Department of Energy

Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513
(859) 219-4000

AUG 20 2009

PPPO-03-365-09

Ms. Maria Galanti
Ohio Environmental Protection Agency
Southeast District Office
2195 Front Street
Logan, Ohio 43138

Mr. Mike Savage
Chief, Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
50 West Town Street, Suite 700
Columbus, Ohio 43215

Dear Ms. Galanti and Mr. Savage:

WORK PLAN FOR THE X-701B SOLID WASTE MANAGEMENT UNIT

Enclosed is the Department of Energy's *Interim Action Work Plan for the X-701B Solid Waste Management Unit Source Area Interim Remedial Measure – Oxidant Mixing at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*. The document is being transmitted to the Ohio Environmental Protection Agency for review and approval.

If you have questions or want to discuss the document, please contact Melda Rafferty of my staff at (740) 897-5521.

Sincerely,

William E. Murphie
Manager
Portsmouth/Paducah Project Office

Enclosure:
Work Plan for the X-701B Solid Waste Management Unit

cc w/enclosure:
T. Fischer, USEPA Region V
Administrative Records
PPPO Records/LEX

cc w/o enclosure:
W. Franz, LPP/PORTS

DOE/PPPO/03-0097&D3

Interim Action Work Plan for the X-701B Solid Waste Management Unit Source Area Interim Remedial Measure – Oxidant Mixing at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

This document is approved for public release per review by:

Henry H. Thomas	August 4, 3008
PORTS Classification/Information Office	Date

DOE/PPPO/03-0097&D3

Interim Action Work Plan for the X-701B Solid Waste Management Unit Source Area Interim Remedial Measure – Oxidant Mixing at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Date Issued—August 2009

Prepared by
LATA/PARALLAX PORTSMOUTH, LLC
managing the
Environmental Remediation Activities at the
Portsmouth Gaseous Diffusion Plant

for the
U.S. DEPARTMENT OF ENERGY
Portsmouth/Paducah Project Office

CONTENTS

APPENDICES iv
FIGURES iv
TABLES iv
ACRONYMS v

1. EXECUTIVE SUMMARY 1
2. INTRODUCTION 2
3. ORGANIZATION 2
4. REMEDIATION APPROACH 3
4.1 REMEDIAL ACTION OBJECTIVES 3
4.2 TECHNOLOGY OVERVIEW 4
4.3 SOURCE AREA REMEDIATION APPROACH OVERVIEW 7
4.3.1 Installation and Remediation of the Initial Six Cells 12
4.3.2 Balance of Source Area Remediation 13
4.3.3 Initial Cell Construction (Cell #1) 13
5. REMEDIAL DESIGN 15
5.1 EXCAVATION AND TREATMENT OF SOILS 15
5.2 STORM WATER CONTROLS 16
5.3 GROUNDWATER CONTROLS 16
5.3.1 Groundwater Modeling 16
5.3.2 Dewatering Plan 17
5.3.3 Treatment 19
5.4 WELL ABANDONMENT 19
5.4.1 Berea Sandstone Monitoring Wells 20
5.4.2 IGWMP Gallia Aquifer Monitoring Wells 20
5.4.3 Non-IGWMP Gallia Aquifer Monitoring Wells 20
5.5 MINFORD SILT MONITORING WELLS 21
5.5.1 Gallia Aquifer Extraction/Recovery Wells 21
5.6 AIR CONTROLS 23
5.6.1 Air Modeling 23
5.6.2 Best Management Practices 24
5.7 SOIL TREATMENT 25
5.7.1 Technology Overview 25
5.7.2 Total Oxidant Demand 27
5.7.3 Delivery Methodology 28
5.7.4 Construction of High Permeability Layer 28
5.7.5 Site Restoration 28
6. MONITORING 29
6.1 SOURCE AREA MONITORING 29
6.1.1 Sampling of First Six Cells 29
6.1.2 Sampling for the Balance of Source Area Remediation 31
6.2 DOWNGRADIENT MONITORING 32
6.2.1 Downgradient Groundwater Monitoring 32
6.2.2 Downgradient Air Monitoring 33

6.3 SAMPLE MANAGEMENT 33
7. SCHEDULE AND MILESTONES 34
7.1 INVESTIGATION SCHEDULE 34
7.2 INVESTIGATION MILESTONES 34
8. WASTE MANAGEMENT 35
8.1 LIQUID WASTE 35
8.2 SOLID WASTE 35
8.3 WASTE SAMPLING 36
8.4 SPECIAL WASTE STREAMS 36
8.4.1 DNAPL Remediation / Settled Solids 36
8.4.2 Radiological Contamination Remediation 36
8.4.3 Metals Remediation 36
8.5 ESTIMATED WASTE VOLUMES 37
9. ENVIRONMENT, HEALTH, AND SAFETY 38
9.1 ENVIRONMENT SAFETY AND HEALTH 38
10. QUALITY ASSURANCE 39
10.1 PROJECT MANAGEMENT 39
10.2 PROCEDURES 39
10.3 QA/QC MEASURES 39

