, or transportation would be expected under the No Action Alternative. Long-term impacts to ecological resources including T&E species would be negligible. This is based upon the location of the contamination being addressed (i.e., in the subsurface or below significant cover such as a cement pad), the relatively small size of the contaminant source areas, and the industrial nature of the units. However, long-term adverse impacts to terrestrial and aquatic biota could occur if the contaminated groundwater beneath the units migrates to the Northwest Plume and into Little Bayou Creek or other surface water body.

Land use. Alternatives 2 and 3 are not expected to have any long-term impacts on land use. The immediate areas surrounding the affected units are currently affected by institutional controls that restrict access. These controls will remain in place under Alternatives 2 and 3, thus land use would remain unchanged.

Air quality and noise. No long-term impacts to air quality or noise would result from Alternatives 2 and 3. After completion of the remedial action, air pollutant and noise levels would be similar to current background levels.

Geology and soils. Alternatives 2 and 3 would have no long-term impact on the geology within the vicinity of the remedial actions. Both alternatives would have a positive long-term impact on soils since contamination sources would be eliminated or reduced.

Water resources. Alternatives 2 and 3 should have an overall positive long-term impact on surface and groundwater resources in the vicinity of the affected units since contaminated soils would be removed and the contaminated groundwater would be treated.

Wetlands and floodplains. No wetlands or floodplains are located within any portion of the units that would be remediated under Alternative 2 or 3; thus, no long-term impacts would occur.

Ecological resources. Alternatives 2 and 3 should have an overall positive long-term impact on ecological resources including any potential threatened and endangered(T&E) species in the vicinity of the affected units since contaminated soils would be removed and the contaminated groundwater would be treated. Removal of contaminated soils and treatment of groundwater would also help to eliminate an additional potential source of contamination to the aquatic and terrestrial resources within an adjacent to Little Bayou Creek.

Cultural resources. No long-term impacts to cultural resources are anticipated from either Alternative 2 or 3. It is very unlikely that any intact archaeological resources are still present because the affected units are located within the fenced industrialized portion of PGDP and they have been previously disturbed from construction and maintenance activities. In addition, no PGDP historical resources would be impacted.

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Socioeconomics. No long-term socioeconomic impacts including any environmental justice issues would result from implementation of either Alternative 2 or 3.

Transportation. No long-term direct or indirect impacts are anticipated for either of the alternatives.

Cumulative impacts. Cumulative impacts are those that may result from the incremental impacts of an action considered additive with the impacts of other past, present, and reasonably foreseeable future actions. No notable cumulative impacts resulting from Alternatives 2 and 3 have been identified except for the positive long-term impacts that would result from the removal and treatment of the contamination.

2.10.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Both Alternative 2 (DPE and Excavation) and Alternative 3 (SPH and Excavation) satisfy the preference for treatment of VOCs - through the combined use of an air stripper and catalytic oxidation - and for treatment of ^{99}Tc - through the use of ion exchange for the C-720 and the C-747-C DNAPL source zones. SPH is expected to be significantly more effective than DPE for the reduction of toxicity and volume of DNAPL. However, DPE offers reversibility while SPH is irreversible. SPH is considered to be irreversible since the addition of heat to the soil will dehydrate the clay soils present and may result in a permanent increase in soil permeability. Although this is considered an irreversible impact, the permeability increase is expected to be only minimal and in most instances will be beneficial to the implementation of future technologies.

Alternatives 2 and 3 include excavation as the primary technology to address the C-746-D ^{99}Tc source zone. Excavation is the only technology with the potential to be highly effective on the ^{99}Tc source zones. Its effectiveness is primarily constrained by the infrastructure limits of excavation.

Alternative 1 does not fulfill any of the criteria that are assessed under reduction of toxicity, mobility, or volume through treatment.

2.10.5 Short-Term Effectiveness

Alternative 1, the No Action alternative, would not be effective from the standpoint that someone who begins using the RGA groundwater beneath or downgradient of the C-720 and C-747-C areas could be exposed to volatile organic contamination. The community surrounding the plant currently is using public water, but agreements are not binding for new residents moving into the impacted areas. The contamination in the UCRS is, in some areas of the target sites, shallow and persons could have direct contact in an excavation scenario. However, all of the target sites are located inside the PGDP security fence, which will prevent the nearby community from coming into direct contact. Workers at the PGDP plant are under programmatic risk management controls that requires signed authorizations prior to excavating in SWMU areas.

The potential for adverse impacts to the surrounding community during the implementation of Alternatives 2 and 3 is minimal. Although both alternatives will result in atmospheric emissions and water releases, each alternative will use engineering controls to treat the vapors and water prior to releasing them. Both alternatives will be performed at locations inside the PGDP security fence that will minimize the danger to the community through the construction and operation of the alternatives.

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Additionally, environmental monitoring will be performed during construction and operation to insure no inadvertent contaminants are released from the target locations.

Both Alternatives 2 and 3 have the potential for worker exposure to contaminated soil and groundwater during construction, operation and sampling during the remedial action. Additionally, alternative 3, SPH also would provide the potential for workers to be exposed to electrical currents and soils and groundwater at elevated temperatures due the subsurface heating and the electricity used to induce the soil heating. Additionally, there is the potential for worker injury during the excavation of the C-746-D in both alternatives due to the use of heavy equipment. However, worker exposure is very unlikely due the PGDP risk management requirements that include the use of appropriate personal protection equipment, operating procedures and engineering controls.

Under the No Action Alternative, there would be no short-term environmental impacts on land use, air quality and noise, geology and soils, wetlands and floodplains, cultural resources, socioeconomics, or transportation. Short-term environmental impacts would also be negligible for ecological resources including T&E species based upon the location of the contamination being addressed, the relatively small size of the contaminant source areas, and the industrial nature of the units.

Land use. Alternatives 2 and 3 are not expected to have any short-term impacts on land use. The immediate areas surrounding the affected units are currently affected by institutional controls that restrict access. These controls are assumed to remain in place under Alternatives 2 and 3; thus, land use would remain unchanged.

Air quality and noise. Impacts to air quality under Alternatives 2 and 3 would include emissions from vehicle and equipment exhaust and fugitive dust from vehicle traffic and disturbance of soils. Site preparation and construction activities would be short-term, sporadic, and localized (except for emissions from vehicles of construction workers and transport of construction materials and equipment). Fugitive dust from excavation and earthwork activities would be noticeable onsite and in the immediate vicinity. Dispersion would decrease concentrations of pollutants in the ambient air as distance from the construction site increased. The use of control measures (i.e., covers and water or chemical dust suppressants) would minimize fugitive dust emissions. No exceedances of primary or secondary National Ambient Air Quality Standards are expected.

Increased noise levels from the transport and use of construction equipment in the immediate vicinity of the remedial actions would also be short-term, sporadic, and localized. Noise levels are already slightly elevated in the vicinity of the affected units because they are located within the industrialized portion of PGDP. No sensitive noise receptors (e.g., residences) are located near the units, thus no noise impacts would occur.

Geology and soils. No short-term impacts to on-site geology would result from either Alternative 2 or 3 and these alternatives would only have result in minor short-term impacts to affected soils. Soil erosion impacts during the remedial actions would be mitigated through the use of control measures (i.e., covers, silt fences, and straw bales). Because soils in the vicinity of the units have been previously disturbed as a result of PGDP construction and maintenance activities, no impacts to prime farmland soils would occur.

Water resources. Under Alternatives 2 and 3, potential short-term adverse impacts to surface waters would originate from soil erosion, runoff, and increased sedimentation during the remedial actions and from an accident involving the release of fuel or other hazardous materials. Soil erosion impacts would be mitigated through the use of appropriate control measures (e.g., covers, silt fences, straw bales) and the potential for an accident and subsequent spill would be mitigated through the adherence to proper

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safety procedures and spill prevention plans. In the event of a spill from an accident, spill response measures (e.g., booms, berms, sorbents, neutralizers, secondary containment, and mechanical removal equipment) would minimize potential adverse impacts to the receiving surface waters.

Wetlands and floodplains. No wetlands or floodplains are located within any portion of the units that would be remediated under Alternative 2 or 3; thus no short-term impacts would occur.

Ecological resources. Due to the industrialized and previously disturbed nature of the affected units, only limited ecological resources are present and short-term impacts to ecological resources under Alternative 2 or 3 are expected to be negligible. No T&E species are known to exist within the vicinity of the areas that would be impacted during the remedial actions.

Cultural resources. No short-term impacts to cultural resources are anticipated from either Alternative 2 or 3. It is very unlikely that any intact archaeological resources are still present because the affected units are located within the fenced industrialized portion of PGDP and they have been previously disturbed from construction and maintenance activities. In addition, no PGDP historical resources would be impacted.

Socioeconomics. Alternative 2 or 3 would not have any direct or indirect short-term adverse impacts on local socioeconomic resources such as population, employment, housing, schools, public services and local government expenditures (i.e., utilities, hospitals, and police and fire protection). The workforce that would be required for remedial actions would be small and would likely be drawn from the local labor market, resulting in no new influx of workers to the area.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations," requires agencies to identify and address disproportionately high and adverse human health or environmental effects their activities may have on minority and low-income populations. No census tracts near the site include a higher proportion of minorities than the national average. Some nearby tracts meet the definition of low-income populations, including two tracts in the north-northeast direction of the prevailing wind, but these are not the tracts closest to the Paducah site. Therefore, there would be no disproportionate or adverse environmental justice impacts to any minority or low-income populations.

Transportation. Only minor short-term transportation impacts would result from Alternative 2 or 3. During the remedial actions there would be a slight increase in the volume of truck traffic in the immediate vicinity, but the affected roads are capable of handling the additional traffic. Also, an increased potential for accidents would be expected with any equipment transportation and offsite transport of waste commensurate with the volume of waste being transported.

Cumulative impacts. No notable short-term cumulative impacts resulting from Alternatives 2 and 3 have been identified.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

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Each of the three alternatives is technically and administratively feasible. However, because of the recalcitrant nature of DNAPL, the potential exists that DPE and SPH will not immediately achieve cleanup goals.

Among the DNAPL source zone technologies, the availability of services and materials is relatively limited for SPH as compared to DPE. Excavation, the primary ^{99}Tc source zone technology of Alternatives 2 and 3, is practically limited to soils above the water table and where the existing infrastructure allows.

2.10.7 Cost

Under this balancing criterion, the cost of each alternative is evaluated. The estimates are intended to aid in making project evaluations and comparisons between alternatives. Consistent with EPA guidance (EPA 1988), the estimates have an expected accuracy of -30% to +50% for the scope of action described for each alternative. The initial cost estimates that were developed for each alternative are presented in Table 9.

Table 9. Cost comparison of remedial alternatives

Present Worth Cost ($K)	Alternative 1: No Action	Alternative 2: DPE and Excavation and LUC	Alternative 3: SPH and Excavation and LUC
Estimated Capital Cost:	$0	$14,029	$12,838
Estimated Annual O&M*:	$0	$6,739	$4,586
Estimated Present Worth:	$0	$20,768	$17,425

*O&M costs include confirmatory sampling and decontamination and decommissioning.

These costs include project management, design, supplies and equipment, construction, construction support, waste characterization, and waste shipping and disposal. The costs do not include an allowance for contingency. Since Alternative 1 is a No Action alternative, no costs are associated with its implementation. Alternative 2 has the highest capital and O&M costs, associated with a longer operation times necessary to meet treatment goals. Alternative 3 has the lowest capital and O&M costs. The duration of operation for Alternative 3 is much shorter than the operation time for Alternative 2.

2.10.8 State Acceptance

The FS, PRAP, and draft ROD were issued for review and comment to both the KDEP and EPA. The KDEP concurs with the need for a remedial action for the UCRS source zones near C-720, C-747-C, and C-746-D consistent with the requirements of the Commonwealth of Kentucky's Hazardous Waste Permit.

2.10.9 Community Acceptance

No groups and organizations opposed a remedial action for the UCRS source zones near C-720, C-747-C and C-746-D. Community response to the alternatives is presented in the responsiveness summary, which addresses comments received during the public briefing and public comment period.

2.11 PRINCIPAL THREAT WASTES

A principal threat waste is a source material containing contaminants that meet the following criteria.

1. The contaminants are highly toxic.

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2. The contaminants are highly mobile and difficult to contain reliably.

3. The contaminants are present at a concentration that could potentially result in a significant risk to human health or the environment under a reasonably anticipated future land use. (A significant risk exceedance would be one that exceeds the EPA generally acceptable risk range by one or more orders of magnitude.)

The source materials in the UCRS at C-747-C and C-720 meet each of these criteria; therefore, these source materials can be considered principal threat wastes. Specific reasons are as follows.

1. The source materials do contain at least one contaminant that is known to be highly toxic. This contaminant is vinyl chloride, a degradation product of TCE that is a known human carcinogen.

2. The source materials do contain several contaminants that are highly mobile in the subsurface. Both environmental sampling results and transport modeling indicate that TCE and its degradation products have and will continue to readily migrate to the major aquifer underlying the sites.

3. Migration from the sources to the underlying aquifer cannot be halted reliably. The source materials are found at a depth that makes containment difficult.

4. A significant risk to potential groundwater users could result if groundwater drawn from the aquifer is used in either an industrial or a residential setting. Potential risks from groundwater use could significantly exceed the EPA's generally acceptable risk range.

The source material in surface soil at C-746-D does not meet these criteria. Therefore, this source material cannot be considered a principal threat waste. Reasons for this determination are as follows.

1. The primary contaminant to be addressed (i.e., ^{99}Tc) is not highly toxic.

2. The sampling results indicate that the ^{99}Tc source is not large enough to significantly impact the aquifer. However, modeling results do indicate the ^{99}Tc is highly mobile in the environment and may affect the Northeast Plume Treatment System.

3. The source material is found in the near surface; therefore, continued migration from this material can be easily halted.

4. Direct contact either with the source material or with the groundwater to which the primary contaminant may migrate does not present a significant risk.

The alternatives chosen for C-747-C and the C-720 area addressed the principal threat wastes at these units in the following ways.

- **Alternative 1: No Action** – As discussed earlier, this alternative is included as a baseline against which other alternatives can be compared. As such, it does not address the principal threat wastes present at C-747-C and the C-720 area.

- **Alternative 2: DPE and Excavation** – As discussed earlier, this alternative would remove and treat contaminated groundwater and vadose zone VOCs from the source materials in the UCRS at C-747-C and C-720. (Excavation is directed toward C-746-D and will not be considered here.) Therefore, this alternative would directly address the principal threat wastes at C-747-C and C-720.

- **Alternative 3: SPH and Excavation** – As discussed earlier, this alternative would volatilize and remove contaminated groundwater and vadose zone VOCs from the source materials in the UCRS at C-747-C and C-720. (Excavation is directed toward C-746-D and will not be considered here.) Therefore, this alternative would directly address the principal threat wastes at C-747-C and C-720.

2.12 SELECTED REMEDY

Based upon the evaluation of the alternatives with regard to the nine criteria, the selected remedy is Alternative 3, SPH, Excavation, and LUCs. The DOE will prepare a detailed design for this remedial action in accordance with the requirements specified in the "Declaration" of this ROD.

2.12.1 Description of the Selected Remedy

The Alternative 3 is the selected remedy. It will consist of the following elements, at a minimum.

- Removal and treatment of VOCs contaminated UCRS groundwater from C-720 and C-747-C using SPH;
- Removal and treatment of vadose zone VOCs from C-720 and C-747-C using SPH;
- Excavation of contaminated concrete and soil from the C-746-D;
- Implementation of LUCs on the C-720, C-747-C, and C-746-D areas; and
- Completion of five-year reviews for the areas since contamination will remain in place following the remedial actions.

SPH typically utilizes arrays of six electrodes located in a hexagonal shape with a neutral electrode located in the center of the hexagon serving as a vapor extraction well. A typical array diameter is 25–35 ft, with the heated zone being approximately 40% larger than the array diameter (i.e., approximate volume of 2,325 yd^3, assuming 50 ft depth). The technology uses electric current to apply *in situ* heating to raise the temperature of the soil to a level where the target contaminant(s) is/are volatilized. The technology can be deployed in the vadose and saturated zones, and may be used in low-permeability or highly heterogeneous soils. Common power sources (60Hz) may be used to heat the ground (typical subsurface applied voltages range from 150–600 volts), producing *in situ* steam to liberate the contaminants, which are removed by way of a vapor recovery system. The SPH will not be applied to the deeper RGA under this action. The SPH portion of Alternative 3 includes the following components:

- Installation of electrodes and vapor extraction wells at each of the two sites (C-720 and C-747-C);
- Heating of subsurface soil, contaminants, and groundwater via application of electrical current to the UCRS soils;
- Withdrawal of volatilized VOCs from the vadose zone by high vacuum (approximately 20-25 inches of mercury) extraction;
- Treatment of contaminated soil vapor through the use of catalytic oxidation or other equivalent contaminant destructive treatment;

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- Treatment of recovered groundwater to remove the volatile organics by air stripping and ^{99}Tc utilizing ion exchange resins.

- Monitoring of contaminants in groundwater and air;

- Discharge of treated groundwater through a NPDES permitted outfall; and

- Discharge of treated vapors to the atmosphere.

Also, included in the Alternative 3 remedial action will include the breakup and removal of the concrete at C-746-D. This portion of Alternative 3 will include the following components:

- Breakup and excavation of 180 x 330 ft concrete pad and associated subsurface piping (2,200 yd^3 *in situ*);

- Excavation of ^{99}Tc contaminated soil located beneath the concrete pad to an estimated depth of 3 ft (4,400 yd^3 *in situ*);

- Excavation of ^{99}Tc contaminated soil in a 10 ft band adjacent to the concrete pad to an estimated depth of 3 ft (1,178 yd^3 *in situ*);

- Treatment, as necessary, and disposal of excavated ^{99}Tc contaminated concrete and soils at a permitted disposal facility;

- Backfilling the area with clean soil; and

- Grading, seeding and mulching of excavation.

Note: Scrap metal that is currently located on the concrete pad will be and removed and disposed in a separate CERCLA action (Scrap Metal EE/CA).

LUCs will be included in Alternative 3 and will consist of the following activities:

- Placement of Property Record Notices to alert anyone searching property records to the important information about contamination and response actions on the property;

- Administrative Controls in the form of "excavation/penetration permit program" that will require a worker to obtain formal authorization prior to excavating or performing other intrusive activities in the area; and

- Access controls in the form of fences, gates and security measures necessary to ensure protectiveness following the remedial response.

Five-year reviews mandated by CERCLA would be required for this alternative, since untreated wastes would remain onsite.

2.12.2 Final Cleanup Levels

This section presents the cleanup levels for the C-747-C and C-720 areas. These cleanup levels were developed considering the scope of the OU described in Sect. 2.4; the descriptions and results contained in Sects. 2.5, 2.6, and 2.7; and the description of the selected remedy in Sect 2.12.1.

As discussed earlier, the purpose of the action is to control risks posed by direct contact with groundwater (residential use) and to minimize any continued migration of contaminants to groundwater. The results of the baseline human health risk assessment indicate that the existing conditions at C-747-C (Oil Landfarm) and the C-720 could result in ELCRs to a resident from use of groundwater contaminated by constituents migrating from source zones and withdrawn from the RGA at the PGDP fence line in excess of 1×10^{-4}. Additionally, sampling results indicate that continued migration of ^{99}Tc from sources at C-746-D (SWMU 99) could impact the Northeast Plume Treatment System. (Because the action at C-746-D is not risk-based a cleanup level for the action is not discussed further here.) The risks from use of groundwater contaminated by constituents migrating from SWMUs 1 and the C-720 area were determined to be primarily from trichloroethene and other volatile organic compounds. Subsequent analysis of the source zones at C-747-C, and C-720 (see Appendix A of this document) determined that addressing the primary risk drivers listed in Table 10 (TCE)would result in residual risks over all COCs below PGDP *de minimis* levels *(Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1*)* or within the EPA target risk range for site-related exposures. Therefore, the remedy described in Sect. 2.12.1 shall address source zone soils contaminated with TCE in excess of 0.179 and 0.311 mg/kg at C-747-C and C-720, respectively. The basis for these soil cleanup levels are the maximum contaminant levels for TCE as described in Sect. 2.12.1, treatment of soils will be monitored at C-747-C and C-720. After the action, source zone contamination at each site will be reduced to levels that allow unrestricted industrial use.

2.13 STATUTORY DETERMINATIONS

The selected remedial action is protective of human health and the environment; complies with CERCLA (as amended by SARA), statutory requirements of K.R.S. 224.46-530 and federal and state ARARs directly associated with this action; and is cost effective. This action uses permanent solutions to the maximum extent practicable, given the limited scope of the action.

2.13.1 Overall Protection of Human Health and the Environment

The selected remedial action, which includes SPH, excavation, and LUCs, provides adequate overall protection to human health and the environment by meeting RAOs at the point of exposure for source unit and target compounds.

2.13.2 Compliance with ARARs

The selected remedy, which includes SPH, excavation, and LUCs will result in source control of soil contaminants contributing to groundwater contamination. This remedy will meet ARARs for the scope of remedial actions encompassed within this ROD. However, the selected remedy does not attain the MCL in groundwater for TCE (5 µg/L or 5 ppb), which is an ARAR for final cleanup of groundwater. The NCP at 40 CFR 300.340(f)(1)(ii)(C)(1), states that an alternative that does not meet an ARAR may be selected when the alternative is an interim measure, and the ARAR will be attained or waived as part of the total or final remedial action. Therefore, this action will be an interim action with respect to PGDP groundwater contamination. Attainment of final ARARs for groundwater will be addressed in the multiple actions for the GWOU as described in the Scope and Role of the Operable Unit section of this ROD. The ARARs summarized in Appendix B list the chemical-specific, location-specific, and action-specific ARARs/TBCs for the remedial actions in the selected remedy.

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Table 10. Cleanup Levels for Driving COCs at SWMUs 1 and 99 and the C-720 Maintenance Facility

Media: Soil in Source Zone **Site Area:** SWMU 1 **Available Use:** Industrial Use in Source Area; Residential Use of Groundwater Drawn from RGA at Property Boundary **Controls to Ensure Restricted Use:** Land Use Controls at Source; None at Property Boundary			
Chemical of Concern[1]	**Cleanup Level**	**Basis for Cleanup Level**[2]	**Risk at Cleanup Level**[3]
TCE	1.121 mg/kg (ppm)	MCL in Water (5 μg/l)	2.9×10^{-6} (Residential Use of Water) 7.2×10^{-8}(Industrial Use of Source Zone)
Media: Soil in Source Zone **Site Area:** C-720 Maintenance Facility **Available Use:** Industrial Use of Source Area; Residential Use of Groundwater Drawn from RGA at Property Boundary **Controls to Ensure Restricted Use:** Land Use Controls at Source; None at Property Boundary			
Chemical of Concern[1]	**Cleanup Level**	**Basis for Cleanup Level**[2]	**Risk at Cleanup Level**[3]
TCE	0.700 mg/kg (ppm)	MCL in Water (5 μg/l)	2.9×10^{-6} (Residential Use of Water) 1.2×10^{-7} (Industrial Use of Source Zone)

ppm = parts per million

[1] Identified in the baseline risk assessment.
[2] Most restrictive value used as basis for cleanup level.
[3] Risk at cleanup level derived utilizing the appropriate cleanup level presented in the table and the appropriate No Action cancer risk screening value in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1. For the resident, the value used was the MCL and the residential use No Action cancer risk screening value in water (1.73 μg/l for TCE). For the industrial worker, the values used were the cleanup level in soil and the industrial use No Action cancer risk screening value in soil (2.51 mg/kg for TCE). The equation used to calculate risk is as follows:

$$\text{Risk} = \frac{\text{Cleanup Level}}{\text{No Action Level}} \times \text{Risk Target}$$

where: Risk is the calculated value.
Cleanup Level is as described above.
No Action Level is as described above.
Risk Target is 1×10^{-6}.

This table presents the cleanup levels for the COCs determined to drive the need for action at SWMU 1 and the C-720 Maintenance Facility. As shown in the table, after attainment of the cleanup levels, residual risks from direct contact with soil will be below the PGDP *de minimis* level (i.e., 1×10^{-6}), *(Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1506&D1*)* and residual risks from use of groundwater contaminated by constituents migrating from soil will be within the EPA risk range for site-related exposures (i.e., 1×10^{-4} and 1×10^{-6}). The residual risks from use of groundwater exceed the PGDP *de minimis* level because these are based upon the MCL in each case.

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In implementing the selected remedy, a number of nonbinding criteria also have been evaluated and included in the ARAR summary found in Appendix B. These criteria have been included within the respective ARAR tables and will be complied with during remedy implementation.

2.13.3 Cost Effectiveness

This remedial action is the most cost-effective alternative evaluated. It has the lowest capital and O&M costs and the shortest duration of operation. In addition, it will effectively meet the cleanup goals.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The Alternative 3 remedial action makes the best application of the use of permanent solutions and treatment of the three alternatives evaluated. Although both Alternatives 2 and 3 will result in the ultimate destruction of recovered volatile contaminants from the target locations, Alternative 3 is expected to recover the largest quantity of in-place volatile contaminants. This is due to the application of heat in the SPH that will provide additional contaminant recoveries from areas that would be by-passed in the Alternative 2 DPE due to low air permeability of some of the finer grained soils. The ^{99}Tc that will be recovered on ion exchange resins and contained in the soils and concrete from the C-746-D excavation will be disposed of at an approved disposal facility. Since the technetium cannot be destructed, the disposal of the soils, ion exchange resins and concrete in a controlled facility makes the best utilization of treatment without destruction.

2.13.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 satisfies the preference for treatment of volatile organic compounds by reducing toxicity and volume through SPH and treatment of off-gas effluent through an air stripper and catalytic oxidation system. Alternative 3 satisfies the preference for treatment of ^{99}Tc by reducing volume of the source zone soils through excavation and treatment of effluent liquids, from both the excavated soils and from SPH, through ion exchange.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The *Proposed Remedial Action Plan for the Groundwater Operable Unit Upper Continental Recharge System Source Zones near C-720, C-747-C, and C-746-D, Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1910&D2, was made available for a 45-day public review and comment period XX, through XX, 2001 [dates to be determined]. The PRAP identified Alternative 3, SPH, Excavation, and LUCs, as the preferred alternative. [Additional verbiage to be added after close of the public comment period.]

2.15 FIVE-YEAR REVIEW

This remedial action will be reviewed periodically. The CERCLA requires remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the site, above levels that do not allow for unlimited use and unrestricted exposure, be reviewed no less often than once every five years after initiation of the selected remedial action. This remedial action may leave waste in place, which will require restricted access and, therefore, will be reviewed no less than once every five years.

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PART 3.