APPENDICES

A. Summary of Historic Soil Sampling Data
B. Sampling and Analysis Plan Summary for Remedial Design
C. Interim Remedial Measure Design
D. Groundwater Calculations
E. Shoring Design
F. Potential Alternative Oxidant, Hydrogen Peroxide

FIGURES

Figure 1 - X-701B Plume
Figure 2 - X-701B Source Area –TCE in the 0'-1' Horizon
Figure 3 - X-701B Excavation / Remediation Profile
Figure 4 - Typical Soil Mixing Curve
Figure 5 - X-701B Well Abandonment
Figure 6 - X-701B Project Schedule

TABLES

Table 1 - X-701B Dewatering Design Parameters
Table 2 - Calculated Contaminant Oxidant Demand
Table 3 - Source Area Soil Sampling for the First Six Cells
Table 4 - Source Area Wells for Groundwater Sampling
Table 5 - Groundwater Analytical Parameters
Table 6 - Downgradient IGWMP Wells with Quarterly Sampling
Table 7- X-701B Estimated Waste Volumes

ACRONYMS

bgs	below ground surface
BMP	Best Management Practices
BZ	Breathing Zone
CHP	Catalyzed Hydrogen Peroxide
COCs	Chemicals of Concern
CSP	Catalyzed Sodium Persulfate
DNAPL	Dense Non-aqueous Phase Liquid
DOE	U.S. Department of Energy
DPT	Direct Push Technology
ES&H	Environmental Health and Safety
EW, RW	Extraction / Recovery Wells
gpm	gallon per minute
GTF	Groundwater Treatment Facility
HAP	Hazardous Air Pollutant
IGWMP	Integrated Groundwater Monitoring Plan
IAWP	Interim Action Work Plan
IRM	Interim Remedial Measure
ISCO	In-Situ Chemical Oxidation
ISMS	Integrated Safety Management System
MAGLC	Maximum Allowable Ground Level Concentrations
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
psig	pounds per square inch gauge
PEMS	Project Environmental Measurements System
PID	Photo Ionization Detectors
PORTS	Portsmouth Gaseous Diffusion Plant
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RAOs	Remedial Action Objectives
SME	Subject Matter Expert
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TOD	Total Oxidant Demand
µg/kg	micrograms per kilogram
USEC	United States Enrichment Corporation
USQD	Unreviewed Safety Question Determination
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria

1. EXECUTIVE SUMMARY

The X-701B Plume encompasses approximately 20 acres, extending eastward for approximately 1,800 feet from the X-701B Pond area (within the limited access security fence) to Fog Road (see Fig. 1). The focus of the selected Interim Remedial Measure (IRM) is in the western portion of the plume where the ongoing "source area" for TCE is located.

Utilizing excavation and direct mixing of oxidant with contaminated soils, the proposed IRM is designed to supplement the oxidant injection events previously completed under the *Ohio EPA Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA 2003*. Independent review of post-injection monitoring data by Ohio EPA and U.S. Department of Energy (DOE) revealed that the injections, although moderately successful in upper soil horizons, were ineffective in addressing trichloroethylene (TCE) contamination in the Lower Gallia formation and weathered surface of the underlying Sunbury Shale. Further injection events were halted in February, 2009 by agreement between DOE and Ohio EPA.

This IRM involves the physical mixing of oxidants directly into the saturated horizon of the overlying Minford formation, the water-bearing Gallia formation, and the highly contaminated weathered Sunbury shale formation that is in contact with the water-bearing Gallia formation. The oxidant(s) react with the organic contaminants, producing innocuous substances such as carbon dioxide, water, and in the case of chlorinated organic compounds, inorganic chloride.

DOE's objective is to facilitate and accelerate cleanup of TCE groundwater contamination within the X-701B Plume through:

- excavation of TCE-contaminated soils within the source area;
- physical blending of TCE-contaminated soils with oxidant at ratios determined through bench scale studies;
- placement of the amended soils back into the excavation; and
- off-site treatment and disposal of limited quantities of highly contaminated soils and liquid DNAPL that cannot be cost-effectively treated through oxidant blending.

Source area remediation will be conducted sequentially from west to east (upgradient to downgradient) in a series of individual cells. The approach is one of action, evaluation, and modification (as necessary) to achieve the overall goals of the remedy. DOE will provide Ohio EPA with regular updates on cleanup progress through informal briefings.

DOE will provide the data collected from the first six cells to Ohio EPA. DOE and Ohio EPA will meet and jointly evaluate the data to determine the effectiveness of the project and the path forward for the remaining cell treatments. Based upon performance evaluation of the initial six cells, DOE may refine implementation techniques for oxidant mixing, dewatering, shoring installation and other physical activities to enhance the effectiveness of the remainder of the project. Refinements will be processed as field changes, with concurrence by Ohio EPA.

Completion of the X-701B Oxidant Mixing IRM is defined as:

Remediation of TCE contaminated soils underlying a 70,000 square foot "source area" generally defined in the Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA, December 2003 through direct mix oxidant blending in accordance with mixing rates and methods specified in this Ohio EPA approved Interim Remedial Measure Work Plan.