RESPONSIVENESS SUMMARY

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RESPONSIVENESS SUMMARY

3.1 RESPONSIVENESS SUMMARY INTRODUCTION

The responsiveness summary has been prepared to meet the requirements of Sects. 113(k)(2)(b)(iv) and 117 (b) of CERCLA, as amended by SARA, which requires the DOE as "lead agency" to respond "...to each of the significant comments, criticisms, and new data submitted in written or oral presentations" on the PRAP.

The DOE has gathered information on the types and extent of contamination found, evaluated remedial measures, and has recommended a remedial action at the UCRS source zones near C-720, C-747-C (Oil Landfarm) and C-746-D Scrap Yard (SWMU 99). As part of the remedial action process, a notice of availability regarding the PRAP was published in *The Paducah Sun*, a major regional newspaper of general circulation. The *Proposed Remedial Action Plan for the Groundwater Operable Unit Upper Continental Recharge System Source Zones near C-720, C-747-C, and C-746-D, Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1910&D2, was released to the general public November 2, 2001. This document was made available to the public at the Environmental Information Center, 115 Memorial Drive, Barkley Centre, Paducah, KY 42001, and at the Paducah Public Library. A 45-day public comment period began November 2, 2001, and continued through December 17, 2001. The PRAP also contained information that provided the opportunity for a public meeting to be held, if requested.

Specific groups that received individual copies of the PRAP included the Natural Resource Trustees and the PGDP CAB.

Public participation in the CERCLA process is required by SARA. Comments received from the public are considered in the selection of the remedial action for the site. The responsiveness summary serves two purposes: (1) to provide the DOE with information about the community preferences and concerns regarding the remedial alternatives, and (2) to show members of the community how their comments were incorporated into the decision-making process.

3.2 COMMUNITY PREFERENCES/INTEGRATION OF COMMENTS

To be completed after the public review period has ended.

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APPENDIX A

DEVELOPMENT OF SOIL CLEANUP LEVELS FOR SWMU 1 AND THE C-720 AREA

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Development of Soil Cleanup Levels for SWMU 1 and the C-720 Area, GWOU ROD, Paducah Gaseous Diffusion Plant, Paducah, Kentucky

1. INTRODUCTION

This appendix presents the fate and transport modeling methods used to derive soil cleanup levels protective of a groundwater user for the contaminants of concern (COCs) driving risk at SWMUs 1 and the C-720 area. In this appendix, a protective soil cleanup level is defined as the maximum concentration that a COC can have in soil above the water table that would not result in exceedance of a target concentration in groundwater at a selected point of exposure. In this appendix, the target concentration in groundwater of each COC is the chemical or compounds MCL, and the point of exposure (POE) is the security fence surrounding the PGDP.

2. MODELING APPROACH

The following approach was used to derive the soil cleanup levels protective of a groundwater user.

1. Develop a conceptual model for each source unit utilizing information contained in the WAG 27 RI Report (DOE 1998) and the GWOU FS Report (DOE 2001a) (presented in Sect. 2 of the ROD.)

2. Utilizing information contained in the baseline risk assessments performed for WAG 27 RI Report, identify COCs that may migrate from the soil source zones to be addressed by the current action (presented in Sect. 2 of the ROD.)

3. Refine the soil source zones for each COC at each source unit by plotting contaminant data contained in the PGDP Oak Ridge Environmental Information System (OREIS) database (described below.)

4. Perform leachate modeling for all COCs using SESOIL to estimate the time variant contaminant loading from each source zone to the RGA (described below.)

5. For all COCs, complete saturated flow and contaminant transport modeling using AT123D and the contaminant loading information from SESOIL (described below).

6. Examine the AT123D output and determine the maximum concentration at the POE of each COC originating from each source unit's source zones (described below.)

7. Compute a cleanup level for each COC using the linear relationship between each COCs SESOIL/ RESRAD input concentration (C_s) and AT123D maximum predicted groundwater concentration at the POE. This computation was performed using the following equation:

$$\text{Soil Cleanup Level} = \frac{C_s \times C_{gw}}{C_{pgw}}$$

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where:

C_s = input soil concentration (i.e., the source term concentration used in SESOIl/RESRAD modeling)

C_{gw} = target groundwater concentration (i.e., the COC's MCL)

$C_{p\ gw}$ = AT123D predicted maximum groundwater concentration at the POE.

3. SOURCE TERM DEVELOPMENT

Source terms for the SWMU 1 (C-747-C Oil Land Farm and the C-720 Building Area) were developed using data taken from the PGDP OREIS and material contained in the RI and baseline risk assessments performed for WAG 27. As noted in Sect. 2.7.1 of the ROD, the contaminants of concern for migration to groundwater used by a hypothetical groundwater used are as follows:

- SWMU 1 – antimony, manganese, TCE, and VC; and
- C-720 Building Area – antimony, silver, vanadium, *trans*-1,2-DCE, TCE, and VC.

To identify source zones, plots were made of the distribution of each of these contaminants within each unit's subsurface. Subsequently, the dimensions of the source zones were evaluated and refined from those used for Multimedia Environmental (MEPAS) modeling in the WAG 27 baseline risk assessment. Additionally, the data for each unit were examined to determine if co-contamination was present. The evaluation resulted in the identification of co-contamination in each unit and the subsequent selection of TCE as the target analyte for organic compound contamination at both units. In addition, the evaluation indicated that antimony should be used as a target analyte for all inorganic chemicals.

3.1 TCE AT C-720 BUILDING AREA

Although, C-720 Building occupies approximately an area of 26,124 m^2, TCE contamination was found to be limited to several well-defined areas. These source were delimited by creating scatter plots with all the sampling locations, distinguished by detect versus nondetect, and vertical depth interval, starting with 0-1 ft, 1-10 ft, 11-20 ft, 21-30 ft, 31-40 ft, 41-50 ft, and 51-60 ft below ground surface (bgs) (see the figures in Attachment 1). Based on these results, 4 source areas were defined for fate and transport analysis. An average thickness of the contaminated zone within each source area was defined, and an average of the detected concentrations within the source area was used as the source term in the modeling. This concentration was assumed to be present throughout the contaminated zone within the source area. The source terms for TCE for the four source areas including the contaminated zone (thickness within the source area) are presented in Table A.1.

3.2 ANTIMONY AT C-720 BUILDING AREA

Like TCE, antimony contamination was found to be limited to a few defined areas. Therefore, scatter plots were created with all the sampling locations, distinguished by detect versus nondetect, and vertical depth interval, starting with 0-1 ft, 1-10 ft, 11-20 ft, 21-30 ft, 31-40 ft, 41-50 ft, and 51-60 ft below ground surface (bgs) (see the figures in Attachment 2). Although there were few separate locations with detected antimony in different depth intervals, the source areas were identical. Therefore, only one source area for antimony from C-720 Building Area was modeled. The average of the detected

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Table A.1. SESOIL Application Data

COCs and Source Zone	No. of Layers	Layer No.	Thickness of Layer (feet)	No. of Sublayers	Sublayer No.	Concentration (mg/kg)
			C-720 Area			
Trichloroethene Source Zone 1	4	1	5	1	1	0
		2	30	6	1	17
					2	17
					3	17
					4	17
					5	17
					6	17
		3	25	5	1	0
					2	0
					3	0
					4	0
					5	0
		4	0.5	1	1	0
Trichloroethene Source Zone 2	4	1	5	1	1	0
		2	30	6	1	6.3
					2	6.3
					3	6.3
					4	6.3
					5	6.3
					6	6.3
		3	25	5	1	0
					2	0
					3	0
					4	0
					5	0
		4	0.5	1	1	0
Trichloroethene Source Zone 3	4	1	5	1	1	0
		2	30	6	1	14
					2	14
					3	14
					4	14
					5	14
					6	14
		3	25	5	1	0
					2	0
					3	0
					4	0
					5	0
		4	0.5	1	1	0

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Table A.1. (continued)

COCs and Source Zone	No. of Layers	Layer No.	Thickness of Layer (feet)	No. of Sublayers	Sublayer No.	Concentration (mg/kg)
Trichloroethene Source Zone 4	4	1	5	1	1	8.1
		2	30	6	1	8.1
					2	8.1
					3	8.1
					4	8.1
					5	8.1
					6	8.1
		3	25	5	1	0
					2	0
					3	0
					4	0
					5	0
		4	0.5	1	1	0
Antimony Source Zone 1	4	1	5	1	1	0
		2	30	6	1	0
					2	0
					3	0
					4	0
					5	0
					6	0
		3	25	5	1	0
					2	87
					3	87
					4	0
					5	0
		4	0.5	1	1	0
			SWMU 1			
Trichloroethene Source Zone 1	4	1	25	5	1	18.2
					2	18.2
					3	18.2
					4	18.2
					5	18.2
		2	20	5	1	18.2
					2	18.2
					3	18.2
					4	18.2
					5	18.2
		3	10	5	1	0
					2	0

Table A.1. (continued)

COCs and Source Zone	No. of Layers	Layer No.	Thickness of Layer (feet)	No. of Sublayers	Sublayer No.	Concentration (mg/kg)
Trichloroethene					3	0
Source Zone 1					4	0
(continued)					5	0
		4	0.5	2	1	0
					2	0
Antimony	4	1	25	5	1	12
Source Zone 1					2	12
					3	12
					4	12
					5	12
		2	20	5	1	12
					2	12
					3	12
					4	12
					5	12
		3	10	5	1	12
					2	12
					3	12
					4	12
					5	12
		4	0.5	2	1	0
					2	0

concentrations within the source area was used as the source term in the modeling. The source term for antimony is presented in Table A.1.

3.3 TCE AT SWMU 1

SWMU 1 occupies an area of approximately 8,947 m^2; however, TCE contamination was found to be limited to several defined areas. This source areas was defined by creating scatter plots including all sampling locations, distinguished by detect versus nondetect, and by vertical depth interval starting with 0-1 ft, 1-10 ft, 11-20 ft, 21-30 ft, 31-40 ft, 41-50 ft, and 51-60 ft bgs (see the figures in Attachment 3). Based upon these results figures, 5 source areas were defined: Area 1 with an approximate area of 859 m^2, and Areas 2 through 5 with an approximate area of 24 m^2 each. However, because the clean-up goal increases with decrease of source area (as will be shown from the results of TCE from C-720 Building), a decision was made to use only the largest source area for this modeling analysis thereby predicting conservative clean-up goals for TCE from SWMU 1. An average thickness of the contaminated zone within the source area was defined based on detected TCE contamination, and an average of the detected concentrations within the source area was used as the source term in the modeling. The source term of TCE for SWMU 1 including the thickness of the contaminated zone are presented in Table A.1.

3.4 ANTIMONY AT SWMU 1

To define the source areas for antimony within SWMU 1, scatter plots were created with all the sampling locations, distinguished by detect versus nondetect, and vertical depth interval, starting with 0-1 ft, 1-10 ft, 11-20 ft, 21-30 ft, 31-40 ft, 41-50 ft, and 51-60 ft bgs (see the figures in Attachment 4). Although there were multiple source areas with detected antimony in different depth intervals, they were all identical; therefore, only one source area from SWMU 1 was modeled. The average of the detected concentrations within the source area was used as the source term in the modeling. The source term for antimony from SWMU 1 is presented in Table A.1.

4. MODELING PARAMETERS

The hydrologic modeling parameters used in the modeling were based on results in the WAG 27 RI Report (DOE 1998) and the GWOU FS Report (DOE 2001a). The conceptual model and modeling parameters were selected so that they would represent site conditions and could account for expected variability in the hydraulic system. Additional chemical-specific modeling parameters used in the modeling included each COCs solubility in water, organic carbon partition coefficient, Henry's Law constant, soil-water distribution coefficient, and diffusion coefficients in air and water, and biodegradation rate constant (set to 0 in all cases). Consistent with the WAG RI Report (DOE 1998), these chemical-specific parameters were selected from the literature utilizing a conservative approach. (That is, all parameters were selected so that the rates of release and migration would be at their maximum value.) The input parameters are presented in Tables A.2 through A.4. (Note that the biodegradation rate constant was set to zero for all COCs.)

Table A.2. Soil parameters for SESOIL/RESRAD modeling

	Parameter value		
Parameter Type	**C-720**	**SWMU 1**	**Source**
Soil type	Silty clay	Silty clay	PGDP site-specific
Bulk density (gm/cm^3)	1.46	1.46	Laboratory analysis
Percolation rate (cm/year)	11	11	PGDP Calibrated Model
Intrinsic permeability (cm^2)	1.65E-10	1.65E-10	Calibrated
Disconnectedness index	10	10	Calibrated
Porosity	0.45	0.45	Laboratory analysis
Depth to water table (m)	18.3	18.3	Site specific (to RGA) based on field observation
Organic carbon content (%)	0.09	0.08	Laboratory analysis
Frendlich equation exponent	1	1	SESOIL default value
Area of source (m^2) – Area 1[a]	1160	859	Estimated from soil contamination area
Area of source (m^2) – Area 2	920	NA	Estimated from soil contamination area
Area of source (m^2) – Area 3	2790	NA	Estimated from soil contamination area
Area of source (m^2) – Area 4	557	NA	Estimated from soil contamination area

NA – Parameter not applicable for the source unit.
[a] Multiple source zone areas were identified as part of source refinement as discussed earlier.

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Table A.3. Hydrogeologic parameters used in AT123D modeling

Parameter Type	Parameter Values C-720	SWMU 1	Source
Bulk density (kg/m^3)	1670	1670	Laboratory analysis
Effective porosity	0.3	0.3	PGDP sitewide model calibrated value
Hydraulic conductivity (m/hour)	19.05	19.05	PGDP sitewide model calibrated value
Hydraulic gradient	0.0004	0.0004	PGDP sitewide model calibrated value
Aquifer thickness (m)	12.2	12.2	Site average
Longitudinal dispersivity (m)	15	15	Approximate values used in the past
Density of water (kg/m^3)	1000	1000	Default
Fraction of organic carbon (unitless)	0.02	0.02	Laboratory analysis
Distance to Fenceline (m)	549	152	Approximate downgradient distance in RGA
Distance to DOE Prop. Boundary (m)	1402	1006	Approximate downgradient distance in RGA
Source area Length (m)	34.6	34.6	Conservative estimate
Source area Width (m)	34.6	34.6	Conservative estimate

Table A.4. Literature-based chemical-specific parameters

COCs	Mol. Wt. (MW) (g/gmol)	Solubility in water (mg/L)	Diffusion in air (cm^2/s)	Diffusion in water (cm^2/s)	Henry's Constant (atm.m^3/mol)	K_{oc} (L/kg)	K_d (L/kg)	Decay Constant (1/day)	MCL (mg/L)	SSL (mg/kg)	SSL*20 (mg/kg)
TCE	131	1100	0.08	9.10E-06	0.0103	94	0.0188	0.00E+00	0.005	0.003	0.06
1,2-DCE[a]	97	800	0.11	1.14E-05	0.0066	78	0.0155	0.00E+00	0.055	0.021	0.42
cis-1,2-DCE[a]	97	3500	0.07	1.13E-05	0.00408	36	0.0071	0.00E+00	0.070	0.020	0.40
trans-1,2-DCE[a]	97	6300	0.07	1.19E-05	0.00938	38	0.0076	0.00E+00	0.100	0.030	0.70
1,1-DCE[a]	97	2250	0.09	1.04E-05	0.0261	65	0.0130	0.00E+00	0.007	0.003	0.06
Vinyl chloride[a]	63	2760	0.11	1.23E-06	0.0270	19	0.0037	0.00E+00	0.002	0.001	0.01
Antimony	122	445	NA	1.00E-06	NA	NA	45	NA	0.006	0.30	5.40

NA – Variable in not applicable to the COC.
[a] These constituents are included here as they are the daughter products of TCE.

5. MODEL APPLICATION

The SESOIL model (Bonazountas and Wagner 1984), used for leachate modeling, estimates pollutant concentrations in the soil profile following introduction via direct application and/or interaction with other media. The model defines the soil compartment as a soil column extending from the ground surface through the unsaturated zone to the top of the saturated soil zone/water table. Processes simulated in SESOIL are categorized in three cycles—the hydrologic cycle, sediment cycle, and pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil-water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure).

Data requirements for SESOIL are not extensive, utilizing a minimum of soil and chemical parameters and monthly or seasonal meteorological values as input. Output of the SESOIL model includes pollutant concentrations at various soil depths and pollutant loss from the unsaturated soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. SESOIL also predicts the monthly contaminant load to the water table from the AOC that can be directly input into the AT123D model for contaminant migration in the saturated zone.

The SESOIL model was arranged in four layers. The first and the second layers usually form the loading zone. The third layer represents the leaching zone. The layers were subdivided into 5 or 6 sublayers of equal thickness in order to obtain better resolution and also be more representative of contamination by depth. The fourth layer (just above the water table) is a very thin (0.3 m) layer, and is used to read predicted leachate concentrations at the water table/vadose zone interface. The application parameters including initial source concentrations, thickness of each layer with number of sublayers are shown in Table A.5.

The AT123D model (Yeh 1981; GSC 1996) computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a mass release (either continuous or instant or depleting source) over a source area. In the present modeling, peak concentrations at the two potential POEs, the PGDP fence line and the property boundary were developed.

6. RESULTS

The soil cleanup levels for the three source areas are summarized in Table A.6. For the C-720 area, soil target cleanup levels (TCLs) were developed for 4 source zones contaminated with TCE and one source zone contaminated with antimony. For SWMU 1, TCLs were developed for one source zone contaminated with TCE and one source zone contaminated with antimony. For all source zones, soil cleanup levels were developed for both POEs (i.e., the PGDP fence line and the property boundary). The results for the POE at the security fence are presented in Sect. 2.12.3 of the ROD.

The soil cleanup levels in Table A.6 for the fenceline POE are largest average concentration allowable in the source zone soils at SWMU 1 and the C-720 Building after remediation occurs. According to the modeling results, attainment of these average concentrations across the source areas will ensure that contamination in the RGA at the fenceline POE will not exceed the target groundwater cleanup criteria (i.e., the MCL for TCE and all other contaminants).

7. LIMITATIONS AND ASSUMPTIONS

As noted earlier, a conservative approach was used to complete this modeling to ensure that the cleanup levels would be protective at the POEs. Listed below are some important assumptions affecting the results of this conservative analysis.

- The use of K_d and R_d to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid- and solution-phase concentrations and that the relationship is linear and reversible.

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Table A.5. Soil Cleanup Goals based on leaching to groundwater at C-720, PGDP

Source Areas	MCL (mg/L)	Source loading (mg/kg)	Cw-max at Source (mg/L)	Cw-max Fenceline (mg/L)	Cw-max DOE Prop. Boundary (mg/L)	Cw-max Little Bayou Creek (mg/L)	Cleanup Goals at the Source with respect to the Receptors at[a]: Source (mg/kg)	Fenceline (mg/kg)	DOE Prop. Boundary (mg/kg)	Little Bayou Creek (mg/kg)
Area-1: TCE	0.005	17	0.95	0.12	0.053	0.020	0.089	0.685	1.592	4.229
Area-2: TCE	0.005	6.3	0.293	0.04	0.015	0.006	0.108	0.877	2.045	5.450
Area-3: TCE	0.005	14	1.32	0.23	0.100	0.039	0.053	0.311	0.700	1.818
Area-4: TCE	0.005	8.1	0.28	0.03	0.013	0.005	0.146	1.319	3.115	8.299
Area-1: Antimony	0.006	87.0	0.026	0.00005	0.0	0.0	20.1	10875.0	infinite	infinite

[a] Value is the average concentration in soil within the source zone that must be attained to ensure that concentration in groundwater at point of compliance is less than or equal to the MCL.

[b] The refined modeling presented here indicates that the identification of antimony as a COC in the baseline risk assessment was due to the conservative assumptions used to perform the transport modeling. Based upon these results, antimony is not a COC for groundwater at C-720, and action to address its migration is not necessary.

Table A.6. Soil Cleanup Goals based on leaching to groundwater at SWMU 1, PGDP

							Cleanup Goals at the source with respect to the receptors at[a]:			
Source Areas	MCL (mg/L)	Source Loading (mg/kg)	Cw-max at Source (mg/L)	Cw-max Fenceline (mg/L)	Cw-max DOE Prop. Boundary (mg/L)	Cw-max Little Bayou Creek (mg/L)	Source (mg/kg)	Fenceline (mg/kg)	DOE Prop. Boundary (mg/kg)	Little Bayou Water (mg/kg)
Area-1: TCE	0.005	18.2	1.21	0.508	0.081	0.011	0.075	0.179	1.121	7.98
Area-1: Antimony	0.006	12.0	0.0027	0.00059	6.0E-06	0.0E+00	26.5	121.2	12000.0	Infinite

[a] Value is the average concentration in soil within the source zone that must be attained to ensure that concentration in groundwater at point of compliance is less than or equal to the MCL.

[b] The refined modeling presented here indicates that the identification of antimony as a COC in the baseline risk assessment was due to the conservative assumptions used to perform the transport modeling. Based upon these results, antimony is not a COC for groundwater at C-720, and action to address its migration is not necessary.

- The use of zero biodegradation rate for the organic compounds is expected to overestimate COC concentrations at the POEs.
- Flow and transport are assumed not to be affected by density variations.
- Aquifer is assumed to be homogenous and isotropic.
- Soil contamination is assumed to be uniform throughout soil column above the leaching zone.

The inherent uncertainties associated with using these assumptions must be recognized. It is also important to note that the major geochemistry of the plume will change over time and be affected by multiple solutes that are present at the site. However, the cleanup levels are expected to be protective because of the simplifying assumptions used, especially the assumption that no biodegradation will occur.

8. REFERENCES

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DOE 2001b. *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant*. DOE/OR/07-1506&D1/R1/V1.

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Yeh, G. T., 1981. *AT123D: Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System*, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, Publication No. 1439.

Yu, C., A.J. Zielen, J.J. Cheng, Y.C. Yuan, L.G. Jones, D.J. Le Poire, Y.Y. Wang, C.O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo III, W.A. Williams, and H. Peterson, 1993. Manual for Implementing Residual Radioactive Material Guidelines using RESRAD Version 5.0. ANL/EAL/LD-3, Argonne National Laboratory, prepared for U.S. DOE.

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ATTACHMENT 1

SOURCE AREA DEVELOPMENT FOR TCE IN C-720 BUILDING AREA

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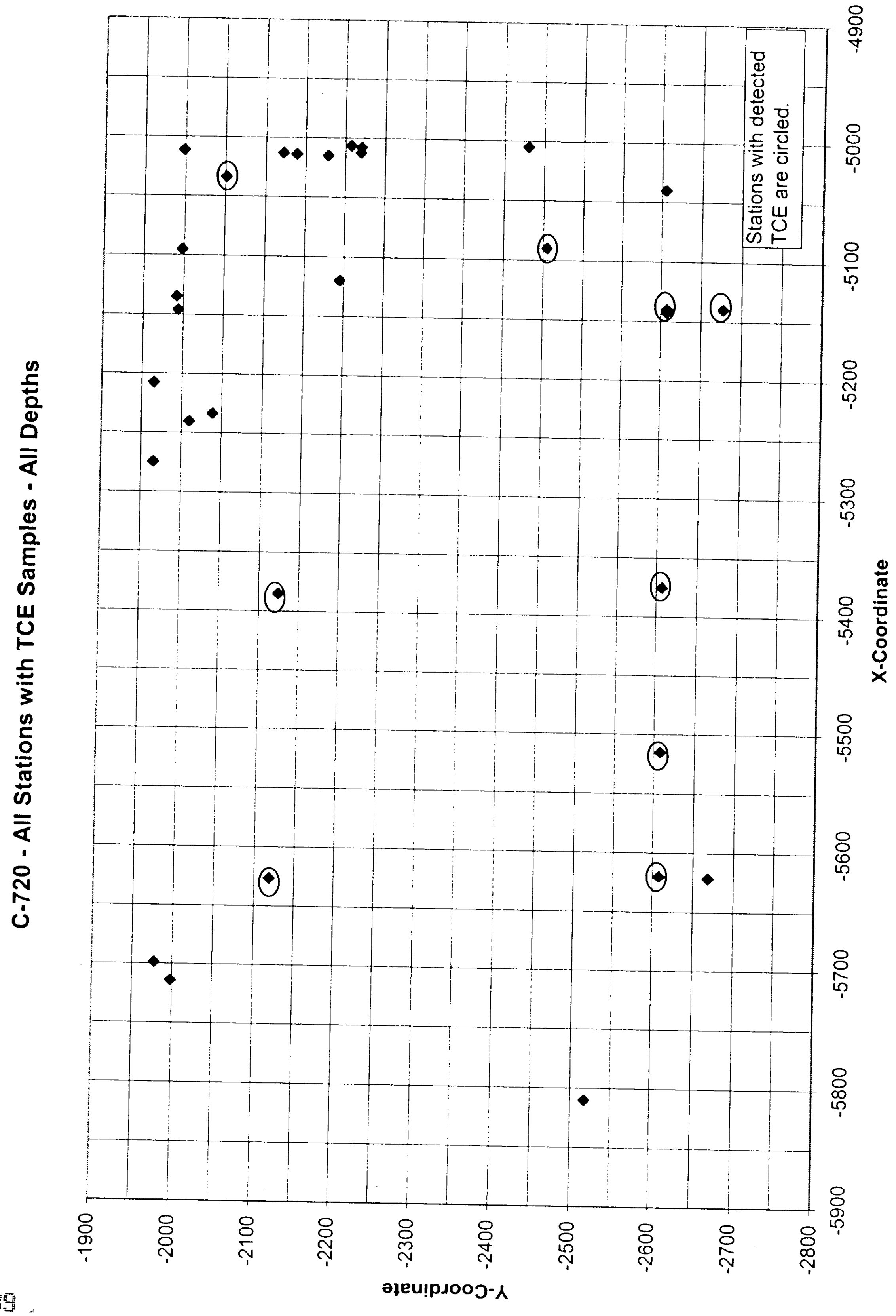
C-720 - All Stations with TCE Samples - All Depths
Stations with detected TCE are circled.
X-Coordinate
Y-Coordinate
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-5000
-5100
-5200
-5300
-5400
-5500
-5600
-5700
-5800
-5900
-1900
-2000
-2100
-2200
-2300
-2400
-2500
-2600
-2700
-2800