2. INTRODUCTION

The IRM presented in this Interim Action Work Plan (Work Plan) is submitted in accordance with the Ohio Environmental Protection Agency (Ohio EPA) Consent Decree, Article X, Additional Work, and the May 28, 2009 Ohio EPA approval letter for the X-701B Interim Remedial Action.

Utilizing excavation and direct mixing of oxidant with contaminated soils, the proposed IRM is designed to supplement the oxidant injection events previously completed under the *Ohio EPA Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA 2003*. Independent review of post-injection monitoring data by Ohio EPA and U.S. Department of Energy (DOE) revealed that the injections, although moderately successful in upper soil horizons, were ineffective in addressing trichloroethylene (TCE) contamination in the Lower Gallia formation and weathered surface of the underlying Sunbury Shale. Further injection events were halted in February, 2009 by agreement between DOE and Ohio EPA.

The IRM defined in this Work Plan is designed to accelerate remediation of the X-701B Groundwater Plume by exposing contaminated soils within the source area and physically blending the soils with oxidant. Direct mixing of oxidant with source area contamination will greatly diminish ongoing TCE contribution to the groundwater plume and significantly reduce the duration of pump and treat system operation.

3. ORGANIZATION

DOE is responsible for Environmental Restoration, Waste Management, and Uranium Programs at the Portsmouth Gaseous Diffusion Plant (PORTS). The goal of the Environmental Restoration Program is to investigate releases from past operations and waste management activities, and to undertake cleanup actions as appropriate, to protect human health and the environment.

In implementing this IRM for the X-701B Groundwater Plume, the investigation and cleanup actions include:

Providing design specifications, remedial engineering, construction, operations, monitoring, and maintenance of the proposed remediation systems.

Providing oversight of field activities during remediation to assure project requirements are met.

Monitoring system performance and optimizing the progress of the remedy.

Tracking the overall progress of the remedy.

4. REMEDIATION APPROACH

4.1 REMEDIAL ACTION OBJECTIVES

The *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA*, *December, 2003,* established the following remedial action objectives (RAOs) for the groundwater remedy.

- Achieve Preliminary Remediation Goals (PRGs) for groundwater when practicable.
- Prevent migration of chemicals of concern (COCs) at concentrations exceeding PRGs from groundwater into surface water.
- Prevent exposure of future off-site residents to COCs in groundwater at concentrations exceeding residential PRGs through potential exposure pathways.
- Prevent exposure of on-site personnel to COCs in groundwater at concentrations exceeding future on-site worker PRGs through potential exposure pathways.

For this project, DOE is not required to meet PRGs.

RAO #1 will be achieved to the extent practicable through the implementation of the Ohio EPA selected remedy for X-701B groundwater, in situ chemical oxidation (ISCO), in accordance with this Work Plan. Although previous oxidant injection based actions have achieved some success in lowering TCE concentrations within source area soils, the oxidant has not demonstrated progress toward achieving groundwater PRGs. This Work Plan presents an aggressive approach to remediation of the X-701B Source Area, located in the western portion of the plume, which will facilitate attainment of the groundwater RAOs through excavation and direct-mix oxidant blending with the highly contaminated source area soils.

RAOs #2 and #3 will be achieved through the continued operation of the X-237 Groundwater Collection System. The IRM presented in this Work Plan requires extraction wells X623-EW02 and X623-EW03 to be removed since the wells are located in the area to be excavated. Because extraction well X623-EW03 is located within the excavation support area and is of limited value, it will also be removed. Replacement/relocation of these wells will be evaluated in consultation with Ohio EPA upon completion of the IRM. Ohio EPA approval of well replacement and/or relocation will be required.

RAO #4 will be achieved through the continued application of administrative controls to protect current and future on-site workers until PRGs are achieved.

The IRM presented in this work plan utilizes oxidant technology, as selected in the *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA, December, 2003*; however it incorporates different oxidants and an improved oxidant delivery system that will:

- Aggressively remediate TCE source elements within the defined source area, and significantly reduce environmental risks and the overall life cycle cost for cleanup of the X-701B Groundwater Plume.
- Significantly reduce the planned cost for the remedy by minimizing waste generation, transportation, and disposal costs.
- Directly mix oxidant into the contaminated media without relying on a recirculation system or oxidant injection for delivery into the non-homogenous subsurface.
- Expose and directly treat the highly contaminated weathered Sunbury shale that slowly but continuously contributes TCE to groundwater through cross media transfer.

The X-701B Plume encompasses approximately 20 acres, extending eastward for approximately 1,800 feet, from the X-701B Pond area (within the limited access security fence) to Fog Road (see Fig. 1). The focus of the selected IRM is in the western portion of the plume where the ongoing "source area" for TCE is located. This source area is bounded by the security fence to the east and approximately by Brown Avenue to the west and is generally defined in the *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA, December, 2003* (see Fig. 2). The downgradient portion of the plume is located east of the limited access security fence. Refer to Figure 2 and Appendix A for a summary of historic soil sampling data.

DOE will make minor field changes to this Work Plan, as necessary, to proceed with the cleanup in an efficient and effective manner. Ohio EPA will receive notification of these minor changes during the course of project execution, which will be documented by either email or written correspondence to Ohio EPA. DOE will consider all significant changes made during the course of project execution to be "changed field conditions," which require revision of work control documents and approval by Ohio EPA in accordance with the previously approved field change process. All changes, whether minor or significant, will be documented in the X-701B final report that will be submitted to Ohio EPA after completion of the project.

4.2 TECHNOLOGY OVERVIEW

The IRM involves the physical mixing of oxidants directly into the saturated horizon of the overlying Minford formation, the water-bearing Gallia formation, and the highly contaminated weathered Sunbury shale formation that is in contact with the water-bearing Gallia formation. The oxidant(s) react with the organic contaminants, producing innocuous substances such as carbon dioxide, water, and in the case of chlorinated organic compounds, inorganic chloride.

There are two main advantages of using ISCO instead of other conventional treatment technologies. First, because the contaminant is destroyed within the source area subsurface, the volume of waste material generated will be very small relative to the benefit achieved. Second, the treatment can be implemented over a much shorter time frame compared to other treatment technologies. These advantages save materials, monitoring, and maintenance. The success of ISCO treatment depends on achieving adequate contact between the oxidant(s) and contaminants by using an effective delivery system. Direct mixing of contaminated media under planned and controlled conditions accomplishes the highest possible level of effectiveness.

It is important to consider the natural oxidant demand (the consumption of oxidant due to reactions unrelated to contaminant destruction) of an aquifer when designing and implementing ISCO. Oxidants are non-selective and will react with other constituents in the aquifer. Oxidant demand can be exerted by the soil matrix (i.e., the organic soil components of soil) and inorganic constituents such as total inorganic carbon. Sufficient oxidant must be added to satisfy the natural oxidant demand as well as destroy the target contaminants.

To establish total oxidant demand (TOD) for the various soil horizons and contaminant levels within and adjacent to X-701B Source Area, DOE performed sampling at 90 locations to augment existing data for use in remedial design of this IRM.