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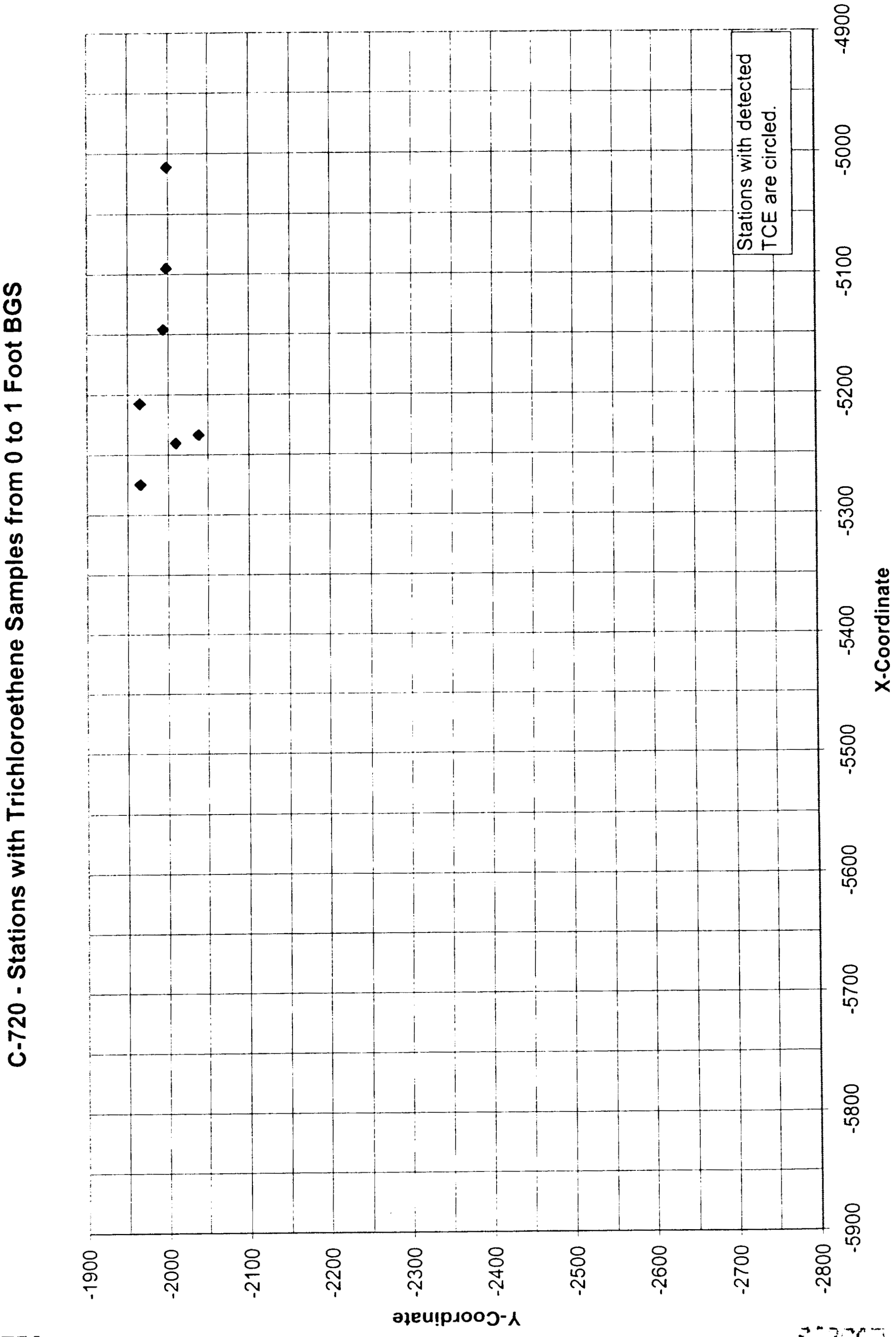

C-720 - Stations with Trichloroethene Samples from 0 to 1 Foot BGS
Stations with detected TCE are circled.
-4900
-5000
-5100
-5200
-5300
-5400
-5500
-5600
-5700
-5800
-5900
X-Coordinate
-1900
-2000
-2100
-2200
-2300
-2400
-2500
-2600
-2700
-2800
Y-Coordinate

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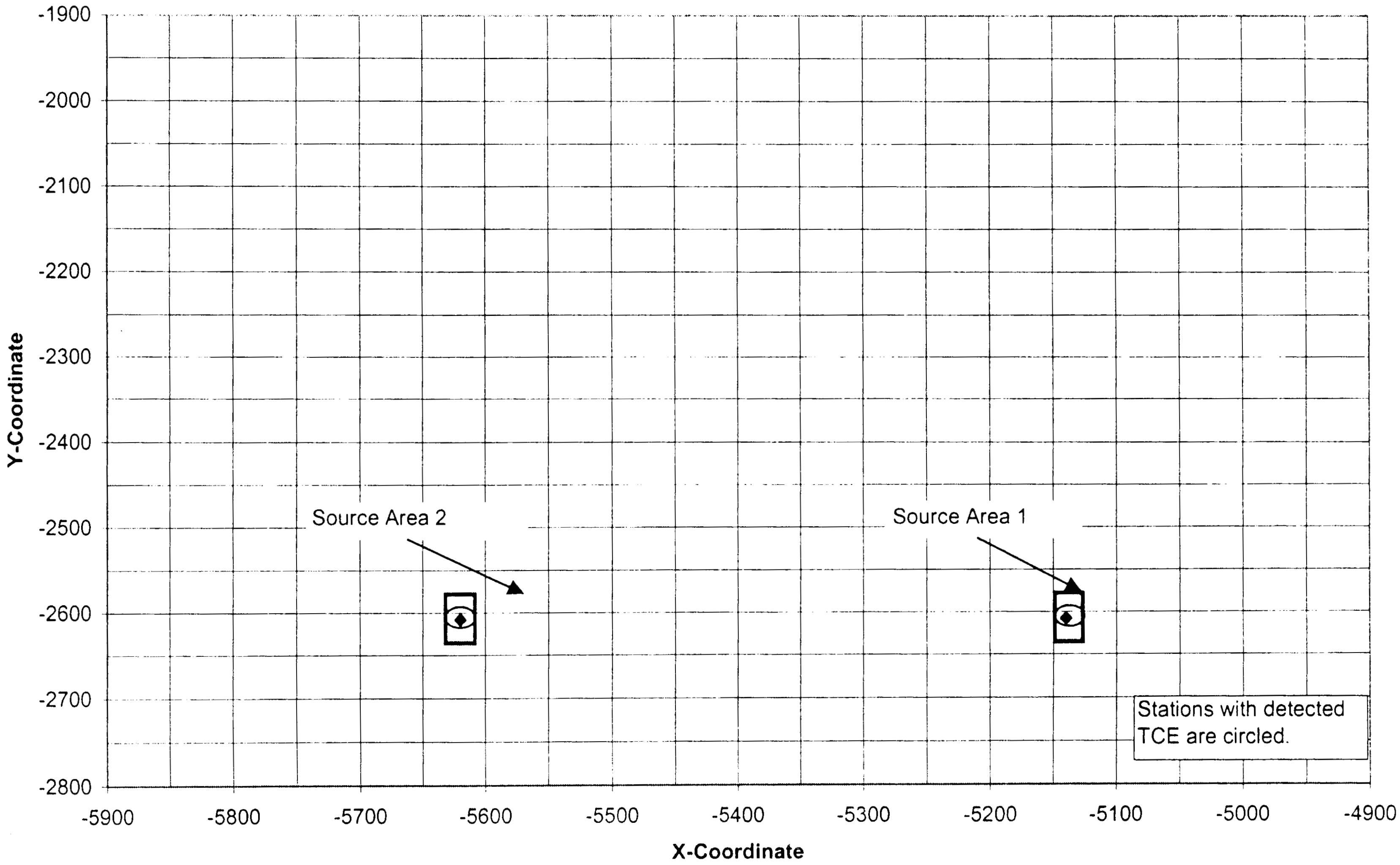
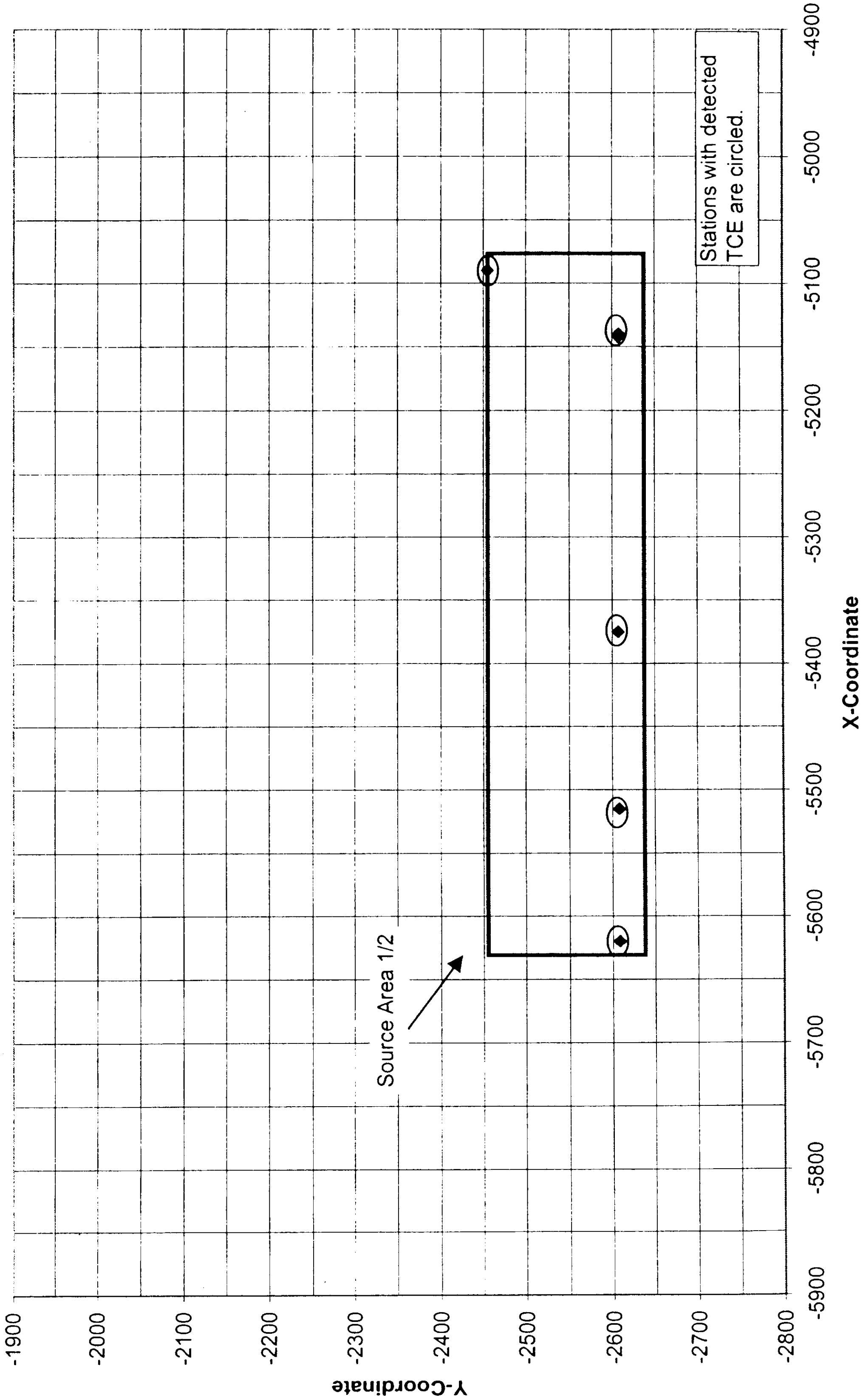
C-720 - Stations with Trichloroethene Samples from 1 to 10 Feet BGS





C-720 - Stations with Trichloroethene Samples from 11 to 20 Feet BGS

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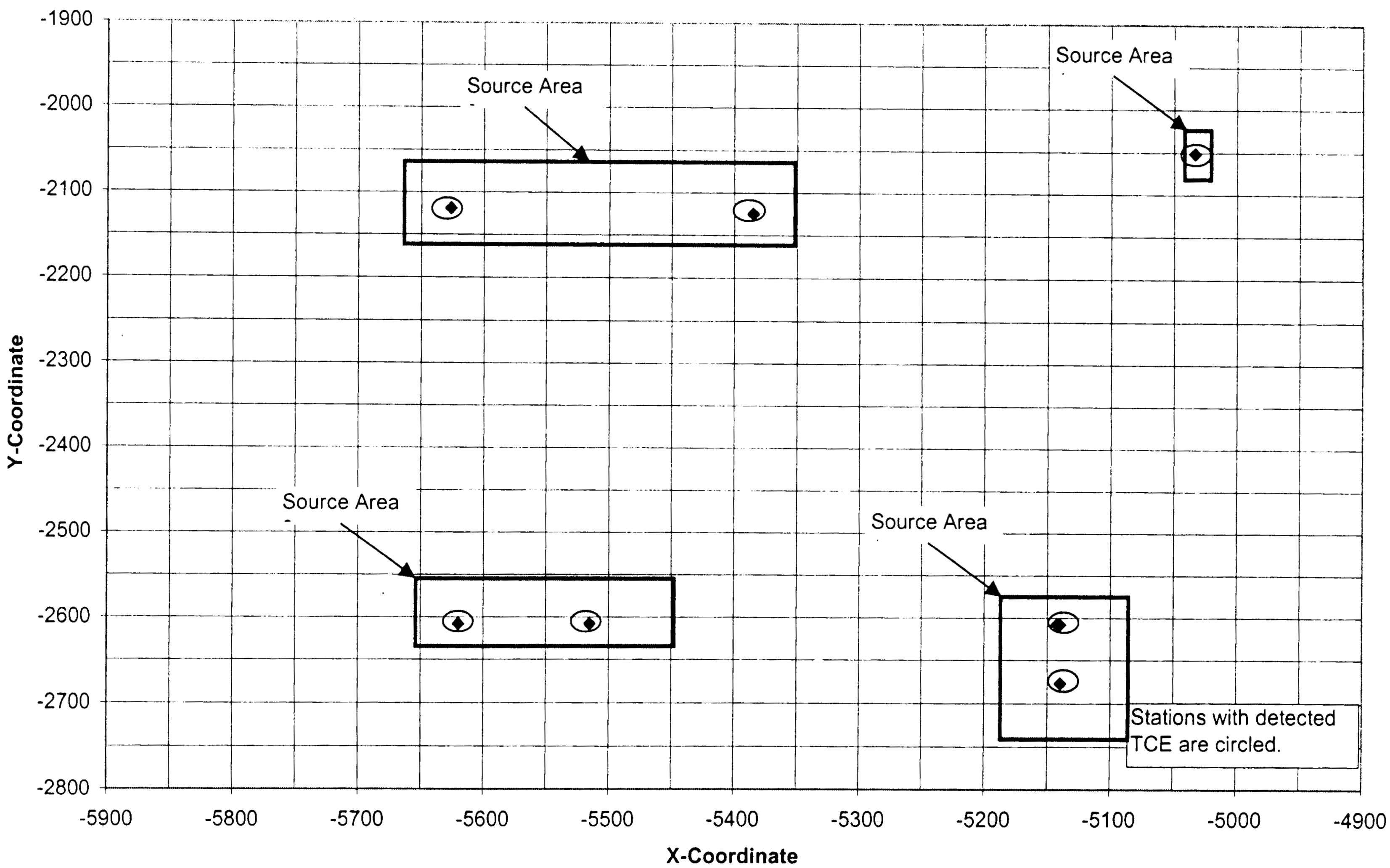
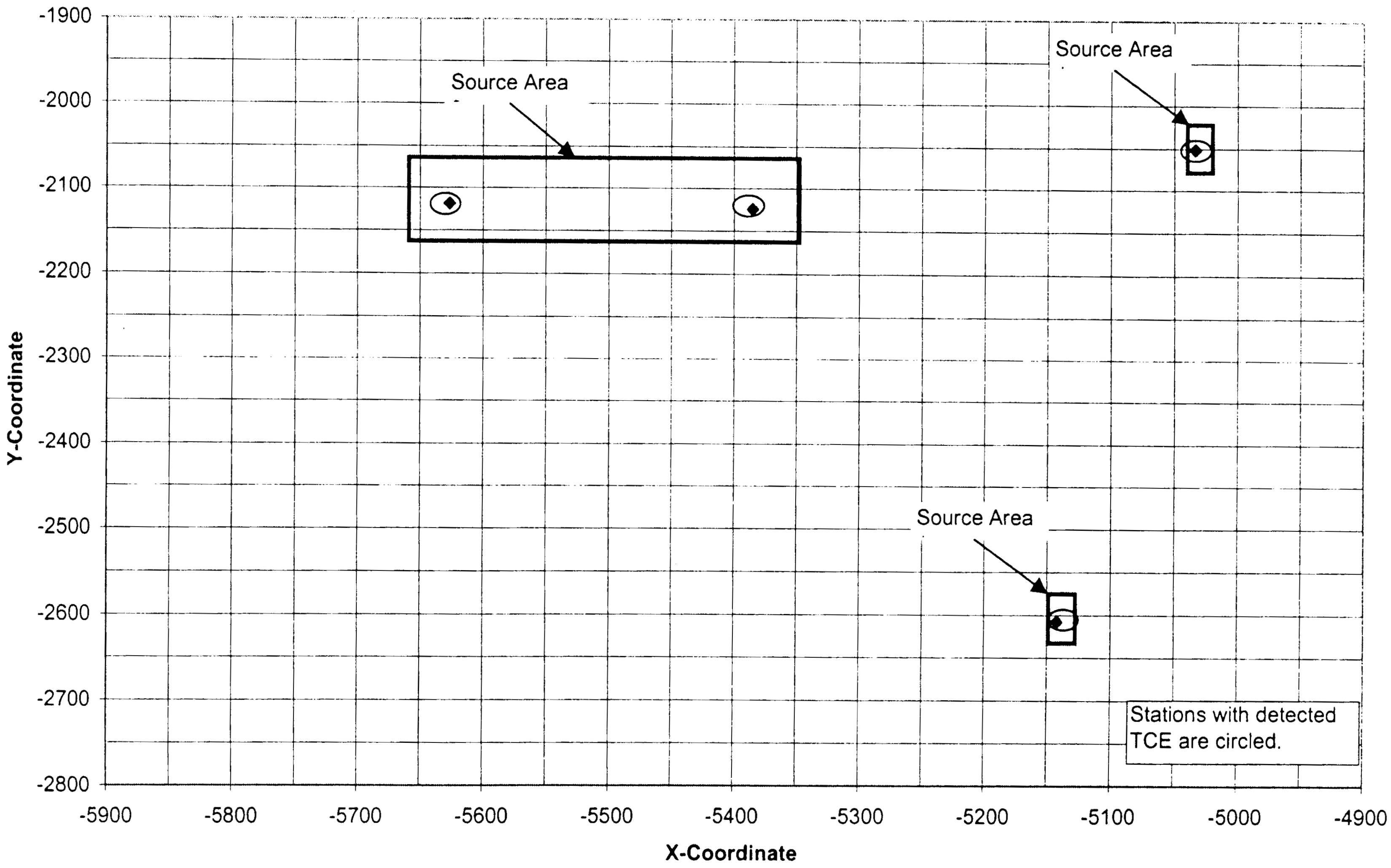
C-720 - Stations with Trichloroethene Samples from 21 to 30 Feet BGS



C-720 - Stations with Trichloroethene Samples from 31 to 40 Feet BGS



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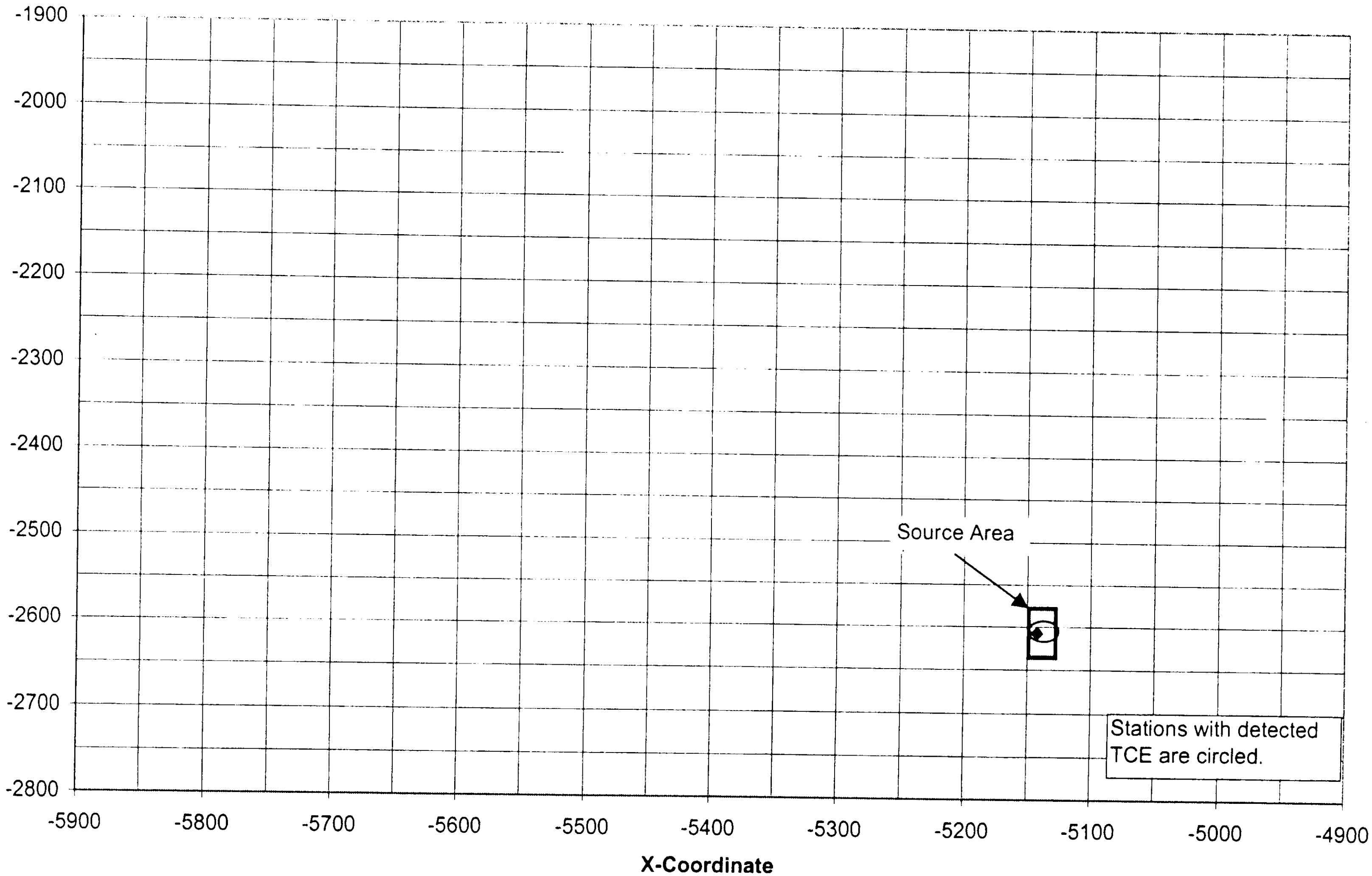
C-720 - Stations with Trichloroethene Samples from 41 to 50 Feet BGS



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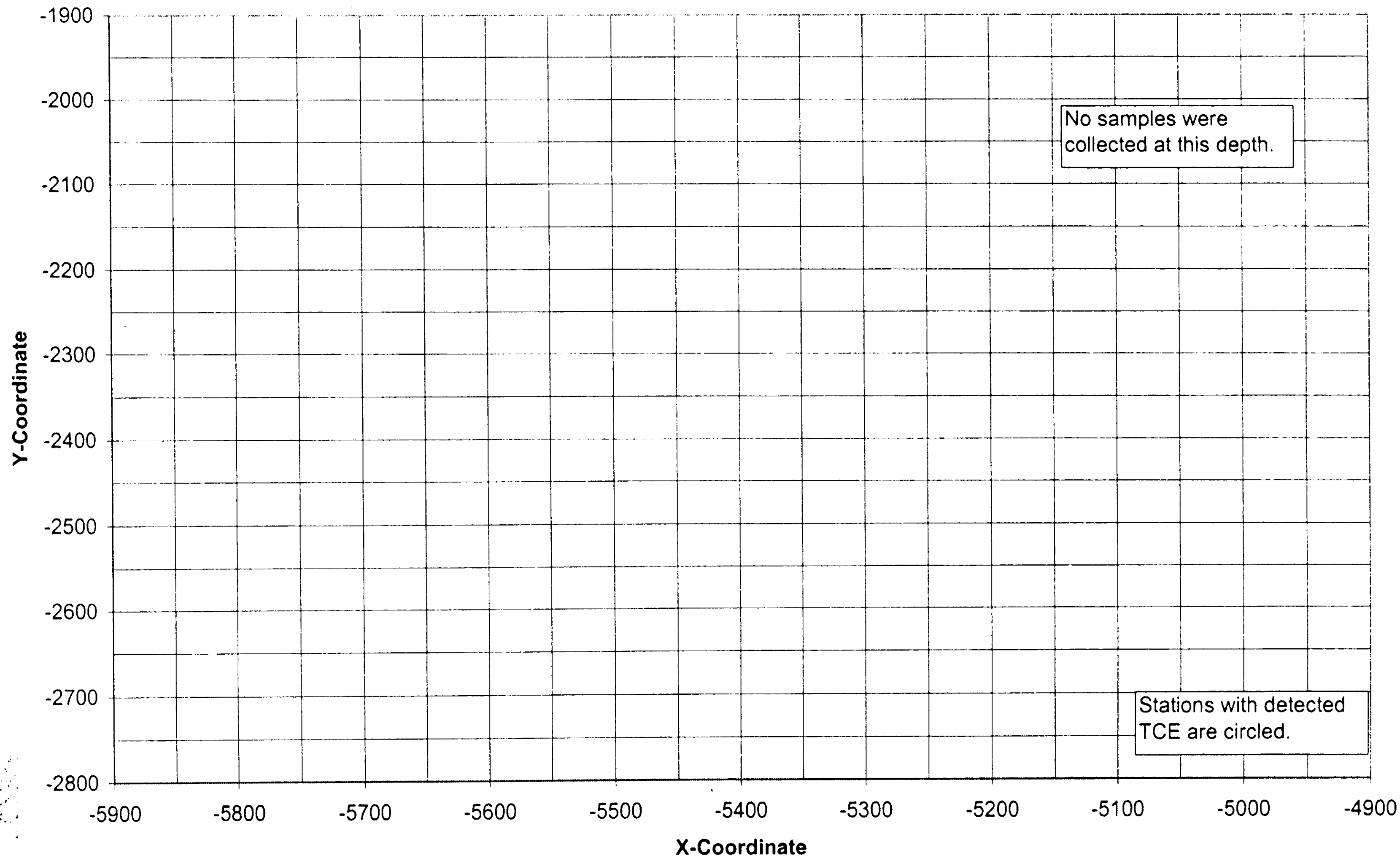
C-720 - Stations with Trichloroethene Samples from 51 to 60 Feet BGS