Figure 1 – X-701B Plume

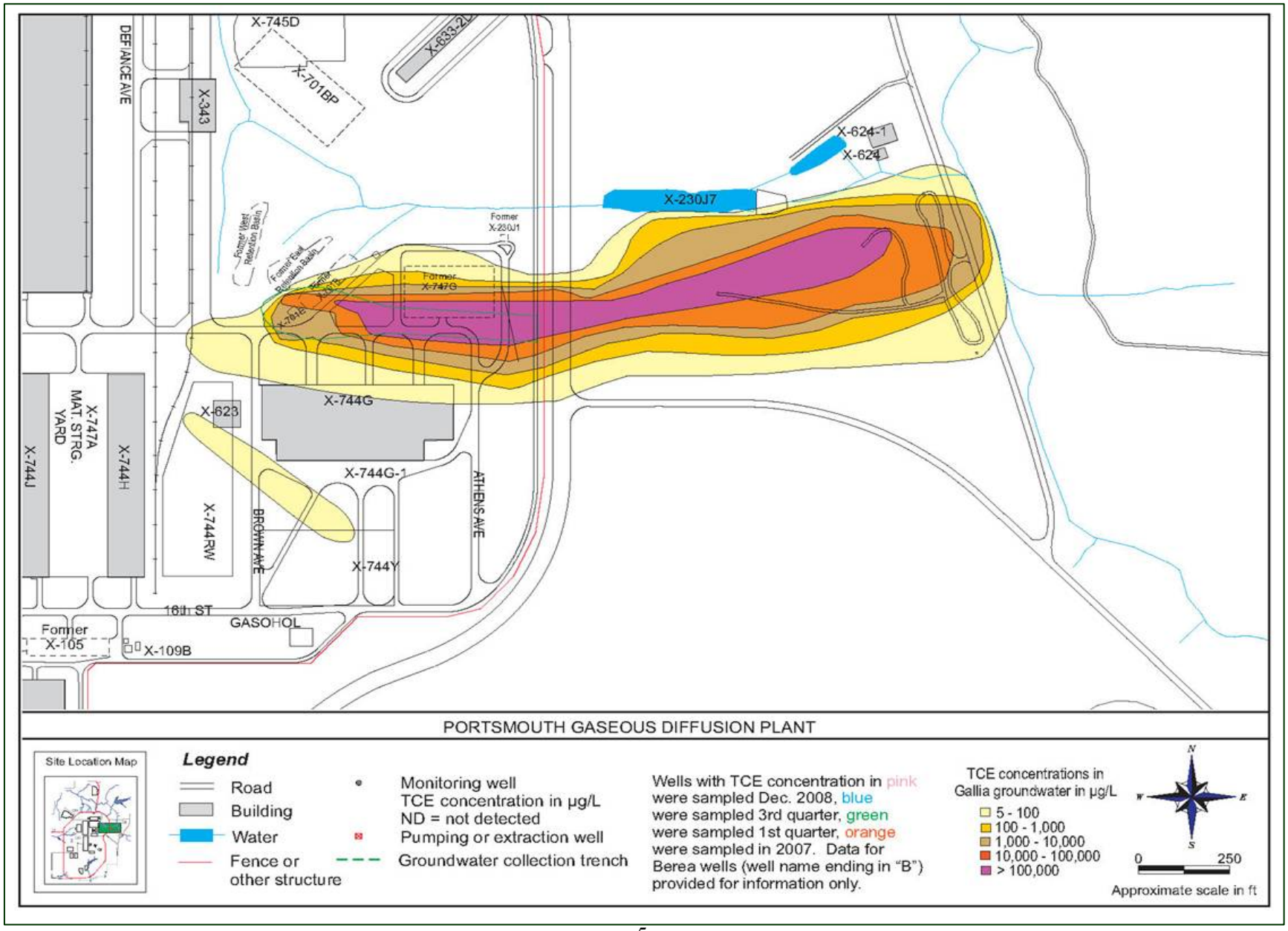
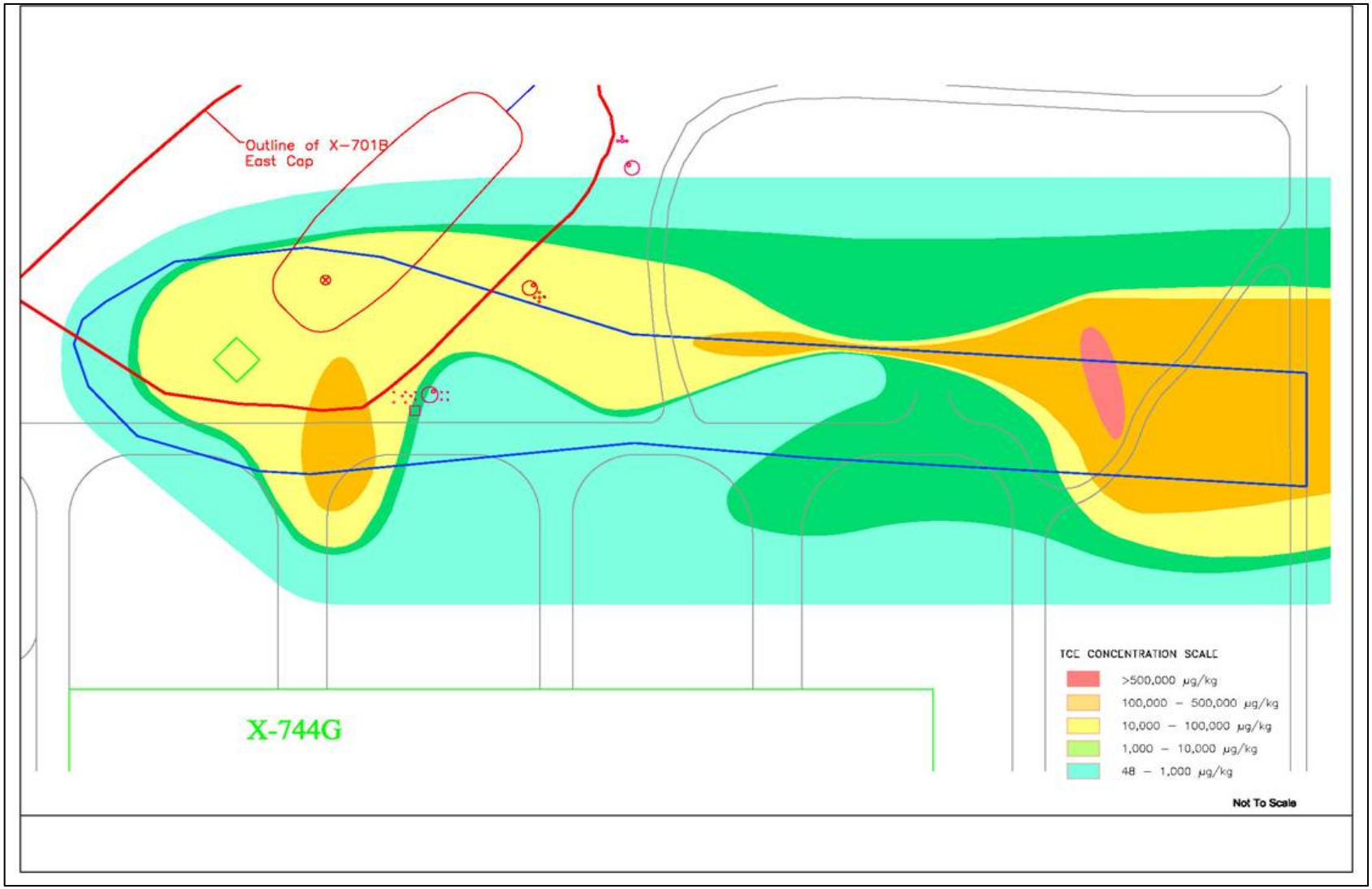


Figure 2 - X-701B Source Area – TCE in the 0'-1' Horizon



Data collected during this sampling program effort is used to:

- establish appropriate oxidant(s) for treatment;
- establish soils targeted for treatment;
- establish soils targeted for removal (if any);
- establish oxidant demand for organic contaminants within the treatment area;
- establish oxidant demand for naturally occurring organic material within the treatment area; and,
- refine site's understanding of the stratigraphy of the source area to permit targeted oxidant blending, and to more clearly define the depth to the Gallia water bearing formation, and anticipated depth to the highly contaminated weathered Sunbury shale.