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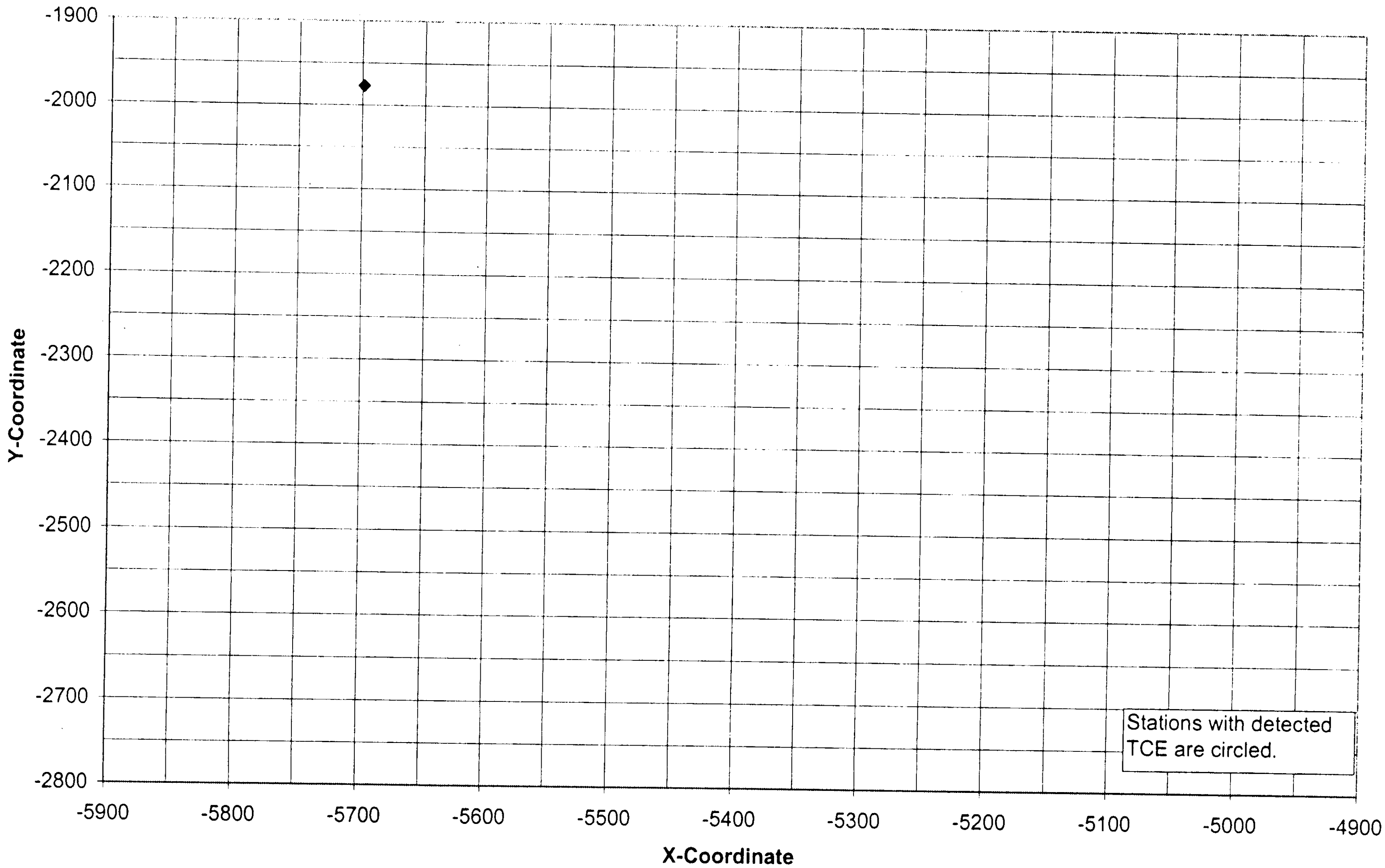
C-720 - Stations with Trichloroethene Samples from 61 to 70 Feet BGS



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ATTACHMENT 2

SOURCE AREA DEVELOPMENT FOR ANTIMONY IN C-720 BUILDING AREA

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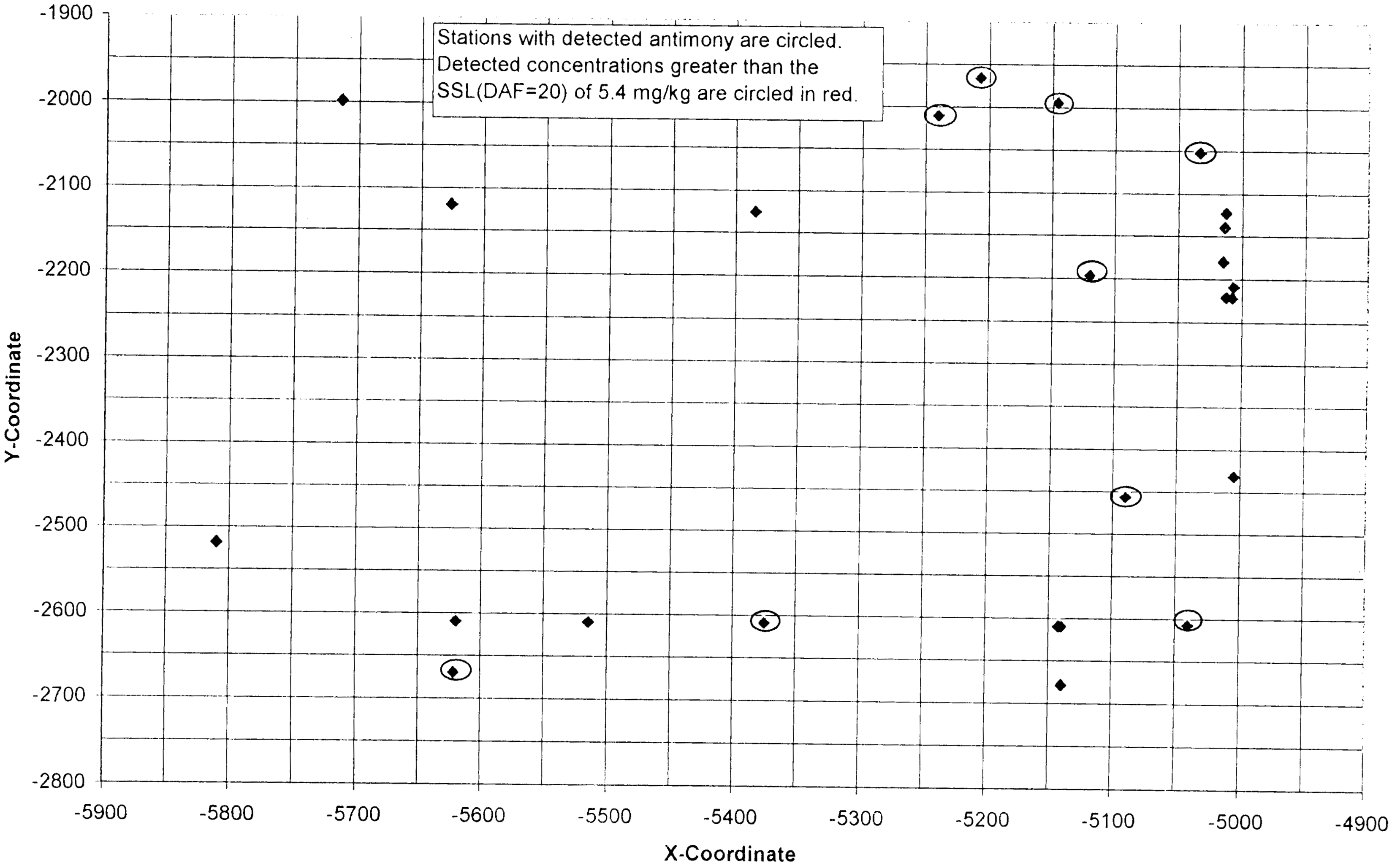
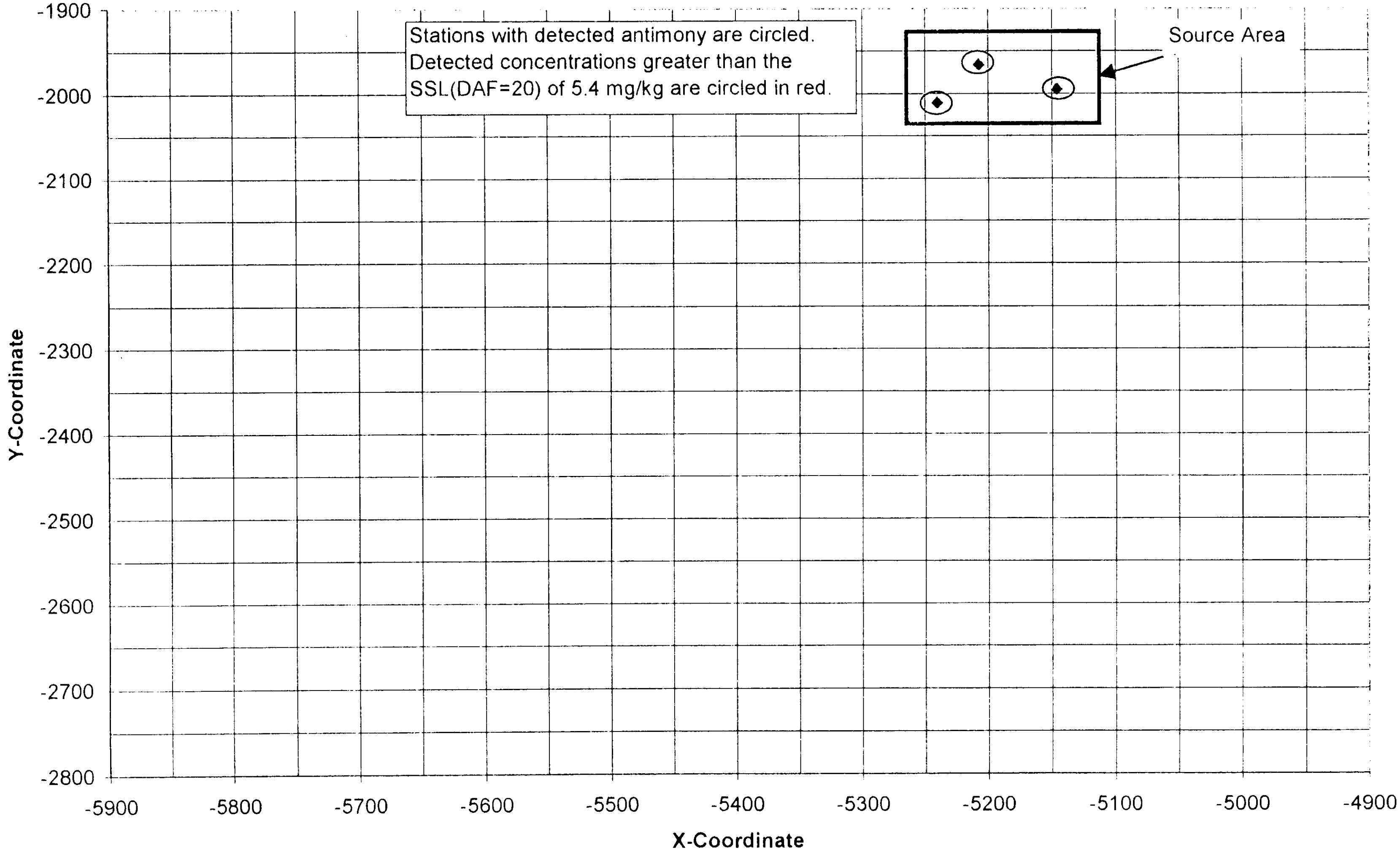
C-720 - All Stations with Antimony Samples - All Depths



C-720 - Stations with Antimony Samples from 0 to 1 Foot BGS



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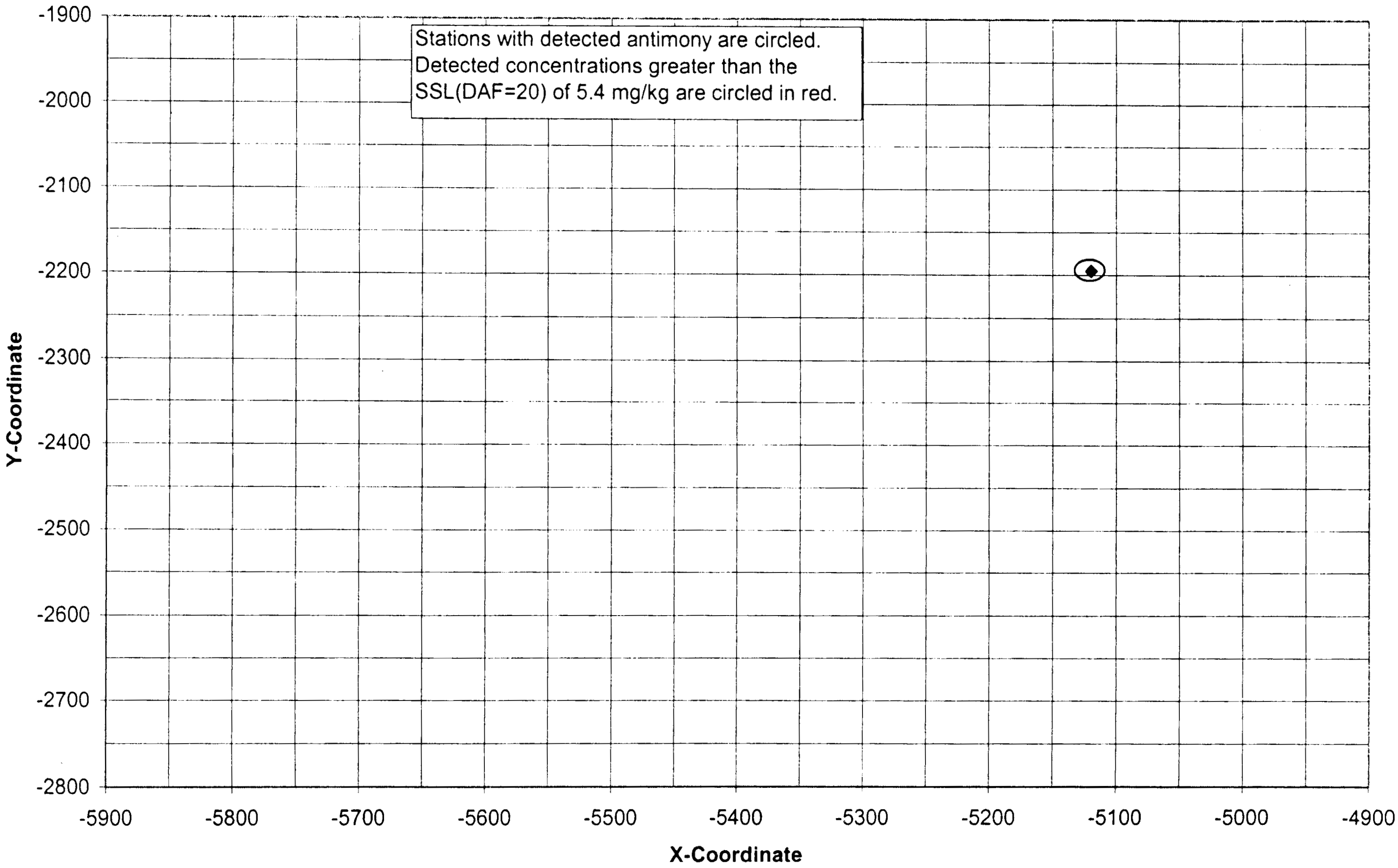
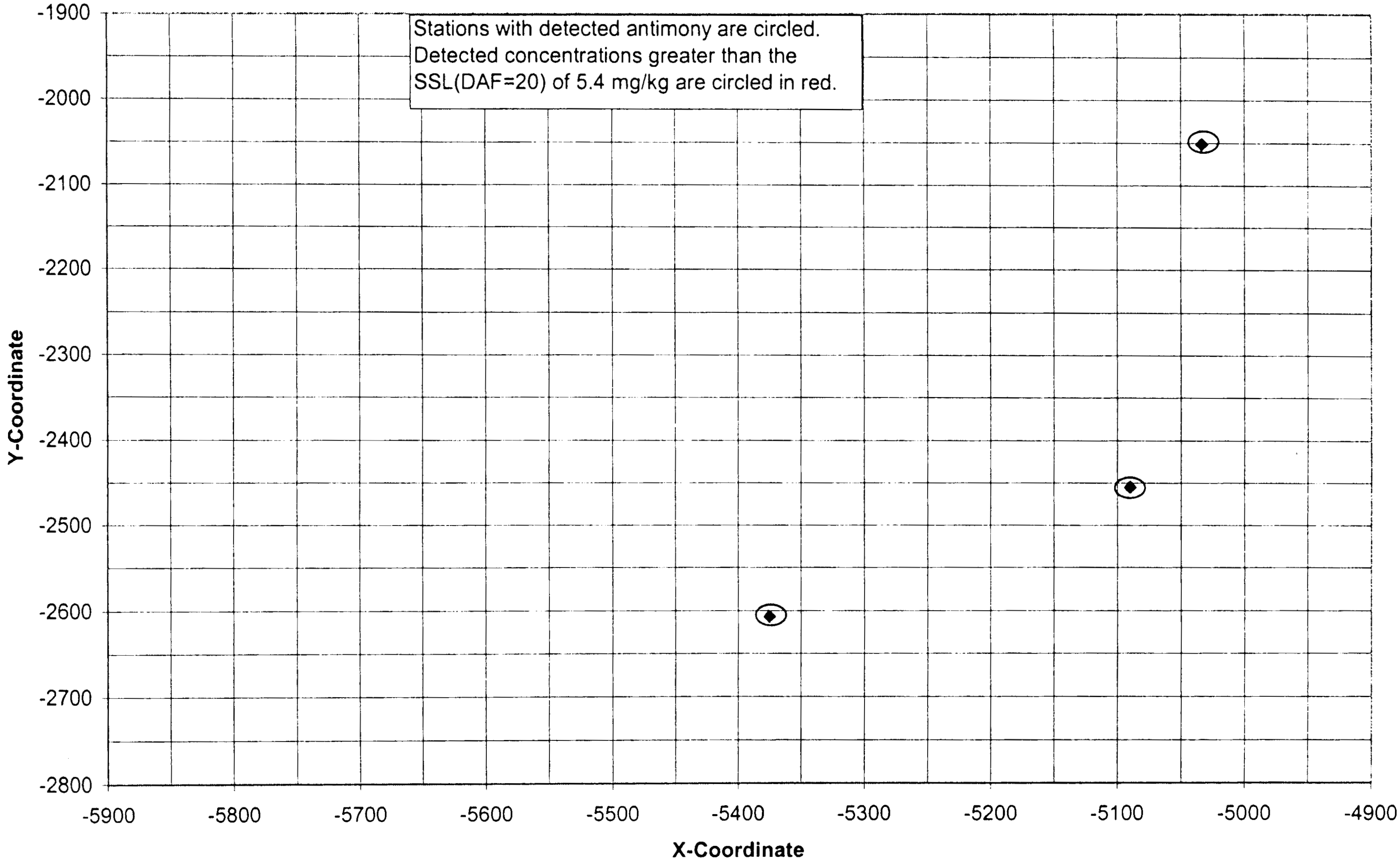
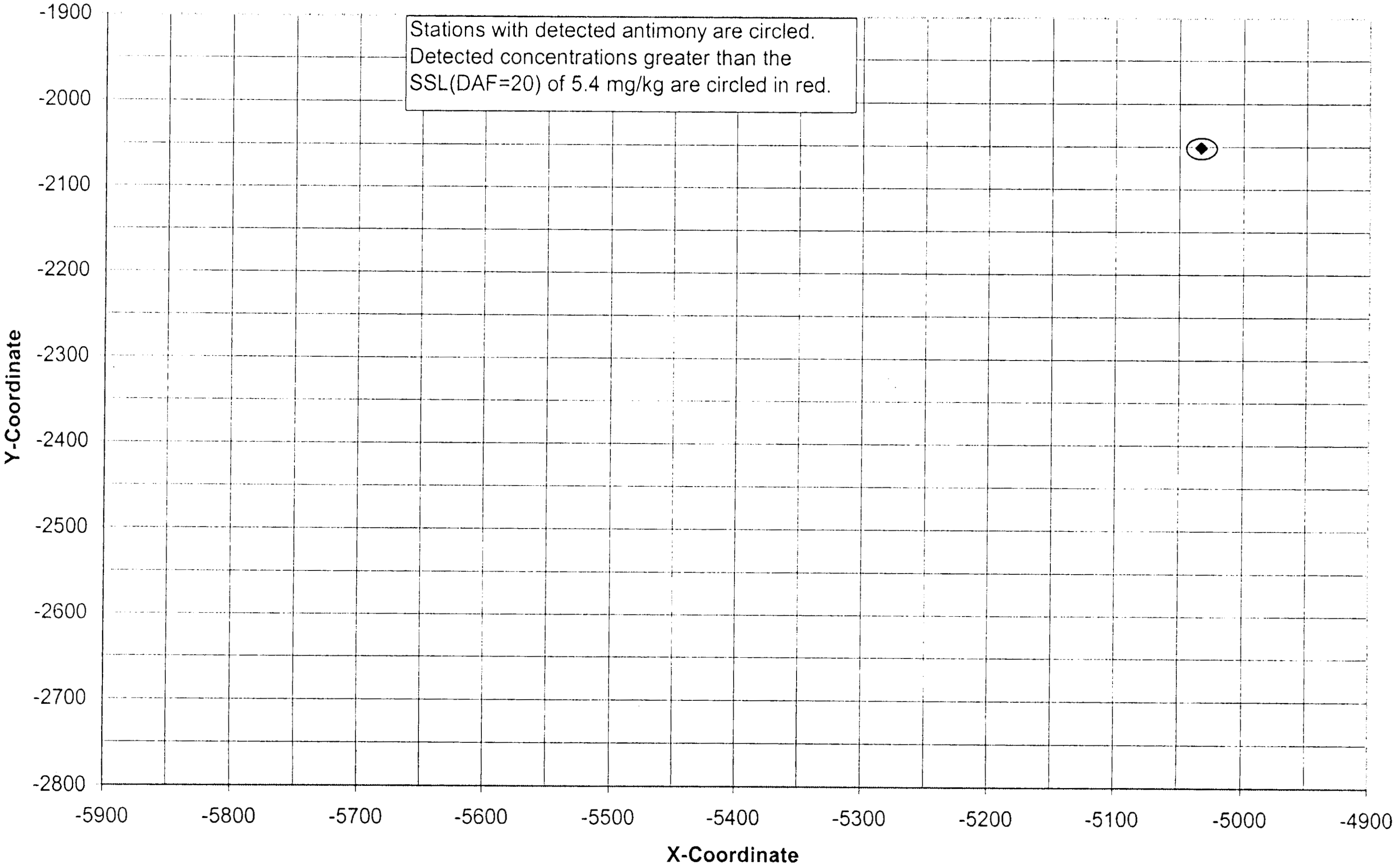