Utilizing contaminant samples collected during the sampling and analysis, DOE is performing bench scale studies to establish TOD for the range of TCE concentrations and various soil matrix combinations within the X-701B Source Area. DOE is also utilizing the bench scale studies to evaluate the effectiveness of alternative oxidants (persulfate, permanganate, peroxide). Preliminary sample results suggest a TOD of 15g/kg for the Minford and Upper Gallia formations and in excess of 20 g/kg for the Lower Gallia and Weather Sunbury shale. These results suggest an oxidant addition of 2 – 4 times higher than recommended by the *Independent Review of the X-701B Groundwater Remedy, SRNL, 2009*. Final sample results will be provided to EPA and incorporated into Appendix B upon receipt and used as the basis for the oxidant mix design in each cell.

Based on prior investigations of the source area, chlorinated solvents exist in the subsurface in multiple phases: dense non-aqueous phase liquid (DNAPL), vapor, dissolved, and adsorbed. The DNAPL can be present in droplets within the pore space, or it can completely fill the pore space, forming a pool. During treatment with oxidant, the destruction of contaminants occurs principally in the dissolved phase. However, some oxidants can accelerate the dissolution of organic solvents from both aquifer solids and DNAPL. In addition, contaminants bound to organic soil matter are usually liberated when the oxidant reacts with the organic matter. Because of these factors, direct mixing of oxidant can initially result in increases in groundwater concentrations if the subsurface has significant DNAPL and/or adsorbed phase contaminant mass. However, this is the result of reductions in DNAPL and/or adsorbed phase mass, and is an indication of successful progress for the remediation.

4.3 SOURCE AREA REMEDIATION APPROACH OVERVIEW

The project will be undertaken as a Resource Conservation and Recovery Act (RCRA) Interim Action within the regulatory framework of Ohio EPA's *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, December 2003*. DOE's objective is to facilitate and accelerate cleanup of TCE groundwater contamination within the X-701B Plume through:

- excavation of TCE-contaminated soils within the source area;
- physical blending of TCE-contaminated soils with oxidant at ratios determined through bench scale studies;
- placement of the amended soils back into the excavation; and
- off-site treatment and disposal of limited quantities of highly contaminated soils and liquid DNAPL that cannot be cost-effectively treated through oxidant blending.

Source area remediation will be conducted sequentially from west to east (upgradient to downgradient). The approach is one of action, evaluation, and modification (as necessary) to achieve the overall goals of the remedy. DOE will provide Ohio EPA with regular updates on cleanup progress through informal briefings.

DOE will provide the data collected from the first six cells to Ohio EPA. DOE and Ohio EPA will meet and jointly evaluate the data to determine the effectiveness of the project and the path forward for the remaining cell treatments. Based on a performance evaluation of the initial six cells, DOE may refine implementation techniques for oxidant mixing, dewatering, shoring installation, and other physical activities to enhance the effectiveness of the remainder of the project. Refinements will be processed as field changes, with concurrence by Ohio EPA.

Completion of this X-701B Oxidant Mixing IRM is defined as:

Remediation of TCE contaminated soils underlying a 70,000 square foot “source area” generally defined in the Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA, December 2003 through direct mix oxidant blending in accordance with mixing rates and methods specified in this Ohio EPA approved Interim Remedial Measure Work Plan.

Figure 3 presents a typical profile of the X-701B Source Area and identifies the planned remediation approach for each horizon.

Figure 3 - X-701B Excavation / Remediation Profile

Approx. Depth bgs (ft)		Planned Interim Action	Estimated Volume (cubic feet)
1 2 3 4 5 6 7 8 9 10	**Top 10 Feet of Minford Silt & Clay Formation - Non-Contaminated**	Perform sampling to confirm meets PRGs for TCE. Remove metals and radiological "hot spots" as identified through sampling and walkover surveys. Excavate, stockpile, and reuse as backfill within the X-701B "source area".	700,000
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29	**Approx. Depth to Saturation Zone - 12'** **Lower 15 Feet of Minford Silt & Clay Formation - Contaminated** **Gallia Aquifer Formation - Contaminated** **High permiability layer to be installed during backfill. Elevation approximate pending design.**	Perform sampling to determine total oxidant demand and characterizes for metals and radiological contamination. Excavate, physically mix with oxidant for treatment and replace at comperable depth within the X-701B "source area". Conceptual design of the backfill includes installation of a gravel layer (non-limestone) within the Gallia horizon to facilitate future flushing of the source zone.	1,330,000
30 31	**Weathered Top of Sunbury Shale - Contaminated Target Zone**	Perform sampling to determine total oxidant demand and identify potential DNAPL locations. Remove identified pooled DNAPL for on-site oxidant treatment or off-site treatment and disposal. Physically mix oxidant with weathered Sunbury shale and approximately 1-2 feet of the Lower Gallia that overlies the weathered Sunbury Shale in the bottom of the excavation.	140,000

Note: "Hotspot" criteria are defined in Section 4 based upon the Geoprobe sampling and analysis program and walkover survey results.

As discussed further in Section 4, DOE has developed a groundwater model specific to X-701B. The model establishes dewatering requirements during excavation, aids in the selection of post excavation backfill design, and quantifies groundwater benefits from the project. Concurrently, DOE has developed an air model for the project to assess cross media transfer of TCE during excavation and oxidant mixing operations and to aid in the evaluation of Best Management Practices (BMP). Utilizing initial model results, DOE has integrated engineering controls and BMP into this work plan. These controls may be modified based upon ongoing sampling and analysis activities throughout implementation of the project. Modifications will be incorporated through the approved field change process.

DOE will perform the following: mobilization and site preparation actions upon completion of sampling, analysis, modeling, and planning activities:

- mobilization and staging of equipment, materials, and temporary facilities;
- installation of berms, silt fencing and other erosion controls consistent with "BMP";
- relocation of 18th Street to provide continued access to the north porch of X-744G;
- relocation of the existing DNAPL separator, located in the X-701E Neutralization Building;
- installation of frac tanks to serve as surge tanks for the dewatering of excavations;
- installation of temporary piping systems from the frac tanks to the existing X-623 Groundwater Treatment Facility;
- relocation and replacement of the existing sump and piping within the X-701B basin, allowing the basin to continue to be used for storm water control;
- capping of the former X-701B Pond influent lines at the perimeter of the work area and visual inspection of exposed line sections for signs of historic leakage;
- installation of piping from the relocated X-701B sump to the X-623 Groundwater Treatment Facility;
- preparation of temporary soil storage areas for the initial excavations;
- installation of temporary roadways for work area access;
- installation of work area boundaries and signage in compliance with the Health and Safety Plan and Radiation Protection Plan;
- closure of selected extraction and monitoring wells;
- installation of site office and break trailers and associated utilities connections; and
- relocation of utilities, including three (3) fire hydrants, overhead power lines, and the removal of three utility poles.

Engineering details for these site preparation activities are presented in Section 4 of this Work Plan and in the design drawings contained in Appendix C.

The initial excavations will occur in the western (upgradient) portion of the source area, near the X-701B Pond and progress eastward for a distance of approximately 700 feet, encompassing the entire "source area" as defined in the *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Ohio EPA, December 2003.*

Crews will install shoring panels to form individual excavation "cells" with nominal dimensions of 30 ft x 38 ft x 31 ft deep and 30 ft x 30 ft x 31 ft deep. Individual cell dimensions will vary somewhat with shoring system procurement, final engineering design, and configuration of the excavation area. The advantages of using shoring systems to create individual cells are as follows.

- Shoring systems eliminate the need for extensive soil layback, which in turn minimizes the volume of soil to be excavated, the excavation footprint, and utilities conflicts.
- The shoring panels reduce groundwater intrusion into the excavation and permits dewatering during excavation to be managed in discrete segments rather than on a project wide basis for the duration of the remediation.
- By creating an excavation of known dimensions, the required quantity of oxidant can be more precisely determined for each cell.
- By limiting the size of each cell, physical mixing of the oxidant will be more controlled and complete than would be possible if applied to a large area.
- Limiting the size of each cell and the number of cells open at any given time will minimize surface water management risks during precipitation events. Under the planned excavation approach, a maximum of three (3) cells will be open at a time.

As shoring is installed to form the cell, one or more well points and down-hole pumps may be installed within the cell to accomplish dewatering of the localized excavation area. Additional well points may be installed adjacent to the cell, as required by the shoring design and final dewatering design (described in Appendix C). In localized areas of the excavation, these additional well points may be used to reduce hydraulic pressure on the shoring and/or reduce nuisance water during the excavation. As excavation of each cell is nearing completion, one or more sumps may also be installed in the cell to maintain control of nuisance water at the excavation bottom.

Excavation of the upper portions of the Minford formation, above the water table, will proceed concurrently with dewatering the cell. Based on historical data, the top 10 feet of the Minford formation is considered to be non-contaminated and will be stockpiled for reuse as final backfill within each cell.

The classification of the top 10 feet of the Minford as "non-contaminated" will be verified, prior to excavation of each cell, through the results from the sampling and analysis program conducted during remedial design. Based on analytical results from the sampling and analysis program, certain soils from depths below 10 ft bgs may also be considered as non-contaminated, subject to Ohio EPA approval, using the approved field change process.