C-720 - Stations with Antimony Samples from 11 to 20 Feet BGS



C-720 - Stations with Antimony Samples from 21 to 30 Feet BGS



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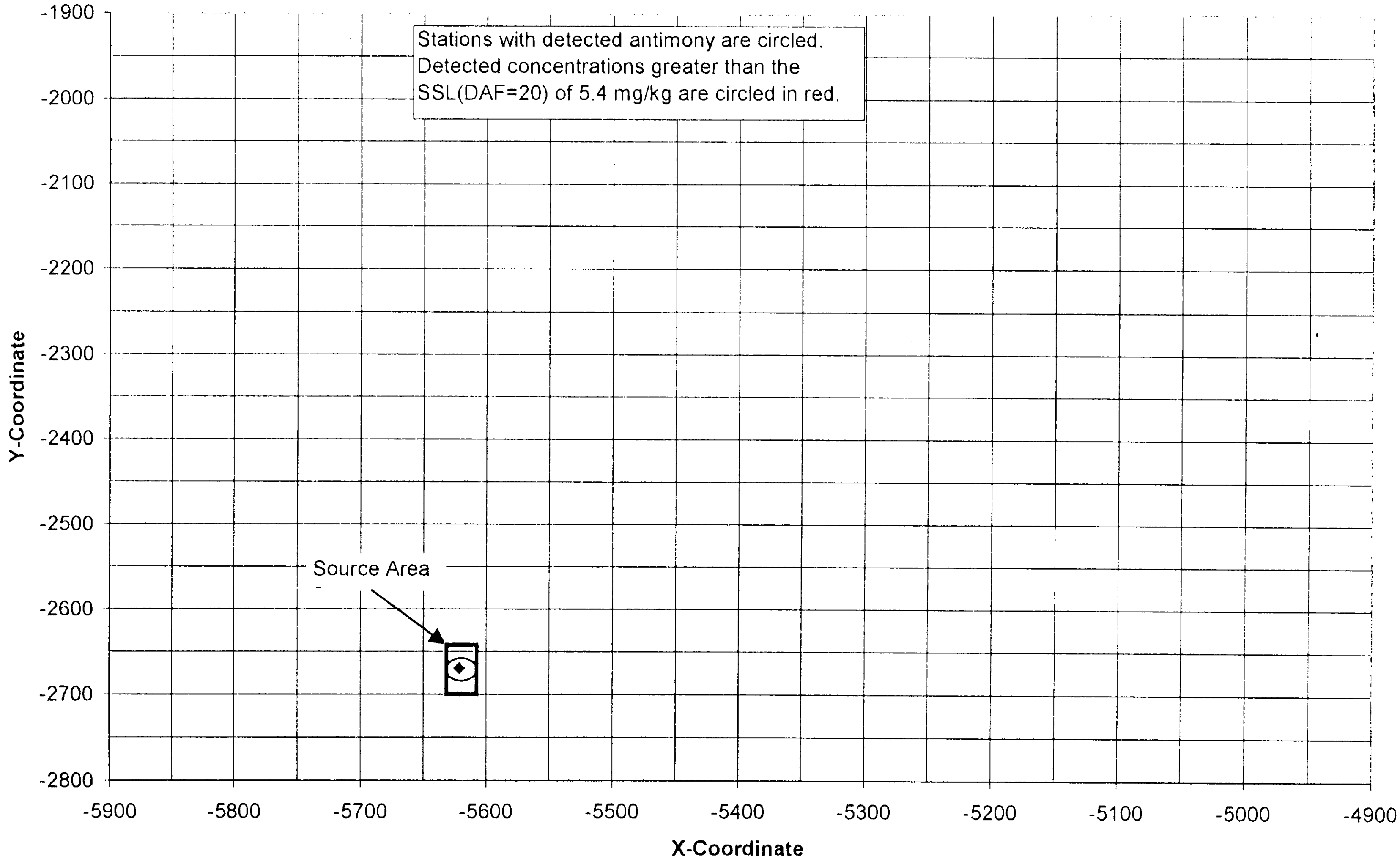
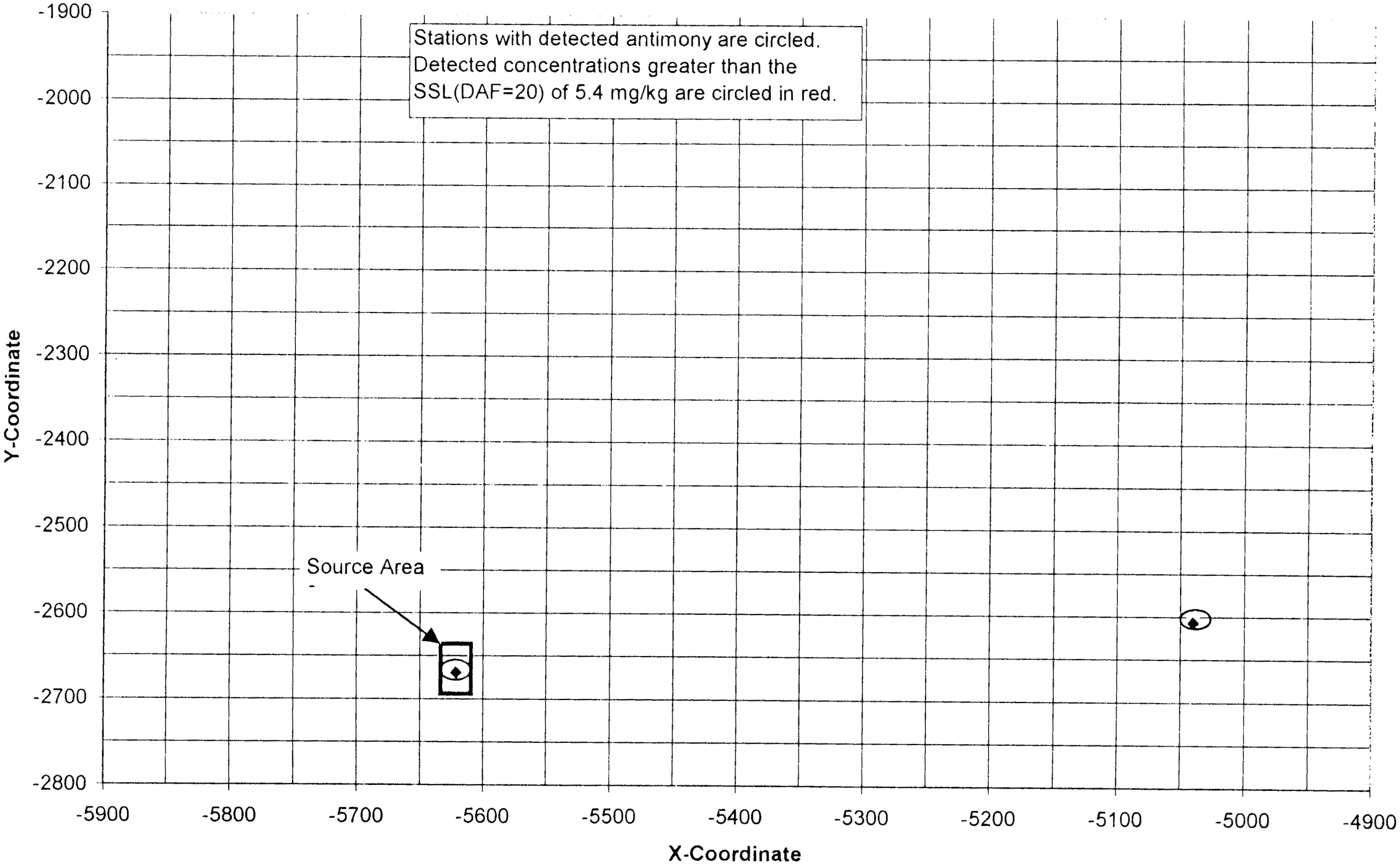
C-720 - Stations with Antimony Samples from 31 to 40 Feet BGS



C-720 - Stations with Antimony Samples from 41 to 50 Feet BGS



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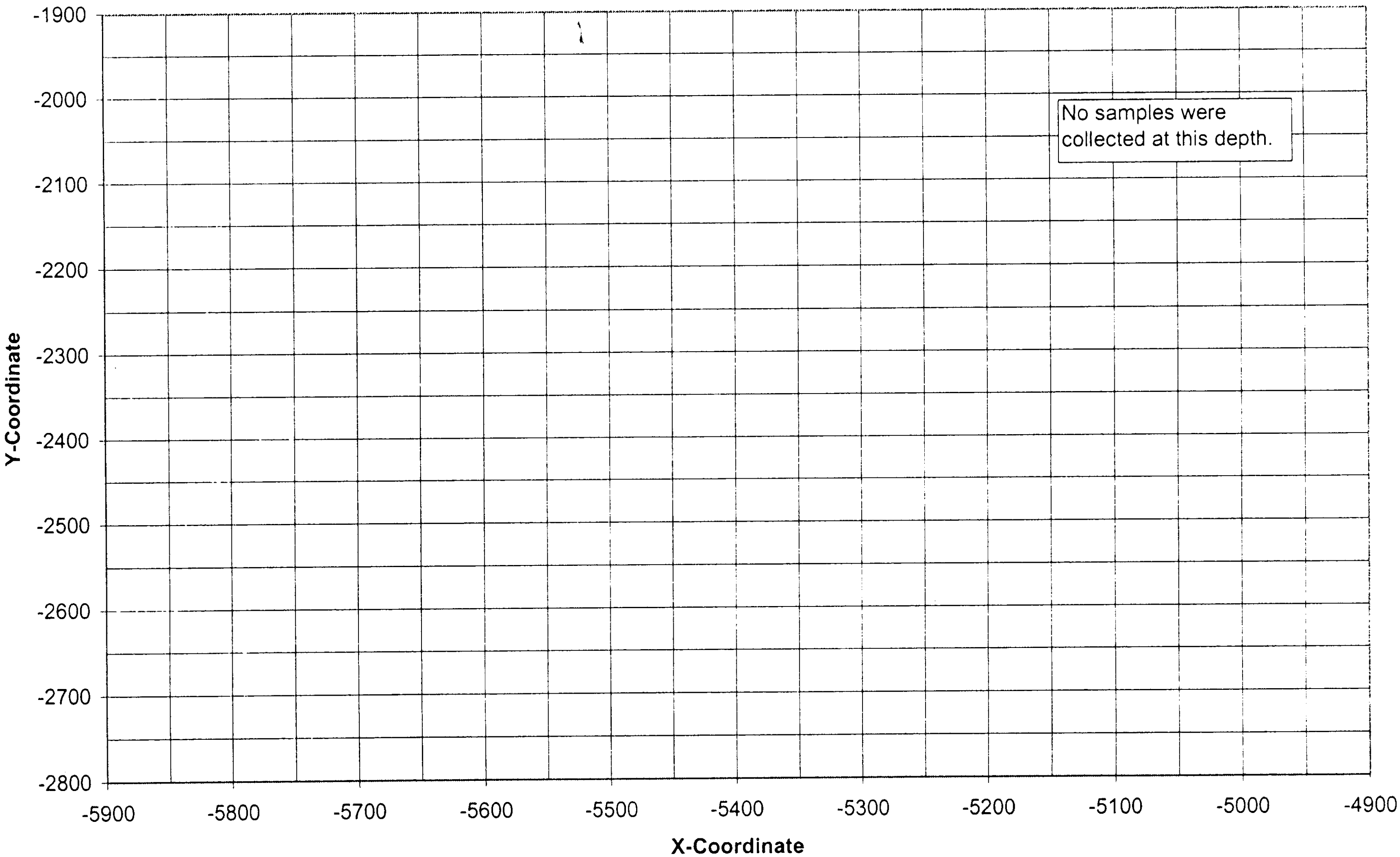
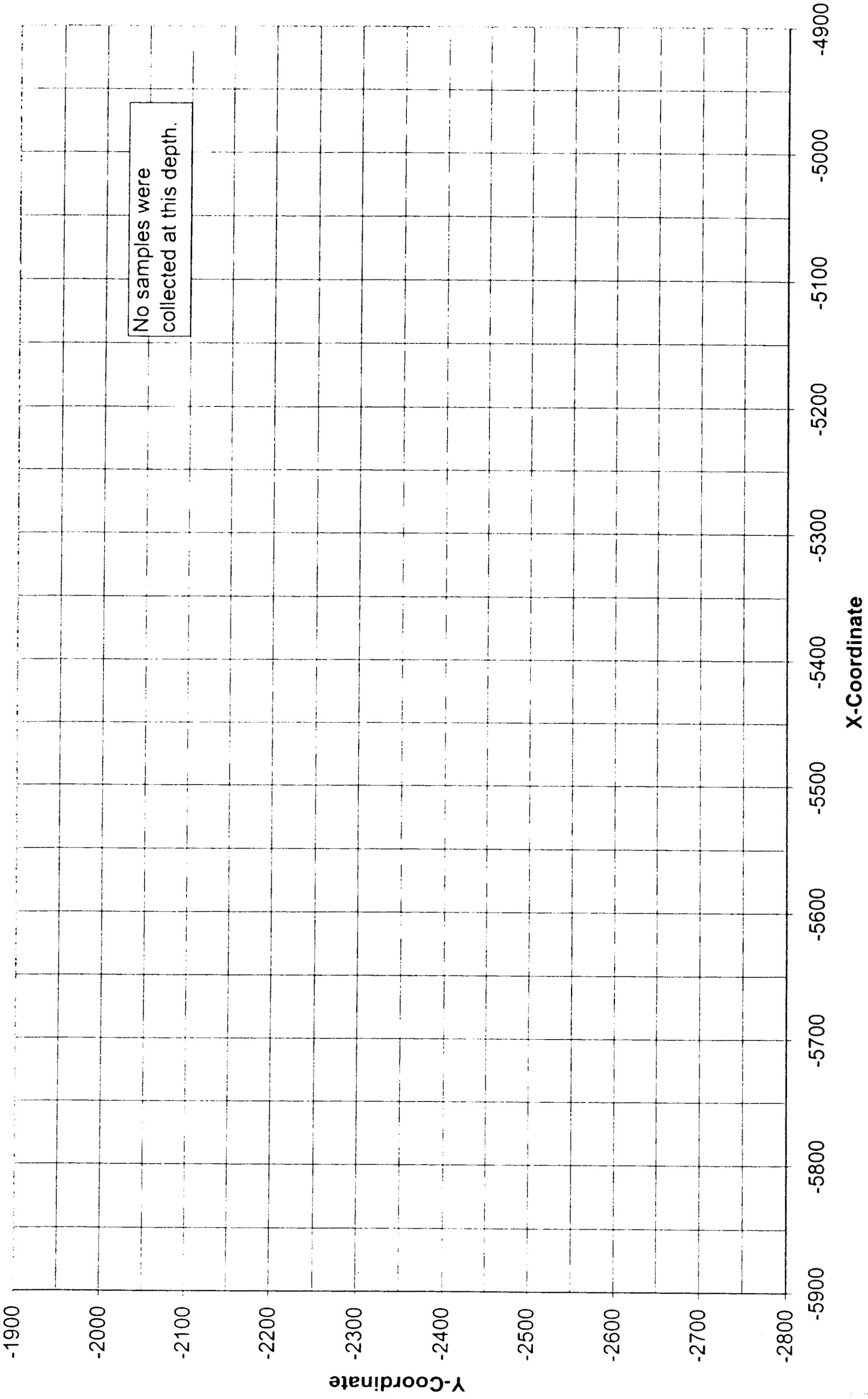
C-720 - Stations with Antimony Samples from 51 to 60 Feet BGS



C-720 - Stations with Antimony Samples from 61 to 70 Feet BGS



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ATTACHMENT 3

SOURCE AREA DEVELOPMENT FOR TCE IN SWMU 1

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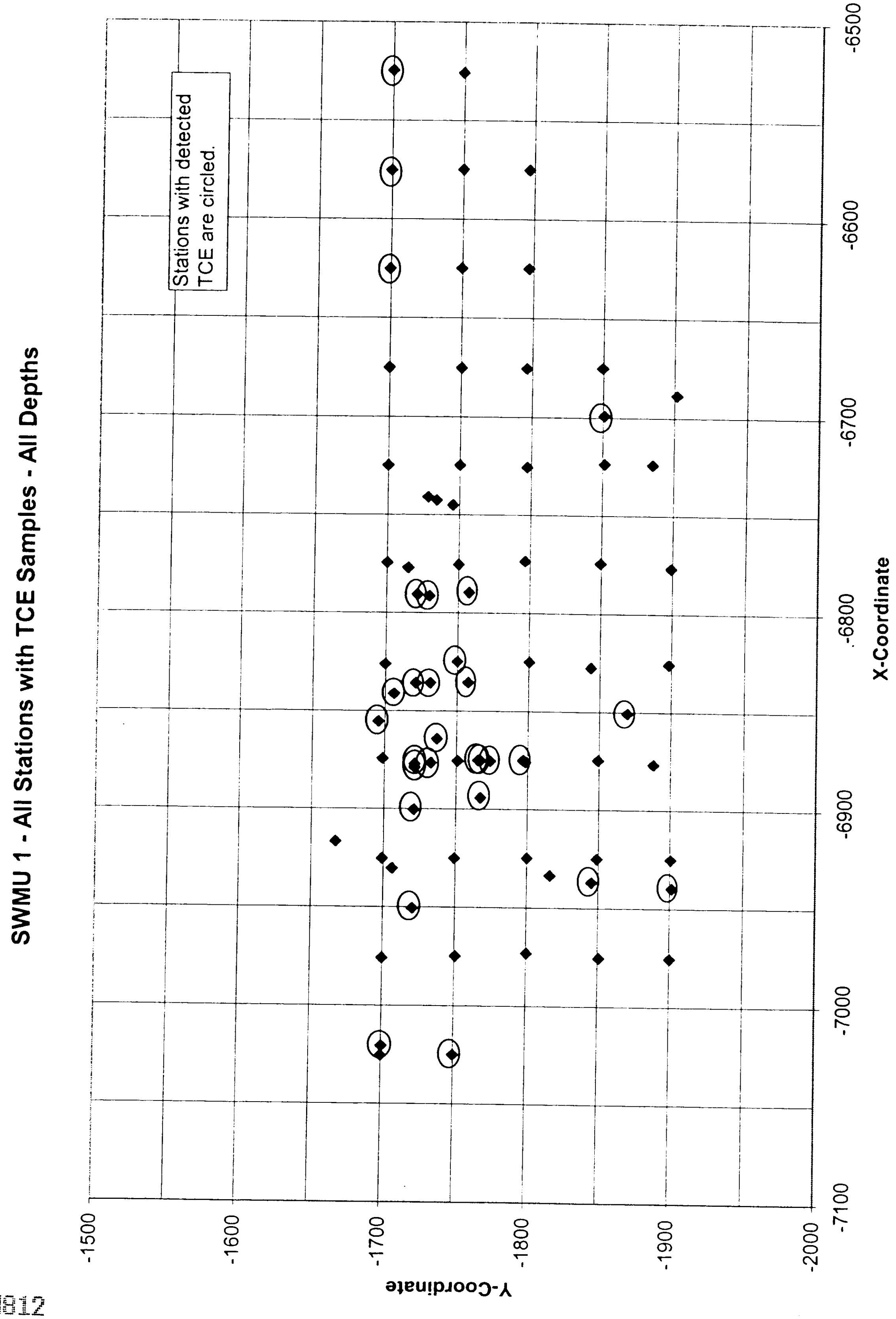
SWMU 1 - All Stations with TCE Samples - All Depths
Stations with detected TCE are circled.
X-Coordinate
Y-Coordinate
-6500
-6600
-6700
-6800
-6900
-7000
-7100
-1500
-1600
-1700
-1800
-1900
-2000

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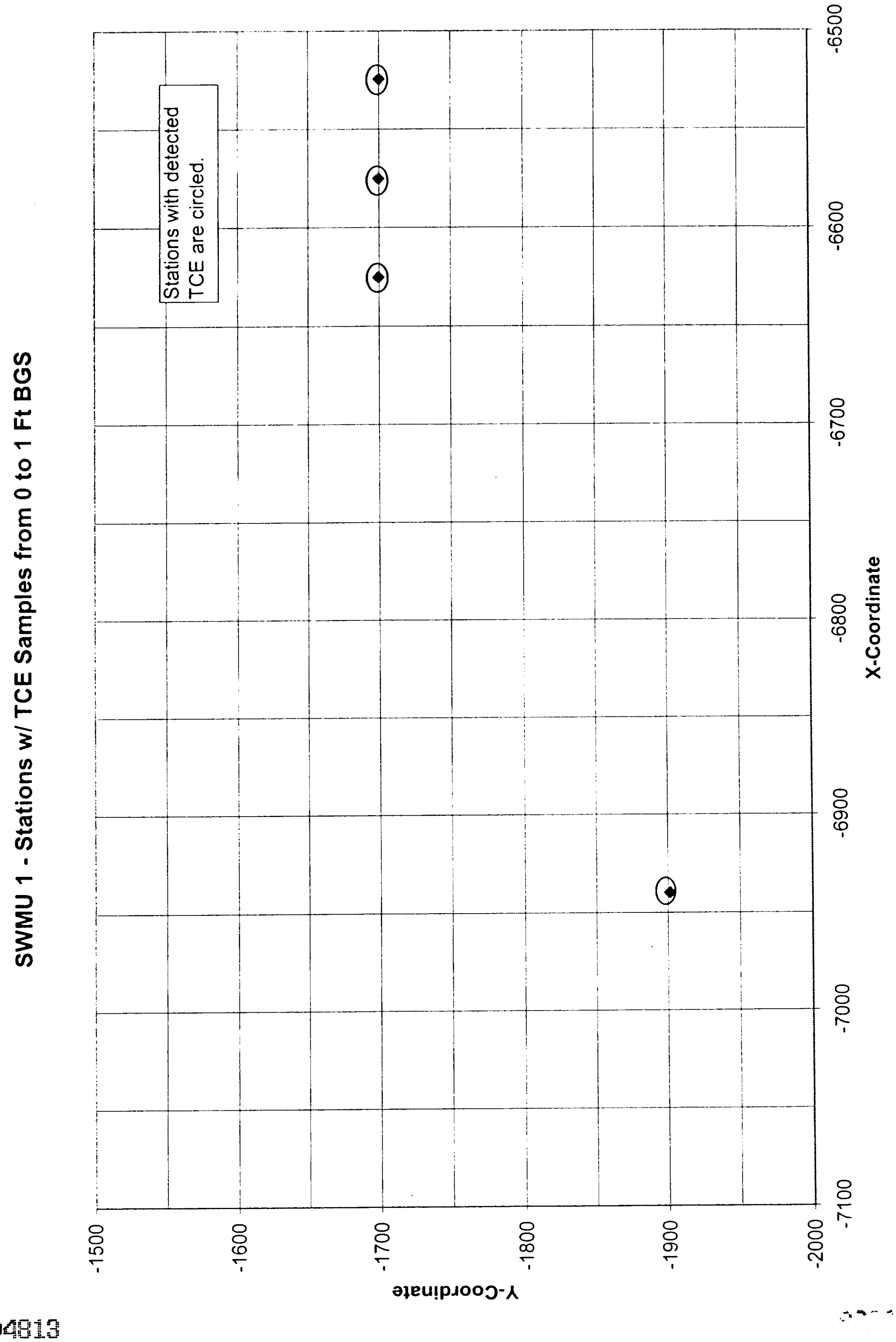
SWMU 1 - Stations w/ TCE Samples from 0 to 1 Ft BGS
Stations with detected TCE are circled.
X-Coordinate
-7100
-7000
-6900
-6800
-6700
-6600
-6500
Y-Coordinate
-1500
-1600
-1700
-1800
-1900
-2000

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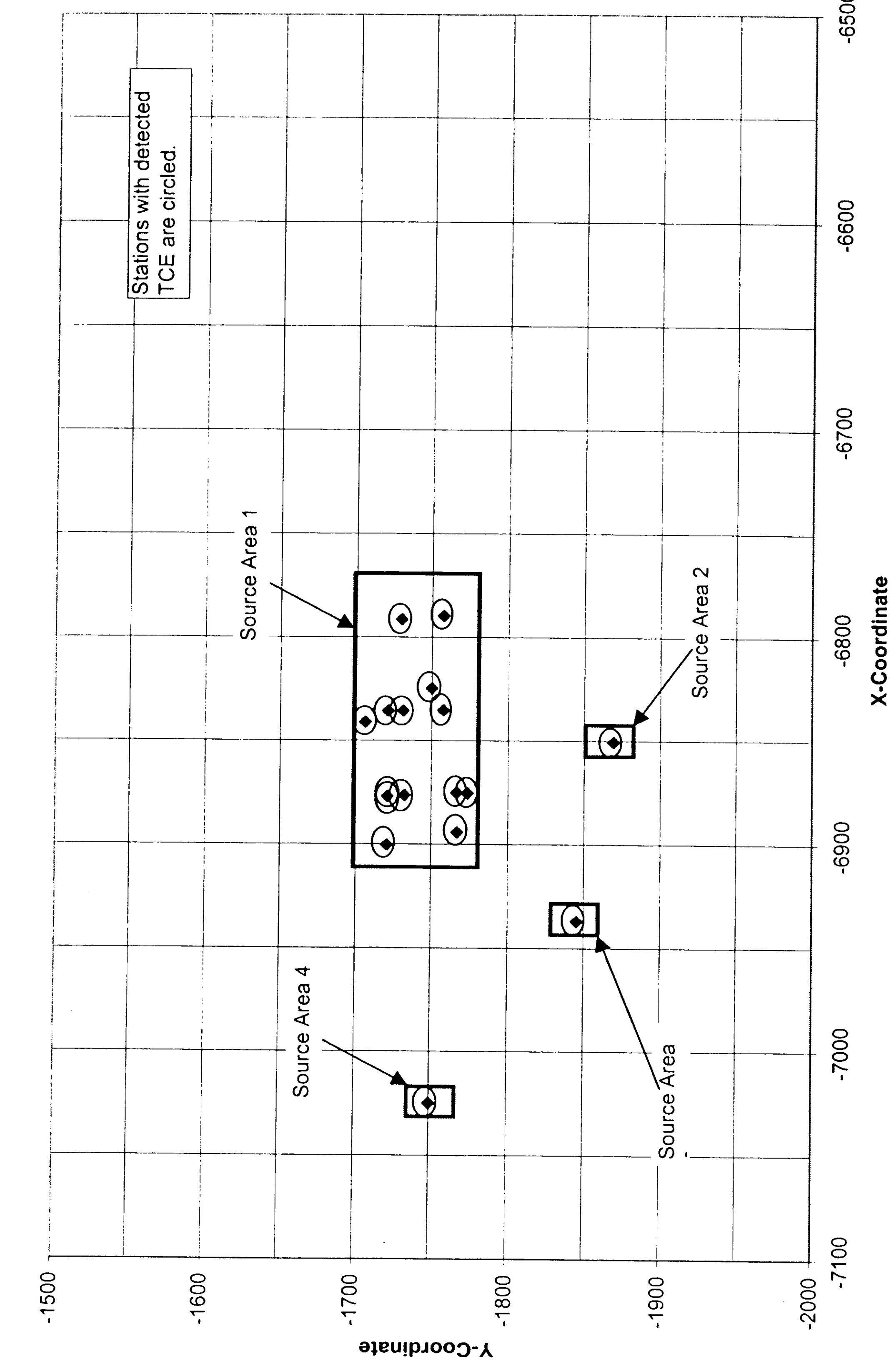
SWMU 1 - Stations w/ TCE Samples from 1 to 10 Ft BGS



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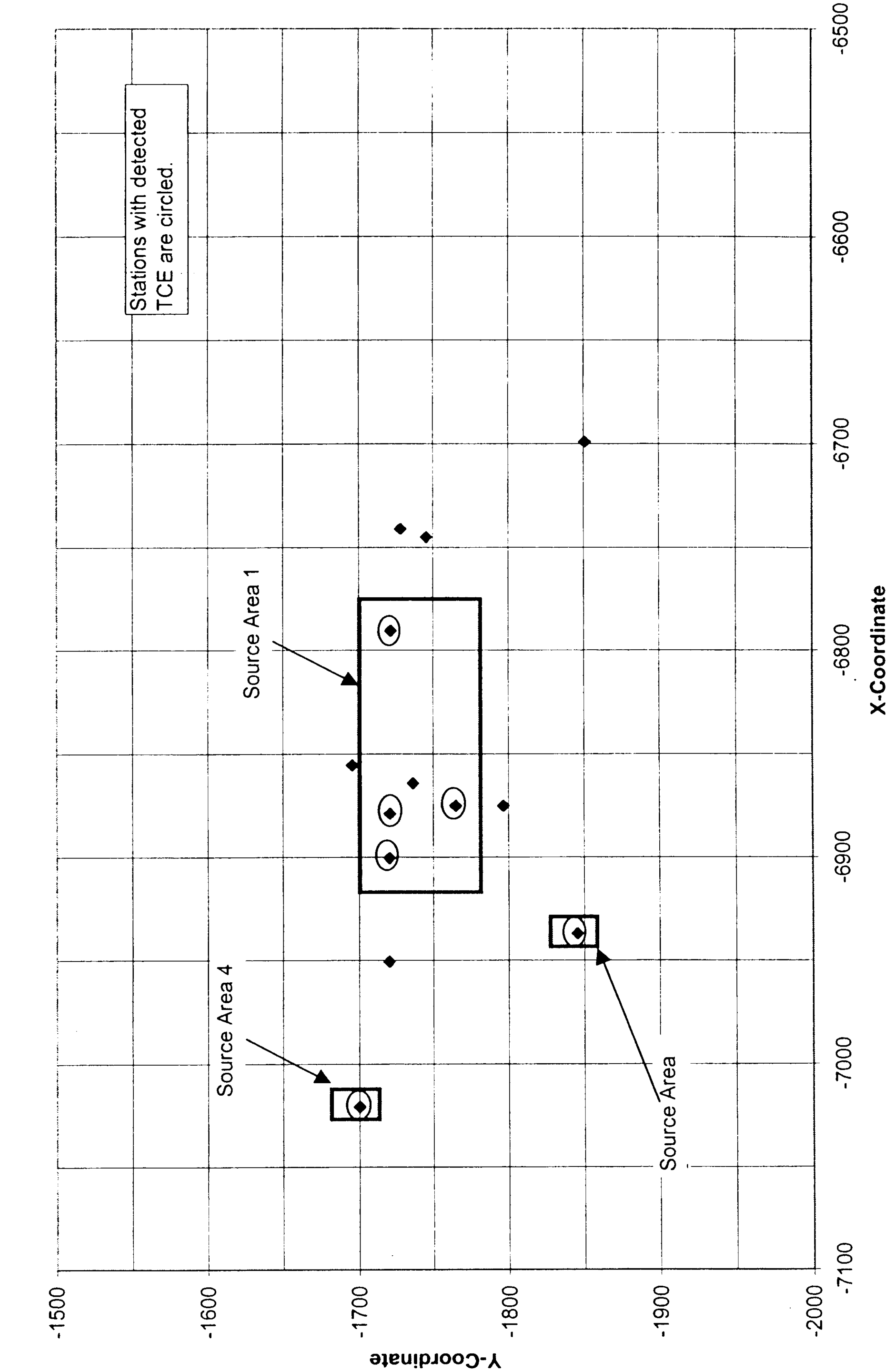
SWMU 1 - Stations w/ TCE Samples from 11 to 20 Ft BGS



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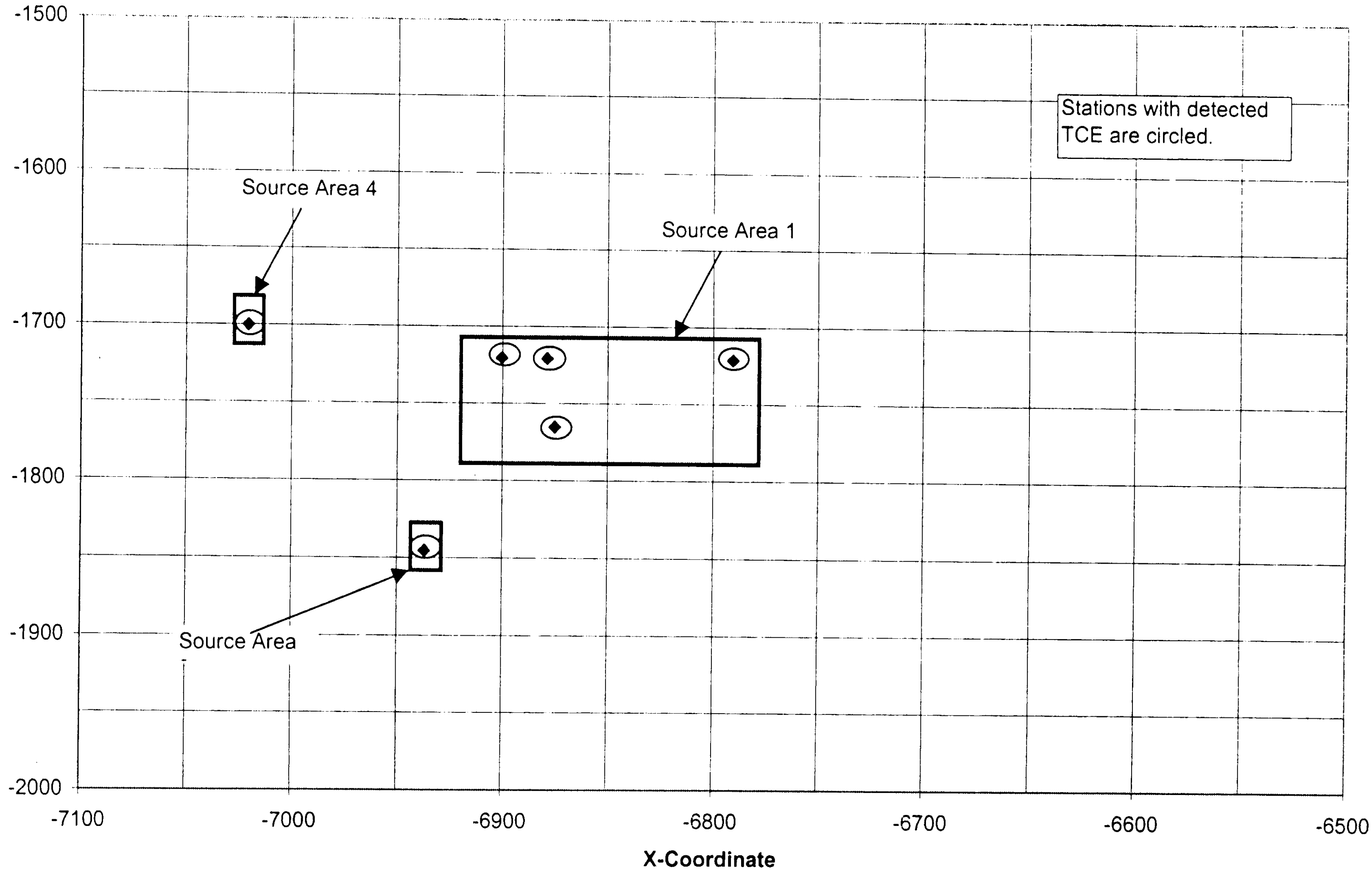
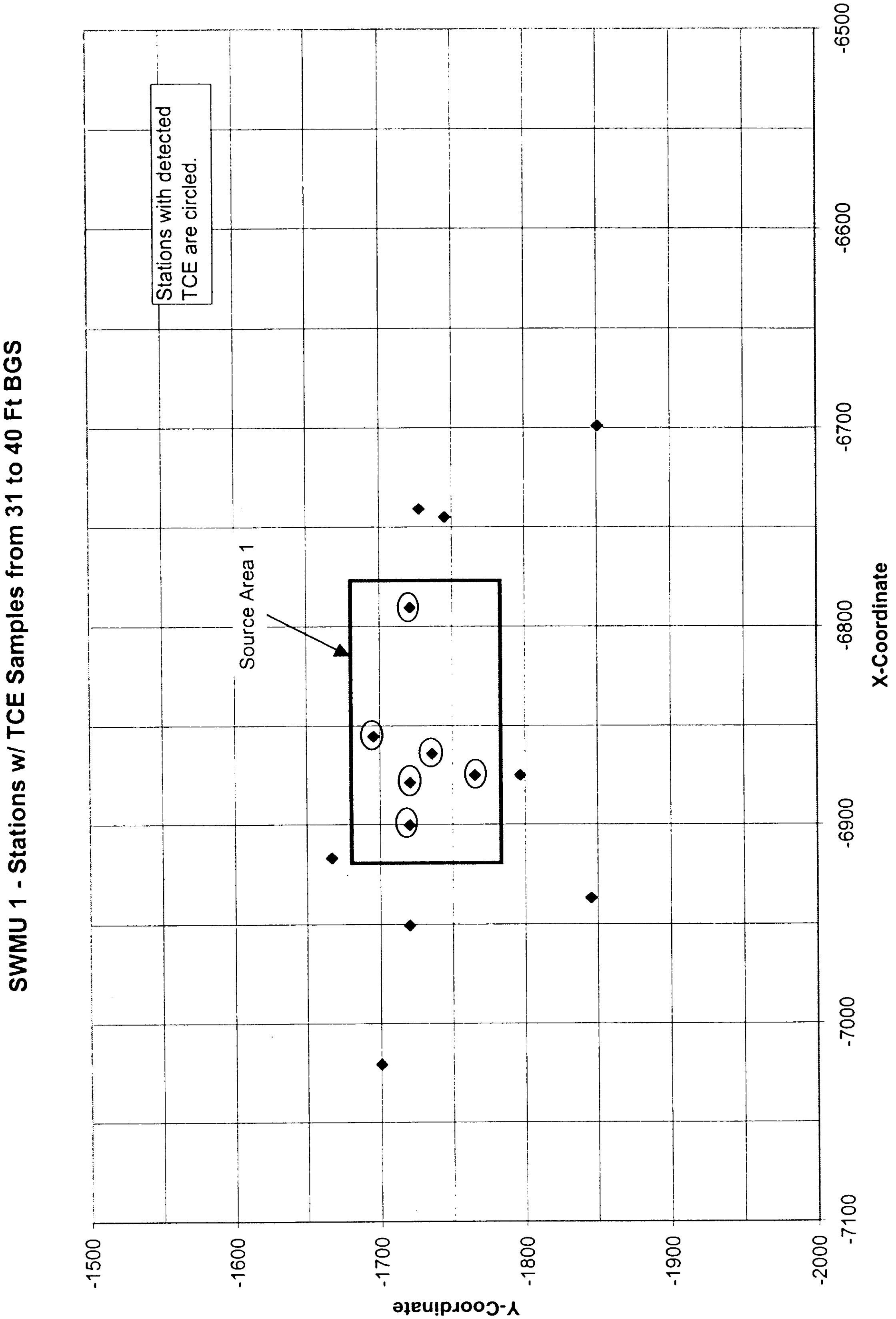
SWMU 1 - Stations w/ TCE Samples from 21 to 30 Ft BGS




SWMU 1 - Stations w/ TCE Samples from 31 to 40 Ft BGS
Stations with detected TCE are circled.
Source Area 1
X-Coordinate
Y-Coordinate
-6500
-6600
-6700
-6800
-6900
-7000
-7100
-1500
-1600
-1700
-1800
-1900
-2000

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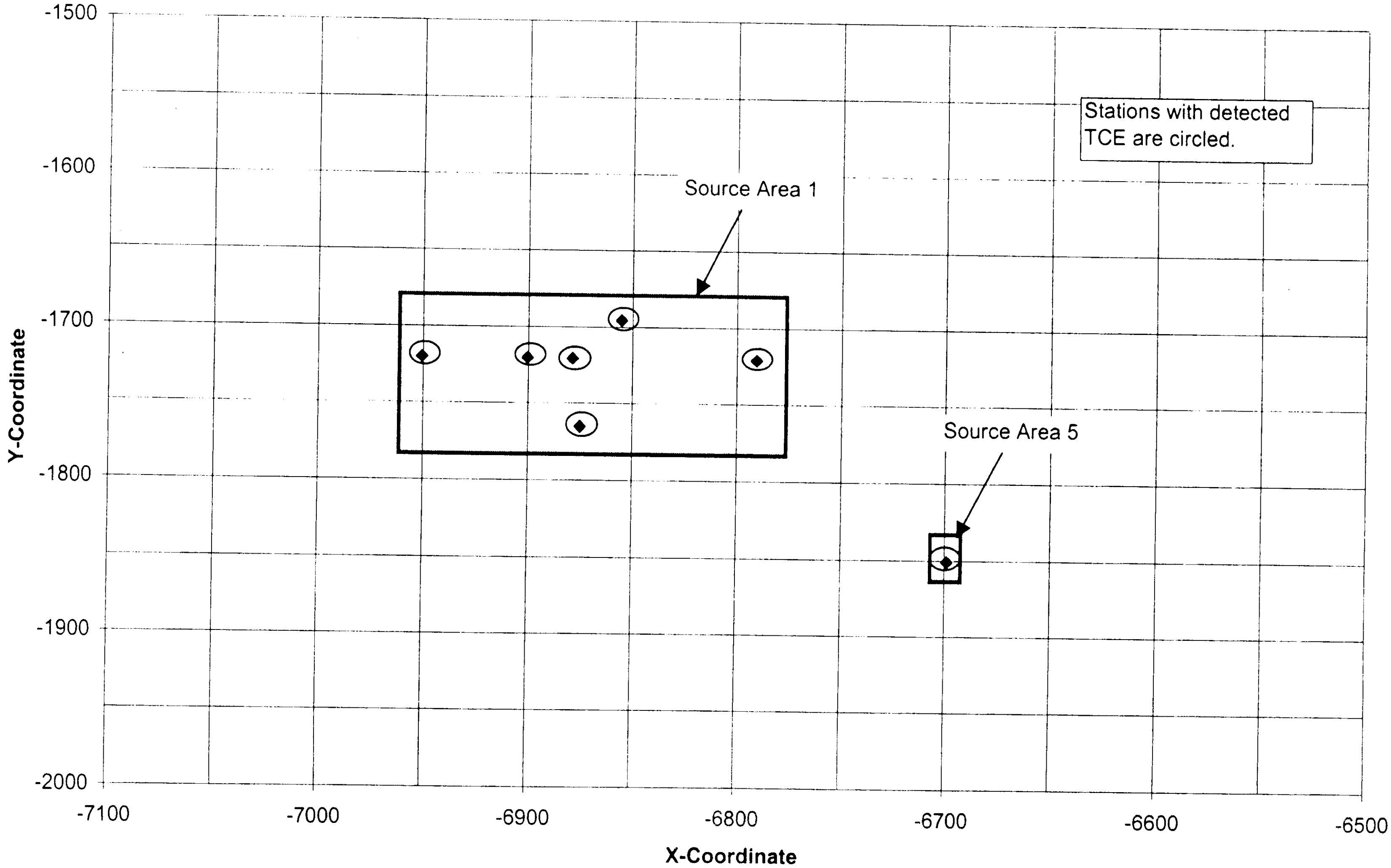
SWMU 1 - Stations w/ TCE Samples from 41 to 50 Ft BGS



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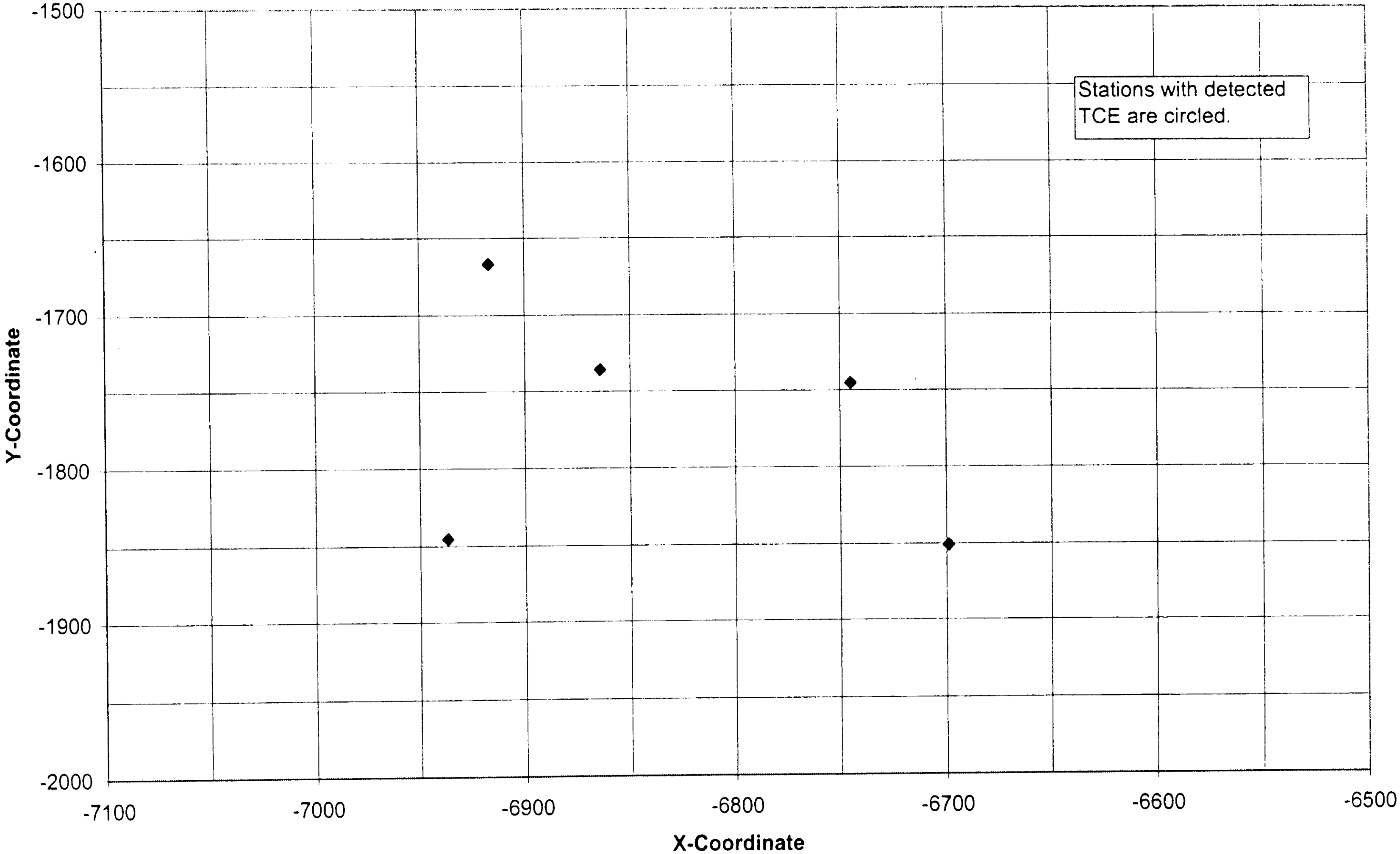
SWMU 1 - Stations w/ TCE Samples from 51 to 60 Ft BGS



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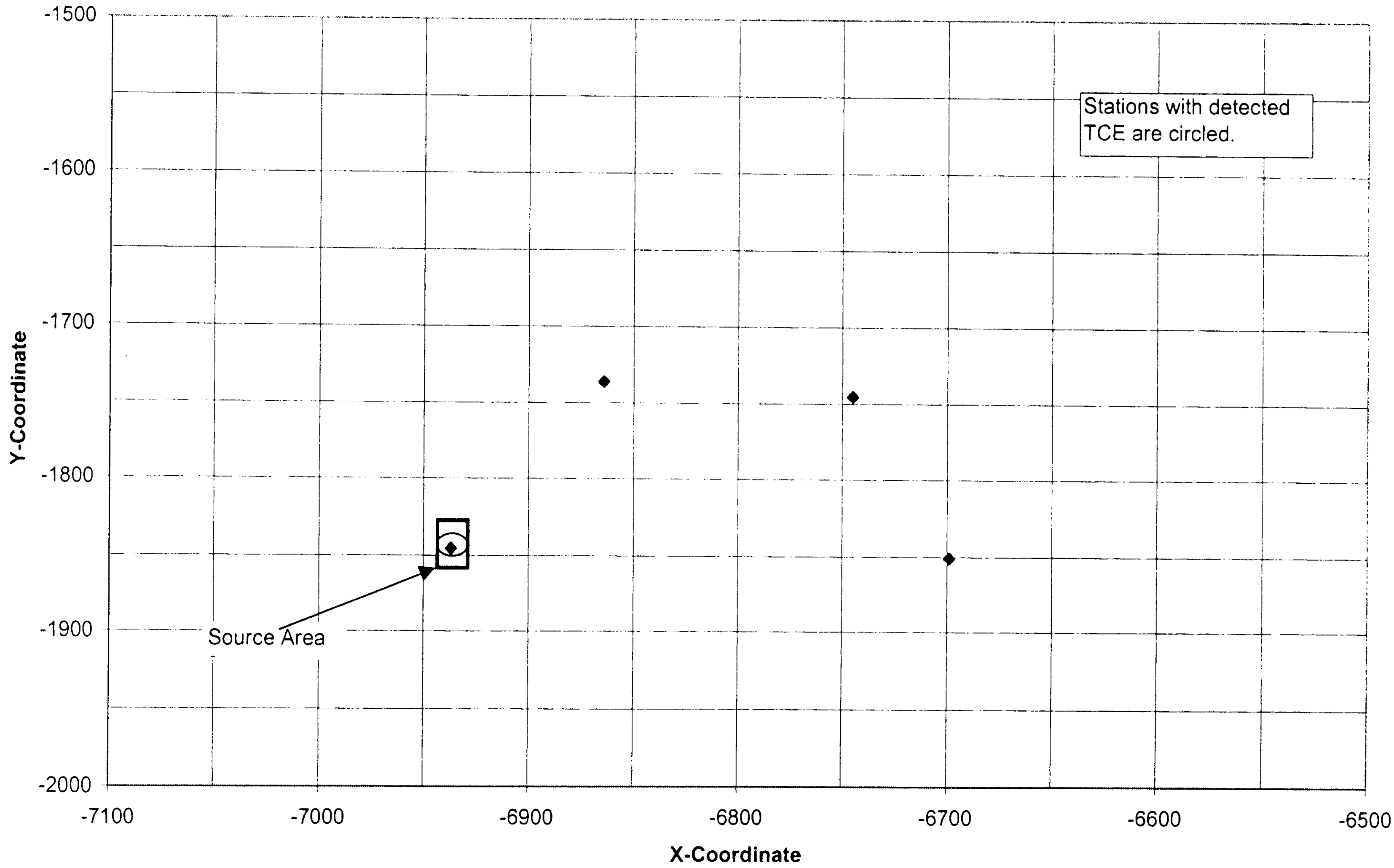
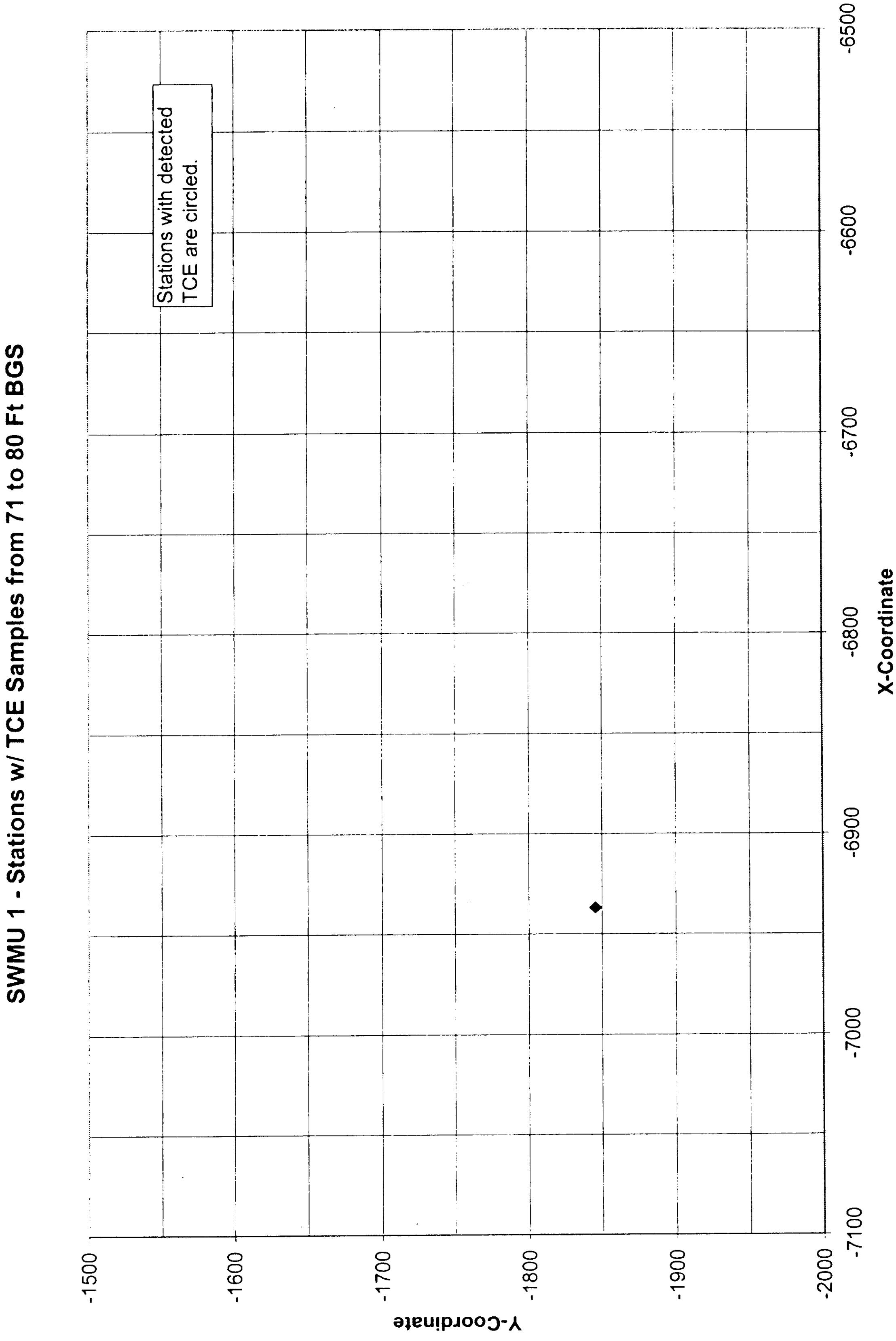
SWMU 1 - Stations w/ TCE Samples from 61 to 70 Ft BGS





SWMU 1 - Stations w/ TCE Samples from 71 to 80 Ft BGS
Stations with detected TCE are circled.
X-Coordinate
-7100
-7000
-6900
-6800
-6700
-6600
-6500
Y-Coordinate
-1500
-1600
-1700
-1800
-1900
-2000

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ATTACHMENT 4

SOURCE AREA DEVELOPMENT FOR ANTIMONY IN SWMU 1

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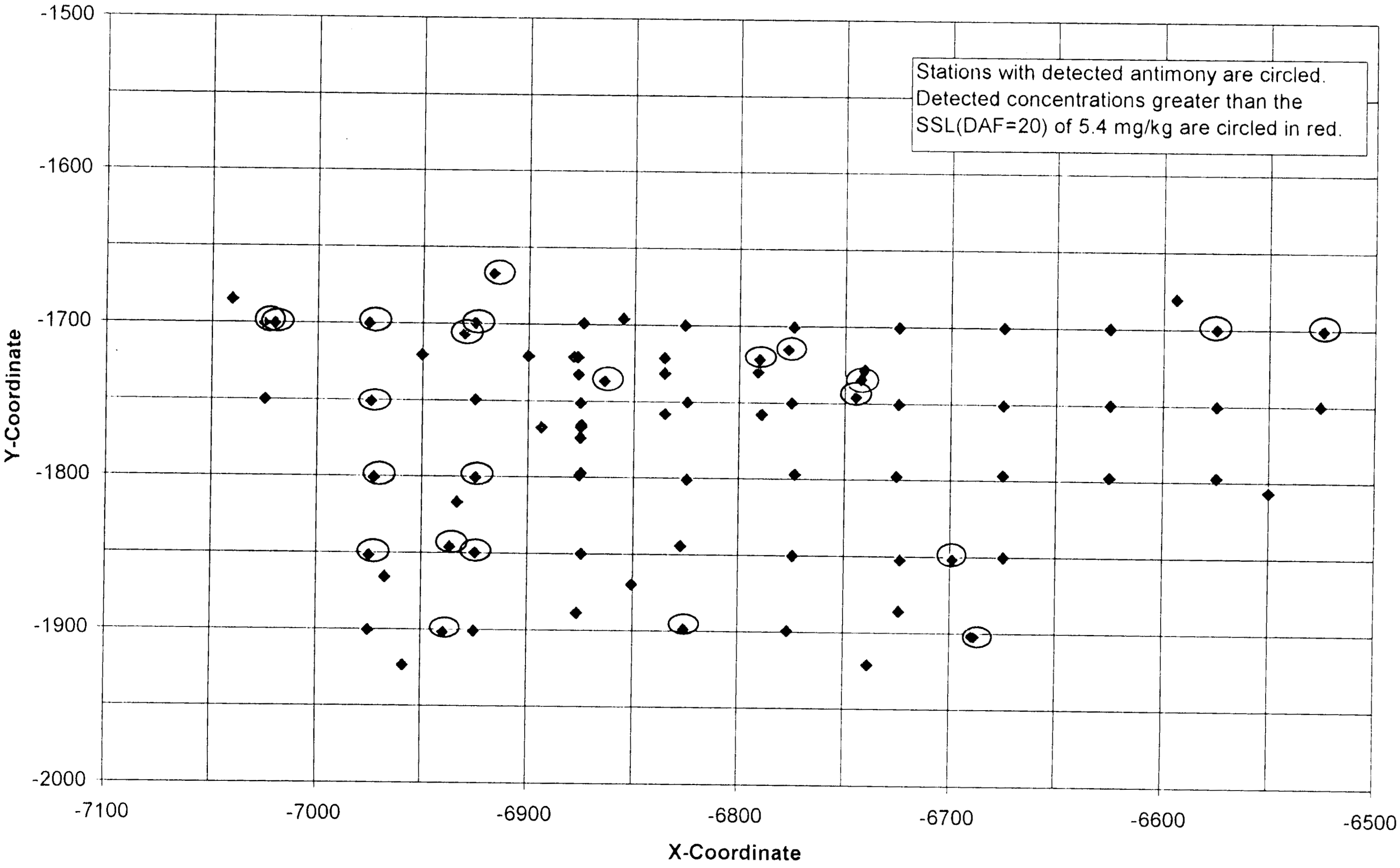
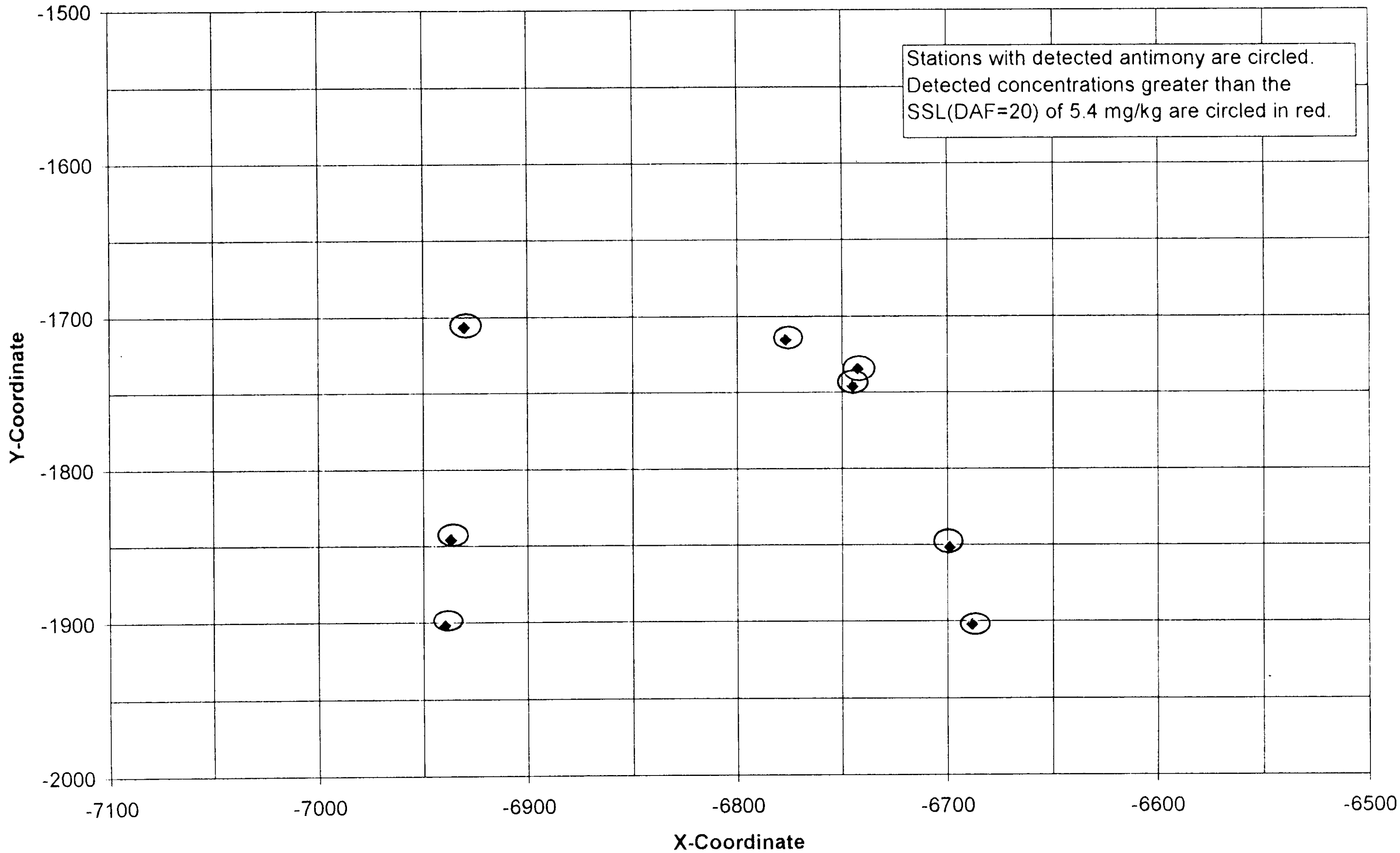
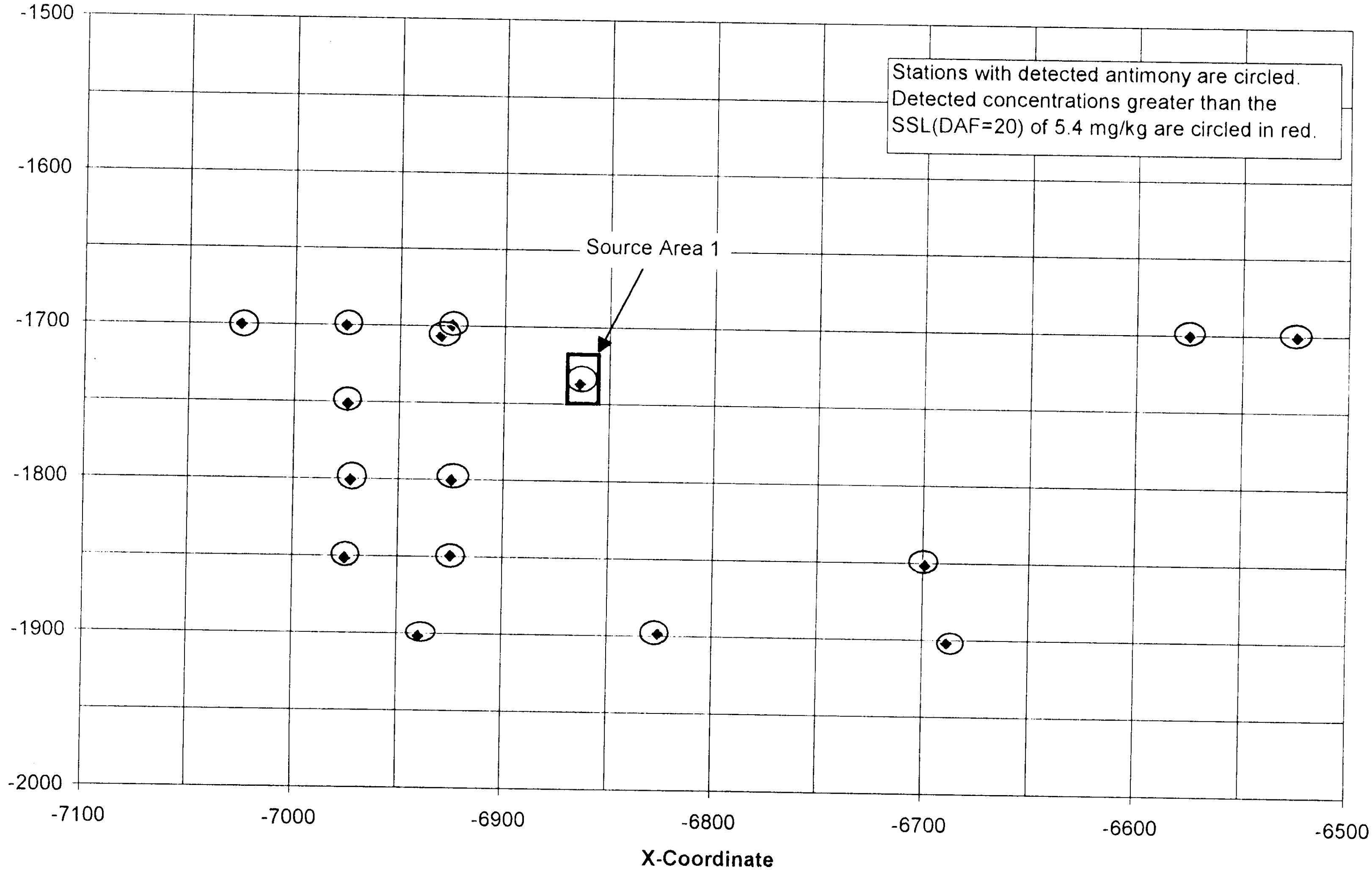
SWMU 1 - Stations with Antimony Samples - All Depths

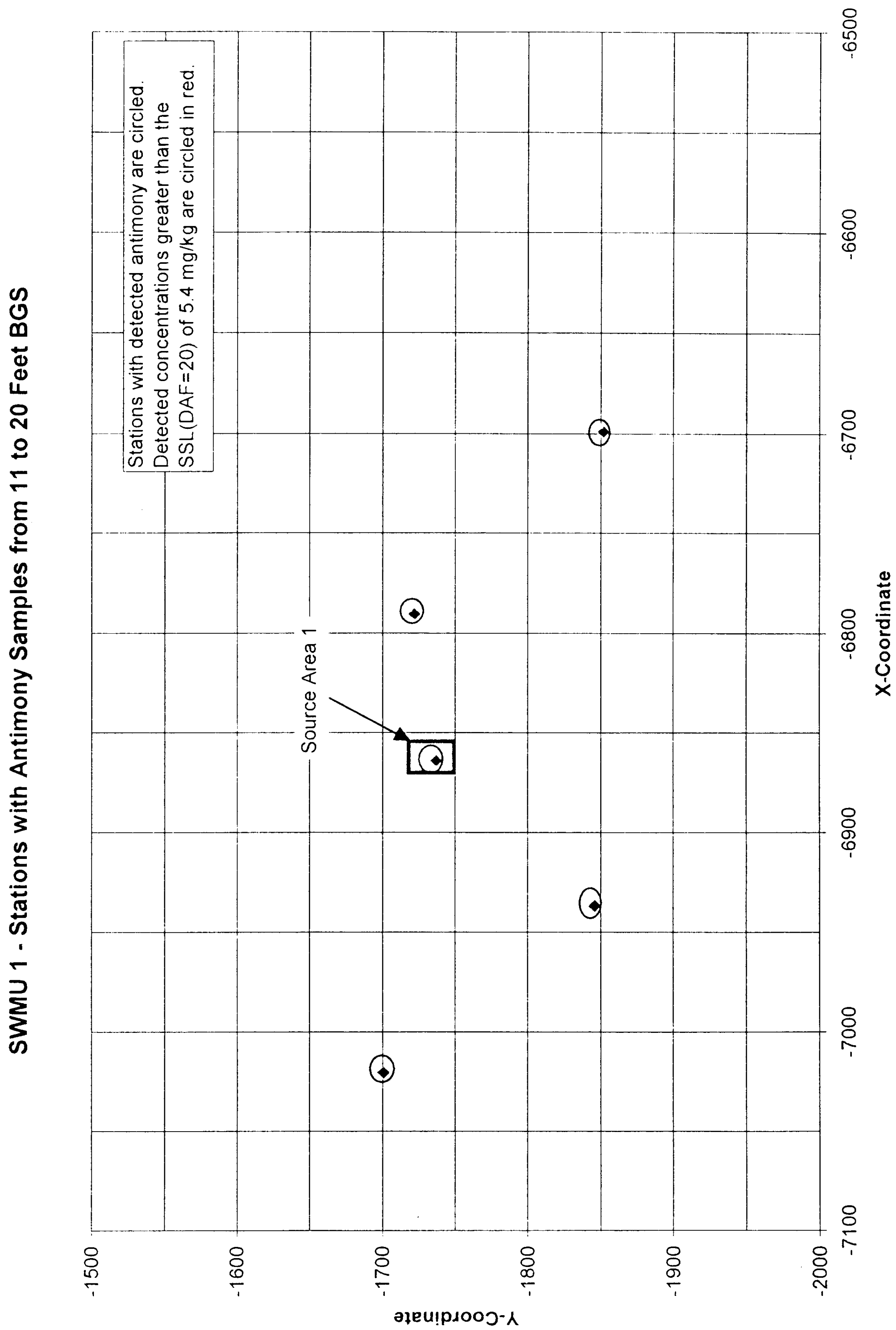


SWMU 1 - Stations with Antimony Samples from 0 to 1 Foot BGS



SWMU 1 - Stations with Antimony Samples from 1 to 10 Feet BGS




SWMU 1 - Stations with Antimony Samples from 11 to 20 Feet BGS
Stations with detected antimony are circled.
Detected concentrations greater than the SSL(DAF=20) of 5.4 mg/kg are circled in red.
Source Area 1
X-Coordinate
Y-Coordinate
-7100
-7000
-6900
-6800
-6700
-6600
-6500
-1500
-1600
-1700
-1800
-1900
-2000

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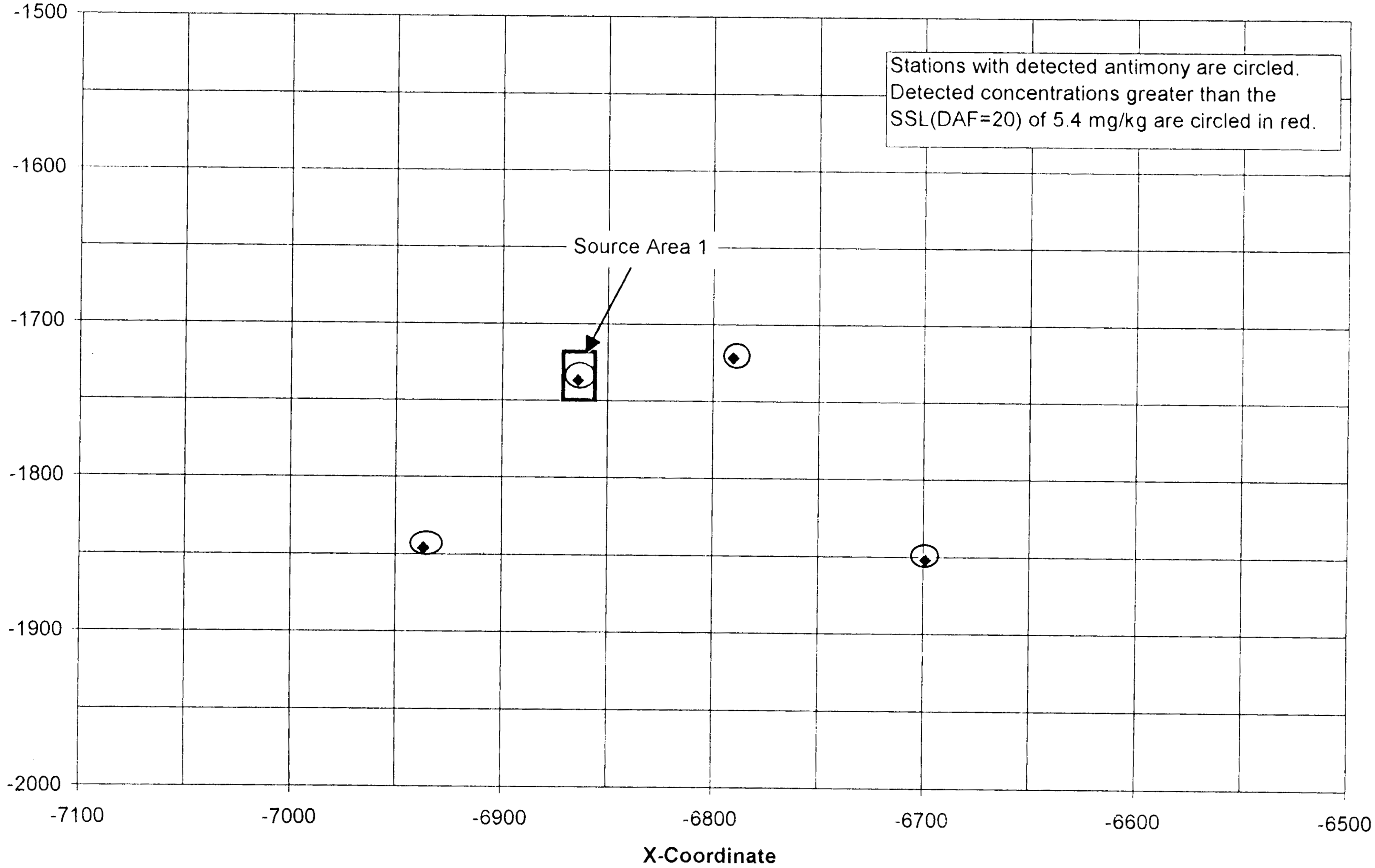
SWMU 1 - Stations with Antimony Samples from 21 to 30 Feet BGS



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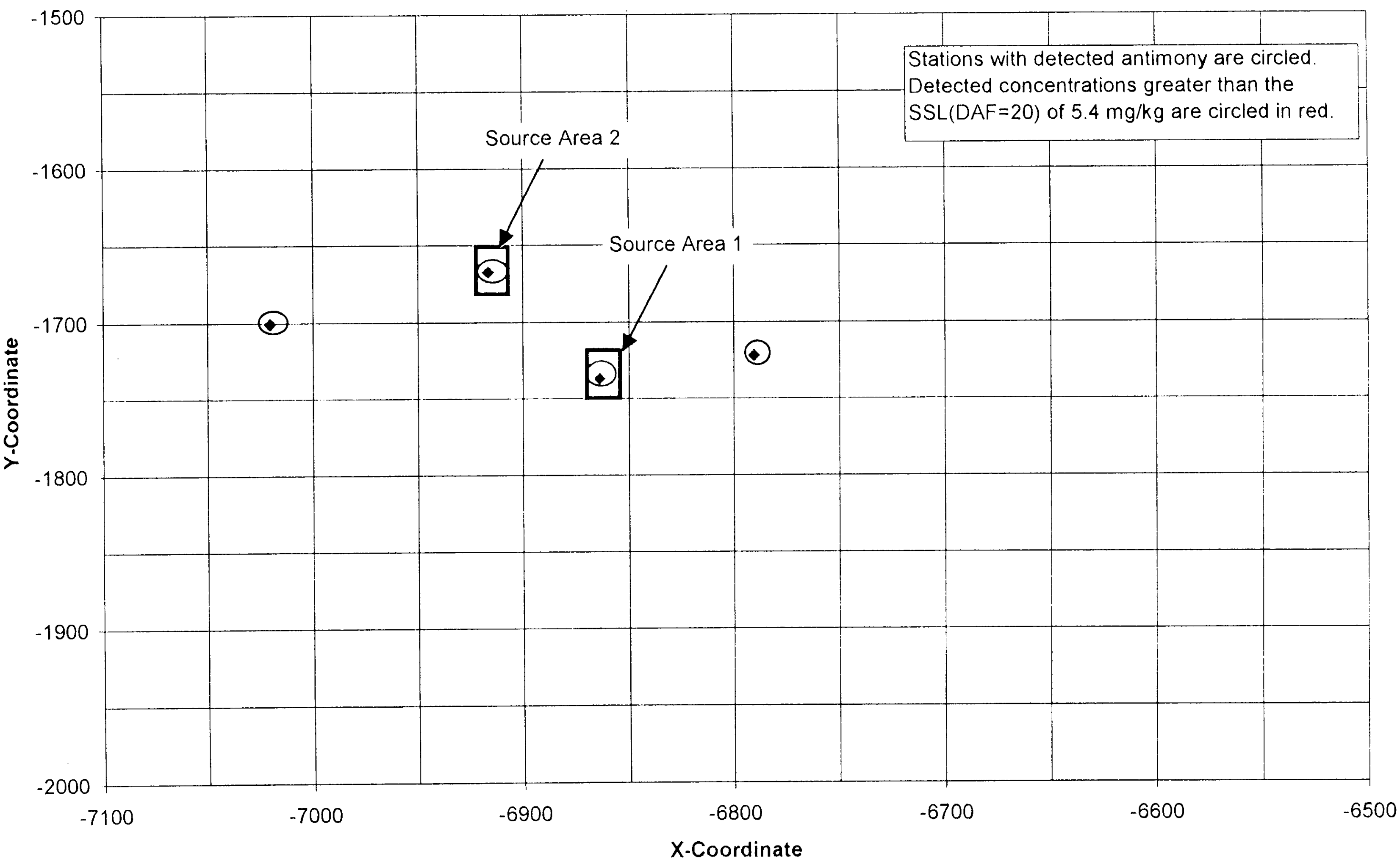
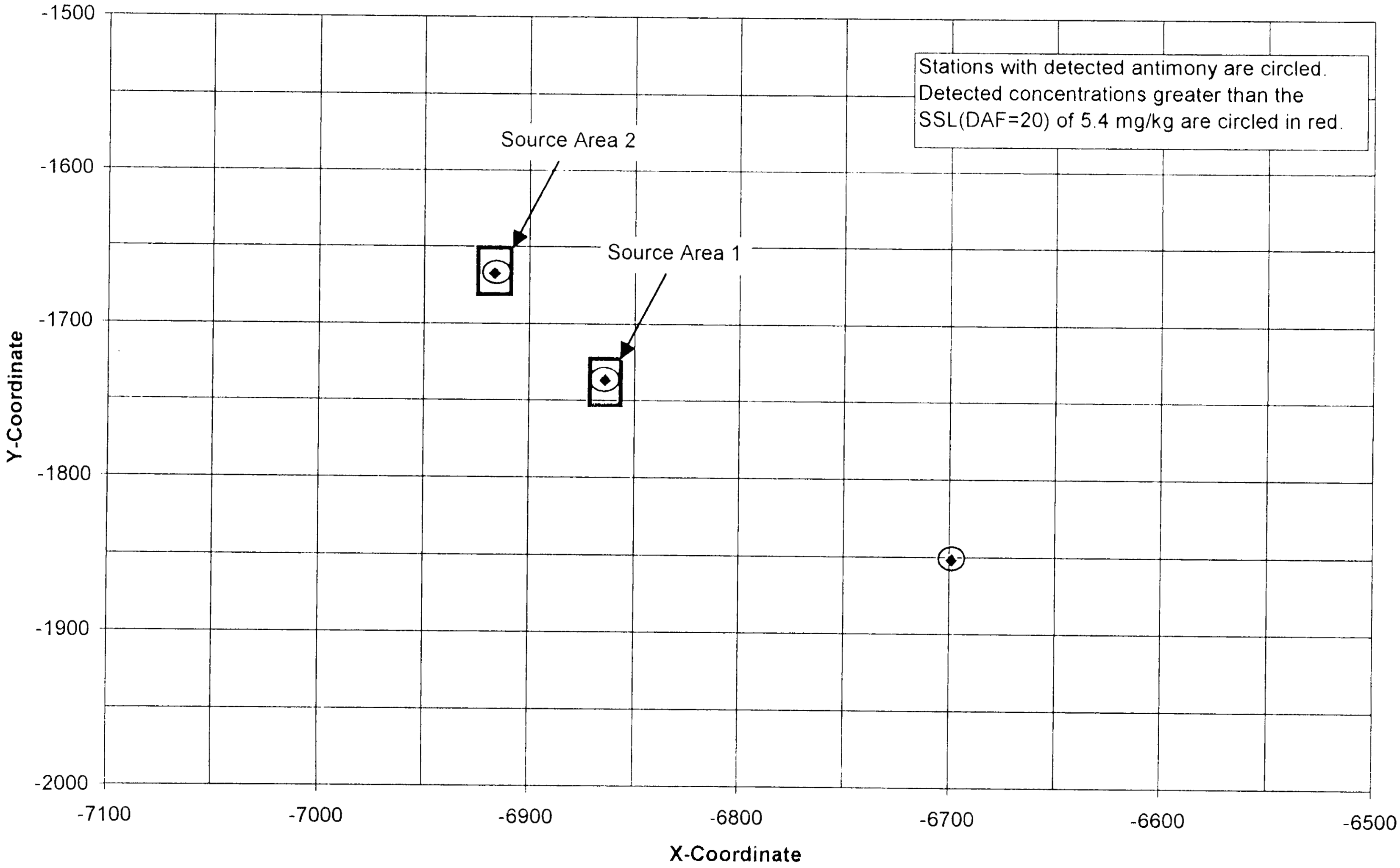
SWMU 1 - Stations with Antimony Samples from 31 to 40 Feet BGS



SWMU 1 - Stations with Antimony Samples from 41 to 50 Feet BGS



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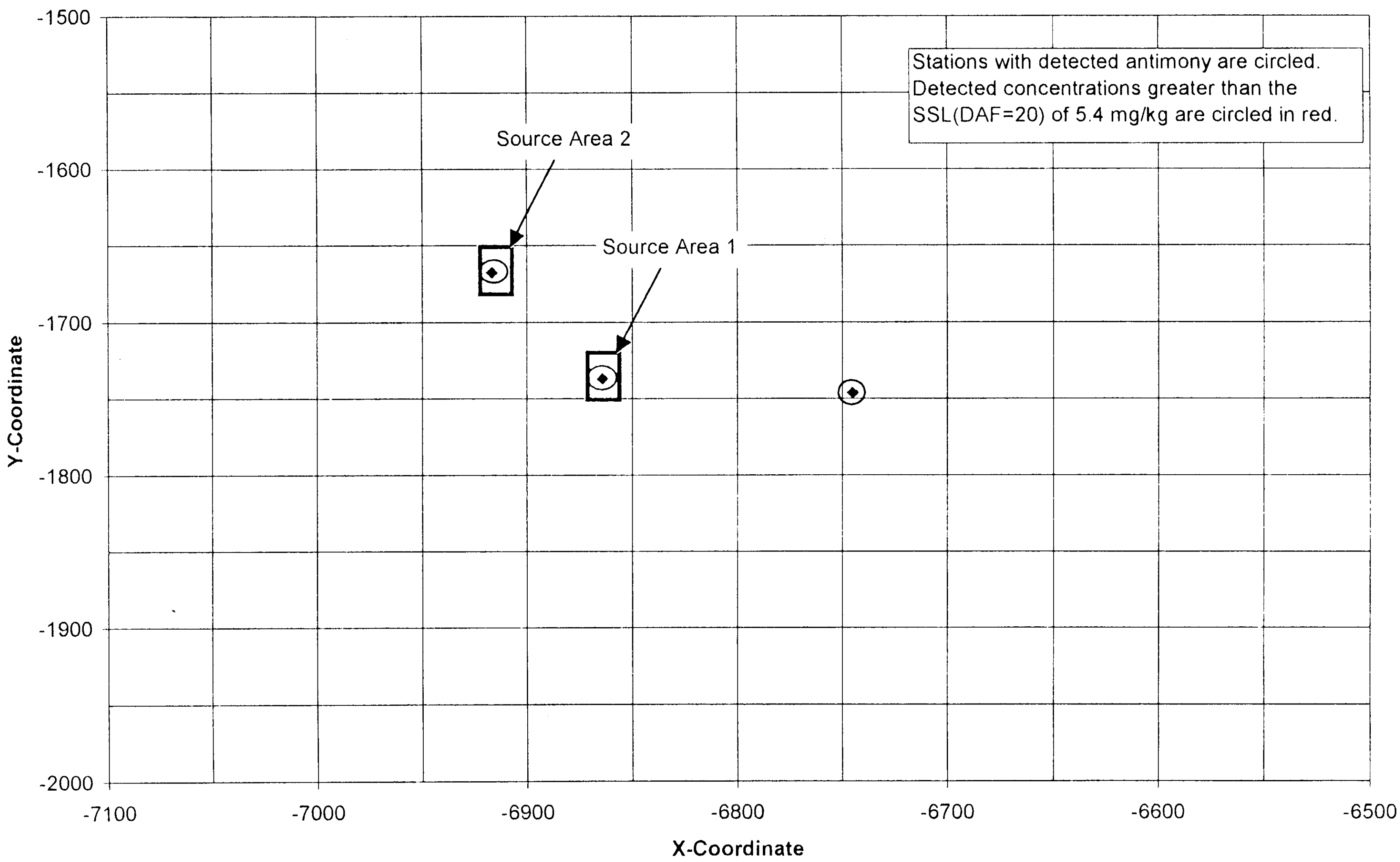
SWMU 1 - Stations with Antimony Samples from 51 to 60 Feet BGS



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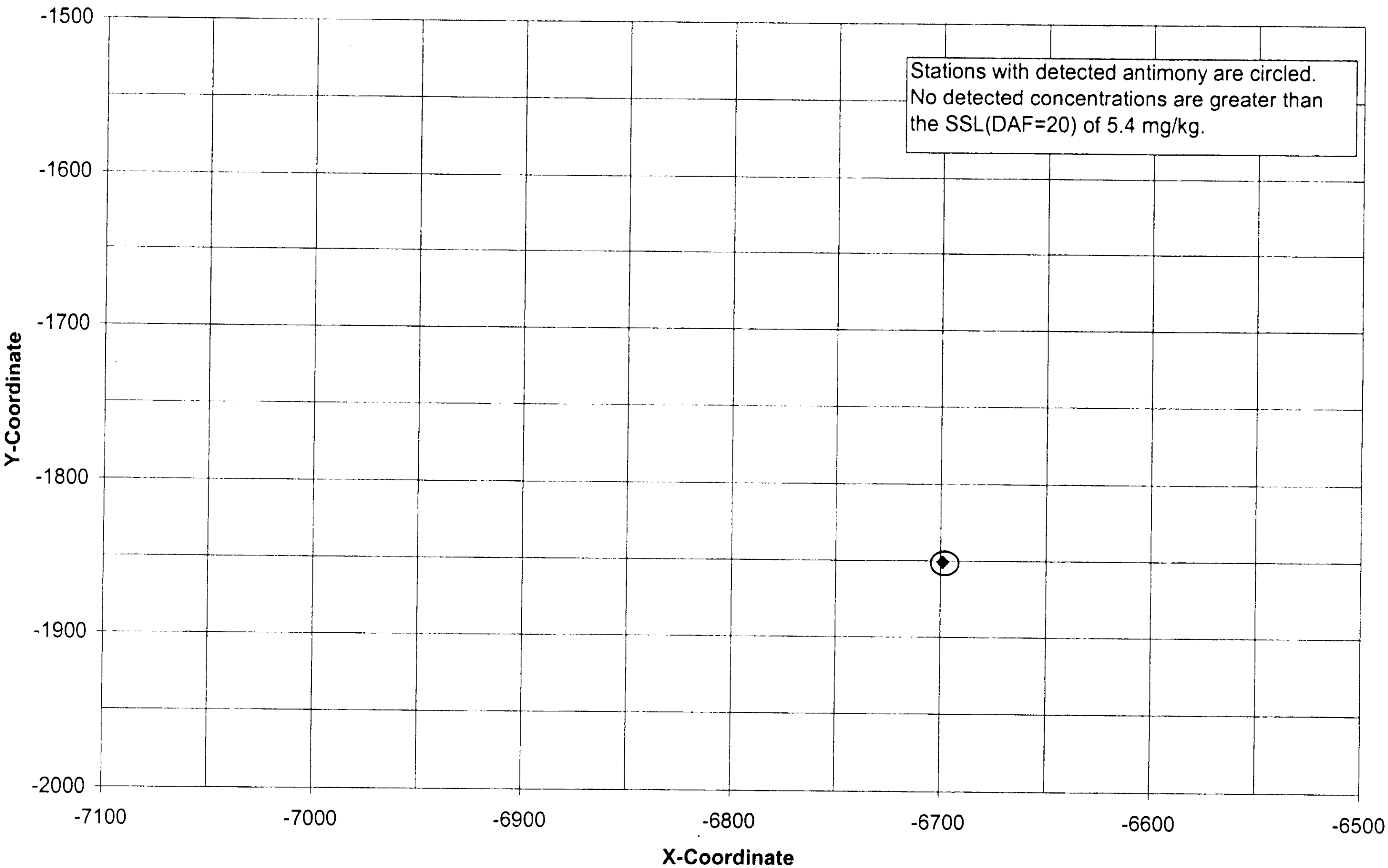
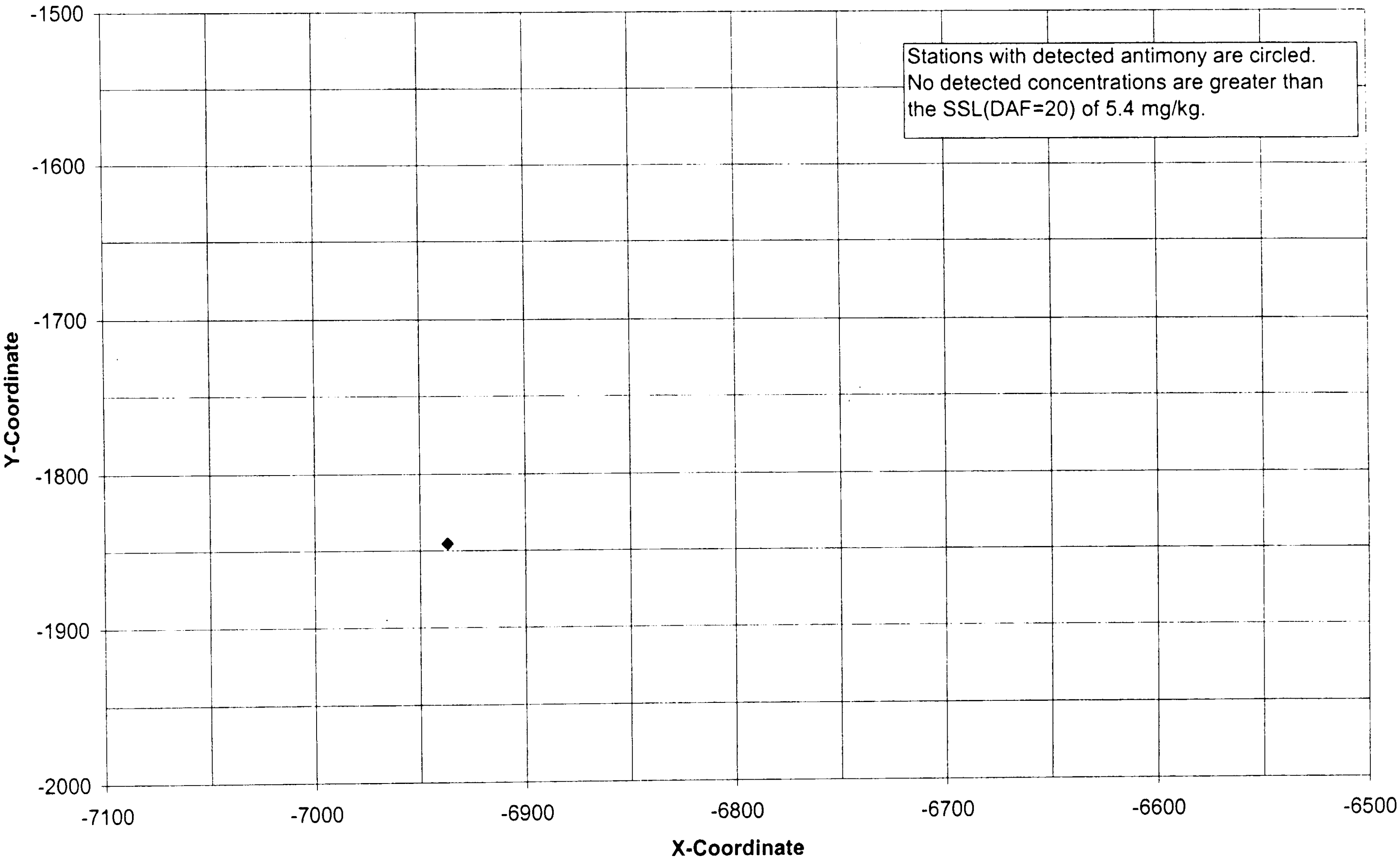
SWMU 1 - Stations with Antimony Samples from 61 to 70 Feet BGS



SWMU 1 - Stations with Antimony Samples from 71 to 80 Feet BGS



APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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Applicable or Relevant and Appropriate Requirements

The Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) of 1980, as amended, requires, in part, that remedial actions for cleanup of hazardous substances must comply with requirements and/or standards under federal or more stringent state environmental laws and regulations where the requirements are applicable or relevant and appropriate. These requirements, are identified as those being specific to the hazardous substances or particular circumstances at a site and must be complied with or a waived under the CERCLA decision making process (40 CFR 300.430(f)(1)(ii) (B)). ARARs include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker radiation protection requirements. However, per 40 CFR 300.405(g)(3), other advisories, criteria, or guidance may be considered in determining remedies as To Be Considered (TBC). Tables B.1, B.2, and B.3, list the chemical-specific, location-specific, and action-specific ARARs for the remedial actions in the selected remedy. A brief summary of the remedial actions and associated ARARs/TBCs follows.

Chemical-Specific ARARs/TBC

These requirements provide health or risk-based concentration limits or values in environmental media for hazardous substances, pollutants, or contaminants. The specific requirements associated with the selected alternative are presented in Table B.1 and are discussed further below.

Groundwater. The selected alternative will result in source reduction of contaminants reaching groundwater. The National Primary Drinking Water Standards include maximum contaminant levels for several of the contaminants found within groundwater at the PGDP and are considered applicable requirements for groundwater. The selected alternative will not result in immediate attainment of the MCL for TCE of 5 µg/L. Under the NCP at 40 CFR 300.340(f)(1)(ii)(C)(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action. Since the selected alternative will not attain all identified ARARs, this action will be interim with respect to groundwater contamination. On completion of the source reduction, a gradual decrease in TCE contamination is expected but will not meet the specified MCL. Since the GWOU contamination is extensive, multiple actions are planned to provide overall remediation of the groundwater. At a minimum, these multiple actions will focus on remediation of (a) on-site sources (including secondary sources such as DNAPL), (b) dissolved-phase groundwater plumes, (c) potential "fenceline" containment or treatment actions, and (d) institutional controls for groundwater. This ROD represents the first of five RODs currently planned for the GWOU and focuses on TCE source reduction within the UCRS at the C-720 Building and the Oil Landfarm (SWMU 1) and ^{99}Tc source reduction at the C-746-D Scrap Yard (SWMU 99). Also,, institutional controls to control groundwater usage will be implemented as a part of this alternative.

Surface Water. Kentucky Surface Water Standards are included as ARARs for this remedial action due to potential recharge of surface water bodies. Source reduction of contaminants to reduce overall groundwater contamination will be part of an overall approach to ensure these requirements are met. Surface water contamination at PGDP is to be addressed in a separate decision document (i.e., ROD) which will be supported by this remedial action. This action supports the general remedial objectives anticipated for the SWOU. It is anticipated that the SWOU FS and ROD will address surface water contamination and evaluate the need for further reduction of contributions made from groundwater, as necessary.

Radiation Protection. Applicable NRC radiation protection requirements include a residual activity at nuclear facilities for unrestricted release of 25 mrem/year. The relevant and appropriate requirements

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found at 40 CFR 190, Subpart B, require exposure to the public not exceed an annual dose equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of exposure to planned discharges or radioactive materials (radon and its daughters excepted). These requirements are equivalent to the exposure criteria under the NRC standards. The dose limit addresses exposure to radiation from all sources and activities at a facility. In addition, DOE is required to utilize procedures to maintain dose ALARA and must not allow an effective dose of >100 mrem/year to the general public from all exposure pathways under DOE Order 5400.5 (TBC). The actual dose that the public might receive from an individual activity such as this remedial action is expected to be a very small fraction of the 100-mrem/year dose limit.

Location-Specific ARARs/TBC

Location-specific requirements establish restrictions on activities conducted within protected or environmentally sensitive areas. In addition, these requirements establish restrictions on permissible concentrations of hazardous substances within these areas. Table B.2 lists the federal and state location-specific ARARs for protection of sensitive resources.

Aquatic Resources (including wetlands). Installation of treatment systems and excavation of contaminant source areas may impact nondelineated wetlands during the construction phase of remedy implementation. As required at 10 CFR Section 1022, 40 CFR 230.10, and 33 CFR 330.5, all activities will be designed to avoid or minimize impacts to wetlands identified within the area of deployment of the remedy. The use of Best Management Practices and proper siting of equipment and construction areas will be considered and conducted as necessary to comply with these requirements.

Endangered/Protected Species. Installation activities must not impact or jeopardize the existence of a listed species or result in the destruction or impact to critical habitat. These requirements are specified at 16 U.S.C. 1531 Section 7(a)(2). Possible existence of endangered species or species habitat must be considered within the area of deployment of the remedy. This ARAR shall be achieved by avoiding such areas. In addition, the requirements of the Migratory Bird Treaty act requires similar measures be taken with regard to protected migratory species. As with endangered species, these requirements shall be complied with through assessment of the area of deployment to ensure no adverse impact occurs.

Action-Specific ARARs/TBCs

Action-specific ARARs include operation, performance, and design requirements or limitations based on waste types, media, and remedial activities. Component actions include removal of source areas, groundwater extraction, treatment and monitoring, institutional controls, waste management, and transportation. ARARs/TBCs for each component action are listed in Table B.3.

General Construction Activities/Excavation of Source Areas. Requirements for the control of fugitive dust and storm water runoff potentially provide ARARs for all construction, excavation, trenching, and site preparation activities. Reasonable precautions must be taken, including the use of BMPs for erosion control to prevent runoff and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. In addition, diffuse or fugitive emissions of radionuclides to the ambient air from remediation activities, which are only one of potentially many sources of radionuclide emissions at a DOE facility, must comply with the Clean Air Act of 1970, as amended, requirements in 40 *CFR* 61.92.

Excavation of source areas during the implementation of this remedy must comply with the general requirements discussed above. However, there are no action-specific ARARs for these excavation activities other than the general requirements to control fugitive dust emissions and storm water runoff. Chemical-specific ARARs for these actions include radiation protection requirements for the public and control of potential fugitive VOC emissions, as applicable. Also, depending on the location of the excavation, location-specific ARARs to protect sensitive resources such as endangered species, protected migratory birds, critical habitat, and/or wetlands may be triggered.

Collection/Treatment of Volatile Organic Constituents. The selected alternative involves *in situ* heating of soils by use of a six-phase heating process. This will result in the collection and recovery of contaminants from the aquifer and vadose zone. Prior to emission of collection vapor/gases, contaminants must be removed to comply with 401 KAR 63:022. A suitable off-gas system shall be employed to ensure contaminant emissions do not exceed allowable levels. This system may include such equipment as condensors and/or filters to accomplish the required contaminant removal.

Water Treatment. Contaminated water, including decontamination fluid, collected storm water, groundwater, and condensate from the off-gas treatment system, shall be treated prior to discharge. Where these waters meet the acceptance criteria for on-site treatment facilities at PGDP, treatment is expected to occur onsite with discharge through permitted outfalls. Where these waters do not meet on-site acceptance criteria or result of exceedance of on-site treatment capacity, they shall be shipped to an appropriate off-site wastewater treatment facility for treatment and subsequent discharge. Shipment to any off-site facility shall be conducted in accordance with the approval requirements of 40 CFR 300.440 *et seq.* (CERCLA Offsite Rule).

Waste Management. All primary wastes (i.e., contaminated soils and groundwater) and secondary wastes (i.e., contaminated personal protective equipment, treatment residuals, decontamination wastewaters) generated during remedial activities will be appropriately characterized either as RCRA wastes (solid or hazardous), PCB waste, radioactive waste(s), and/or mixed wastes and, respectively, managed in accordance with appropriate RCRA, TSCA, or DOE Order/Manual requirements. Wastes managed within a CERCLA unit or AOC must comply with the aforementioned ARARs. When wastes are transferred outside a CERCLA unit or AOC, waste management must be conducted in direct compliance with all applicable laws and regulations, rather than ARARs. As mentioned above for water treatment, shipment of CERCLA wastes to any off-site facility shall be conducted in accordance with the approval requirements of 40 CFR 300.440 *et seq.* (CERCLA Off-site Rule).

Transportation. Any remediation wastes that are transferred offsite or transported in commerce along public rights of way must meet all requirements found in the federal and Commonwealth of Kentucky transportation laws and regulations. Such transportation is conducted outside of the CERCLA unit or AOC and, therefore, not ARARs; consequently these requirements are not included with the action-specific ARARs listed in Table B.3. These transportation requirements include provisions for proper packaging, labeling, marking, manifesting, recordkeeping, licensing, and placarding that must be fully complied with for shipment. Prior to shipment of CERCLA wastes to any off-site facility, DOE must ensure the acceptability of receiving site under the CERCLA Off-site Rule (40 CFR 300.440 *et seq.*).

Table B.1. Summary of Chemical-Specific ARARs for Primary Source Area – Direct Heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
National Primary Drinking Water Standards	40 *CFR* 141	Provides chemical-specific numeric standards for toxic pollutants expressed as MCLs and MCLGs.	These requirements are relevant and appropriate due to the nature of the contaminants found within the groundwater.
National Secondary Drinking Water Standards	40 *CFR* 143	Provides secondary MCLs for public water systems.	These requirements are TBCs, as they have been established as guidelines for the states and are not federally enforceable.
Kentucky Surface Standards including • Warm Water Aquatic Habitat Criteria • Kentucky Domestic Water Supply • Kentucky General Standards • Kentucky Outstanding State Resource Waters	401 KAR 5:031 and 5:026	Provides chemical-specific numeric standards for pollutants discharged or found in surface waters. Provides chemical-specific numeric standards for pollutants in domestic water supplies.	These standards are applicable to the segment of the Ohio River into which the Little Bayou Creek discharges. The requirements found in these standards are applicable due to the groundwater to surface water interface to Little Bayou Creek and subsequently to the Ohio River. Note: CWA Water Quality Criteria are not relevant and appropriate because Kentucky has promulgated these state standards determined to be appropriate for Kentucky waters.
Radiation Exposure of the General Public at DOE Facilities	DOE Order 5400.5	Specifies that the general public must not received an effective dose equivalent of >100 mrem/year from all exposure pathways. In addition, all releases of radioactive materials resulting in doses to the general public must meet the ALARA criteria.	This requirement is TBC information.
Decommissioning Standards at Nuclear Facilities	10 *CFR* 20, Subpart E	Specifies a residual activity at nuclear facilities for unrestricted release of 25 mrem/year.	These standards are considered to be applicable to the GWOU.
Environmental Radiation Protection Standards for Nuclear Power Operations	40 *CFR* 190, Subpart B	Requires that the annual dose equivalent to the public must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and radiation from these operations.	These standards are considered to be relevant and appropriate and are equivalent to the NRC standards.

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
CWA = Clean Water Act
DOE = U.S. Department of Energy
GWOU = Groundwater Operable Unit
KAR = Kentucky Administrative Regulation
MCL = maximum contaminant level
MCLG = maximum containment level goal
NRC = Nuclear Regulatory Commission
TBC = to be considered

Table B.2. Summary of Location-Specific ARARs for Primary Source Area – Direct Heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Protection of Wetlands	10 *CFR* Section 1022 Executive Order 11990 40 *CFR* 230.10 33 *CFR* 330.5	Activities must avoid or minimize impacts to wetlands to preserve and enhance their natural and beneficial value. If wetland resources are not avoided, measures must be taken to address ecologically sensitive areas and mitigate adverse effects. Such measures may include, minimum grading requirements, runoff controls, design and construction considerations. Allows minor discharges of dredge and fill material or other minor activities for which there is no practicable alternative provided that the pertinent requirements of the NWP system are met.	These requirements are applicable due to the presence of wetlands but will be met through avoidance of wetlands during construction and implementation of alternatives.
Endangered Species Act	16 U.S.C. 1531 et seq. Section 7(a)(2)	Actions that jeopardize the existence of listed species or result in the destruction of adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat-applicable.
Migratory Bird Treaty Act	16 U.S.C. 703-711 Executive Order 13186	Federal Agencies are encouraged (until requirements are established under a formal MOU) to do the following: • avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions; • restore and enhance the habitats of migratory birds, as practicable; • prevent or abate the pollution or detrimental alteration of the environment for the benefit of migratory birds, as practicable; • ensure that environmental analysis of federal actions required by the NEPA or other established environmental review processes evaluate the effects of actions and agency plans of migratory birds, with emphasis on species of concern; and • identify where unintentional take will likely result from agency actions and develop standards and/or practices to minimize such unintentional take.	Action that is likely to impact migratory birds, habitats, and resources-applicable.

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
MOU = Memorandum of Understanding
NEPA = National Environmental Policy Act
NWP = Nationwide Permit

Table B.3. Summary of Action-Specific ARARs for Primary Source Area – Direct Heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Fugitive Dust Emissions during site preparation and construction activities.	401 KAR 63:010	Precautions must be taken to prevent particulate matter from becoming airborne. Such precautions must be incorporated into the planning and design of activities and include actions such as • wetting or adding chemicals to control dust from construction activities; • using materials such as asphalt or concrete (or other suitable chemicals/fixing agents) on roads or material stockpiles to prevent fugitive emissions; and • using covers on trucks when transporting materials to and from the construction site(s). The requirement specifies that for on-site construction activities, no visible emissions may occur at the PGDP fenceline. Similar points of compliance shall be identified for construction activities that occur outside the fence.	These requirements are applicable and will be met through the use of appropriate dust control practices identified during alternative design phase.
Toxic Emissions	401 KAR 63:022	The regulations require that a determination of toxic emissions be made in order to assess the applicability of required controls. Calculations of the significant emission levels are compared to the allowable emission limits specified in Appendix A of 401 KAR 63:022. If emission levels are exceeded, the best available control technologies must be incorporated into equipment/process design.	These requirements are considered to be applicable and shall be complied with through calculation of significant emission levels for toxic materials and application of the best available control technology, as necessary, during the design of the alternative.
Monitoring Well Installation	401 KAR 6:310	Monitoring wells (including extraction wells) must be constructed in a manner to maintain existing protection against the introduction of pollutants into aquifers and to prevent the entry of pollutants through the borehole. In addition, abandoned wells must be plugged and abandoned in accordance with the requirements specified.	These requirements are considered to be applicable. Compliance with well design and protection standards shall be achieved through the use of approved well design and materials of construction. While in service, wells shall be secured as required. Abandoned wells shall be plugged and abandoned as required.

Table B.3. (continued)

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Discharge of Stormwater and Treated Groundwater	40 *CFR* 122 401 KAR 5:055	Stormwater discharges from construction activities on-site are subject to the requirements of the KPDES permit. This requires the BMPs to control stormwater runoff and sedimentation be employed. Although off-plant construction activities within the contaminated area are not subject to the permit, these requirements should be considered relevant and appropriate and be incorporated into any off-site construction activities. Discharge of treated groundwater will be conducted in compliance with the substantive requirements of the KPDES program and the CWA.	These requirements are considered applicable for all on-site construction or treatment activities where a discharge of stormwater or treated groundwater occurs. For off-site construction activities, these requirements are considered relevant and appropriate and will be adhered to. Compliance with these ARARs shall be achieved by application of required controls during the design phase of the alternative.
Hazardous Waste Management	40 *CFR* 260 through 264 and 268 401 KAR 31 through 34, 36 and 37	All wastes or environmental media containing wastes must be characterized to determine whether the waste also is a hazardous waste in accordance with 40 *CFR* 262.11 and 401 KAR 32:010. If it is determined that a waste is a hazardous waste or that environmental media contain a hazardous waste subject to the RCRA regulation, the substantive requirements of 40 *CFR* 262 through 268 are applicable. These standards include design and operation of storage and accumulation areas, waste handling and shipment, and treatment technologies or numeric standards applicable to wastes prior to disposal.	These requirements are applicable and will be complied with through characterization of wastes and environmental media generated as a result of implementation of the alternative. Waste management will be predicated upon the characterization and will comply with all substantive requirements associated with hazardous waste management, if identified as such.
PCB Waste Management	40 *CFR* 761	TSCA requirements for the management of PCB wastes or items containing >50 ppm PCBs or from a source of 50 ppm or greater. Requirements include the following: • management of waste and material; • characterization of PCB-containing materials; • labeling and storage for disposal; • manifest completion for shipment off-site; • decontamination of affected equipment or items; and • disposal of PCB wastes. These requirements will be complied with in the event that PCBs are found at concentrations requiring compliance with this part.	These requirements are applicable if PCBs are found or result from items or equipment regulated under 40 *CFR* 761. Activities necessary to comply with these ARARs shall be incorporated into the planning phase of the alternative implementation.

ARAR = applicable or relevant and appropriate requirement
BMP = best management practice
CFR = *Code of Federal Regulations*
CWA = Clean Water Act
KAR = Kentucky Administrative Regulation
KPDES = Kentucky Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
PGDP = Paducah Gaseous Diffusion Plant
RCRA = Resource Conservation and Recovery Act
TSCA = Toxic Substances Control Act

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