Contaminated soils from the Lower Minford and Upper and Middle Gallia formations will be excavated and directly mixed with oxidant as they are placed as backfill in an adjoining cell. The mixing implement is a hydraulic rotary tiller attachment mounted to a "long stick" tracked excavator. The attachment is specifically designed for mixing amendments into soil. The oxidant quantity and mixing duration for each soil horizon in each cell is predetermined during the bench studies and final design and incorporated into the detailed engineering design (Appendix C).

The bottom 2-3 feet of soils in each cell, comprised of the highly-contaminated Lower Gallia formation and weathered Sunbury shale, will be directly mixed with oxidant within the bottom of the excavation. Oxidant quantities and mixing durations are predetermined during bench studies and engineering design. Individual cut sheets, detailing oxidant quantities and mixing durations, for each planned excavation cell are included in detailed engineering design (Appendix C).

During backfill and blending operations, DOE will install a high permeability sand layer at the approximate elevation of the existing Gallia aquifer. This high permeability layer will further enhance the X-701B Source Area remediation by allowing continued down-gradient aquifer flushing to the east interceptor trench and X-624 Groundwater Treatment Plant. The location, thickness, and design permeability of this layer are determined through the groundwater model (Appendix D) and incorporated into engineering design (see Appendix C).

Once excavation, mixing and backfilling are completed in each cell, the well points and shoring will be removed, allowing the amended soils to re-hydrate and the oxidant to destroy the TCE. The shoring and well points will be reused to construct the next cell in the remediation sequence.

Upon completion of the interim remedial measure, disturbed areas will be graded and re-vegetated. The final grading design will not adversely impact the existing X-701B Source Area cap design.

4.3.1 Installation and Remediation of the Initial Six Cells

DOE will install the first six (6) cells to demonstrate the effectiveness of the planned excavation and soil mixing approach. DOE and Ohio EPA have established implementation criteria upon which the first six cells will be evaluated. The criteria are as follows:

- ability to maintain excavations in compliance with DOE safety requirements;
- ability of the engineered shoring system to maintain structural stability under hydraulic pressure;
- ability to effectively dewater excavation cells and manage seepage or inflow;
- ability to physically blend oxidant with soil;
- ability to collect and remove DNAPL (if encountered in the initial six cells) during excavation or to effectively treat DNAPL;
- ability to control contamination within the work area boundary as a result of soil excavation, relocation, dewatering, and modified groundwater flow; and
- ability to control TCE air emissions within regulatory limits.

The planned cell layout for the first six cells is presented in engineering design contained in Appendix C.

The first six cells will also be used to refine excavation efficiency and remediation effectiveness for subsequent Phase II activities. Considerations affecting excavation efficiency include time, energy, and costs to:

- install shoring;
- adequately dewater the cell;
- adequately blend oxidant with soil at the various soil horizons; and
- remove shoring.

Remediation effectiveness is the system's ability to reduce contaminant mass and achieve remediation goals. Due to oxidant reaction times (weeks to months) and the need to rehydrate each cell following direct mix treatment to achieve thorough oxidant blending, treated soils will not be sampled prior to backfilling. However, DOE will perform a soil and localized groundwater sampling for the first six cells in accordance with Section 5.

DOE will utilize sampling and analytical methods consistent with the Ohio EPA approved Sampling & Analysis Plan for the X-701B IRM, described previously, to determine soil remediation effectiveness. Analytical results will be evaluated against soil PRGs for TCE and compared to characterization results from the remedial design sampling program. DOE will provide the data collected from the first six cells to Ohio EPA. DOE and Ohio EPA will meet and jointly evaluate the data to determine the effectiveness of the project and the path forward for the remaining cell treatments (either stop project due to ineffectiveness or the project continues). DOE will also use the data to refine direct mix remediation techniques for the remainder of the project.

4.3.2 Balance of Source Area Remediation

The planned cell layout for the remaining cells is shown in engineering drawings contained in Appendix C. Methods of excavation, dewatering, and media treatment are as described in Section 4 and the engineering design included Appendices C and E. Variations, if any, will be based on the efficiency / effectiveness evaluation of the first six cells. Any refinements to the planned interim remedial approach will be processed as field changes to this Work Plan and approved by Ohio EPA.

4.3.3 Initial Cell Construction (Cell #1)

The remediation approach to the initial cell (cell #1) is unique in that there will not be an adjacent excavated cell in which to place and amend contaminated soils from cell #1. The top ten feet of non-contaminated Minford soils and the contaminated Minford and upper Gallia formation must be removed and temporarily relocated to permit access to the contaminated Lower Gallia and weathered Sunbury shale for oxidant mixing. The approach for this cell is described below.

After confirmation through the sampling and analysis program that the top ten feet of the Minford formation in this cell is non-contaminated, the soil will be excavated and stored in a temporary staging area located outside the source area but within the work area (see Appendix C). The top ten feet from two other cells, located in the eastern portion of the source area, also will be confirmed as non-contaminated, excavated, and staged in the temporary staging area. The excavation will be bermed to control surface water run-on and run-off and used as a test mixing area for contaminated soils from the first cell.

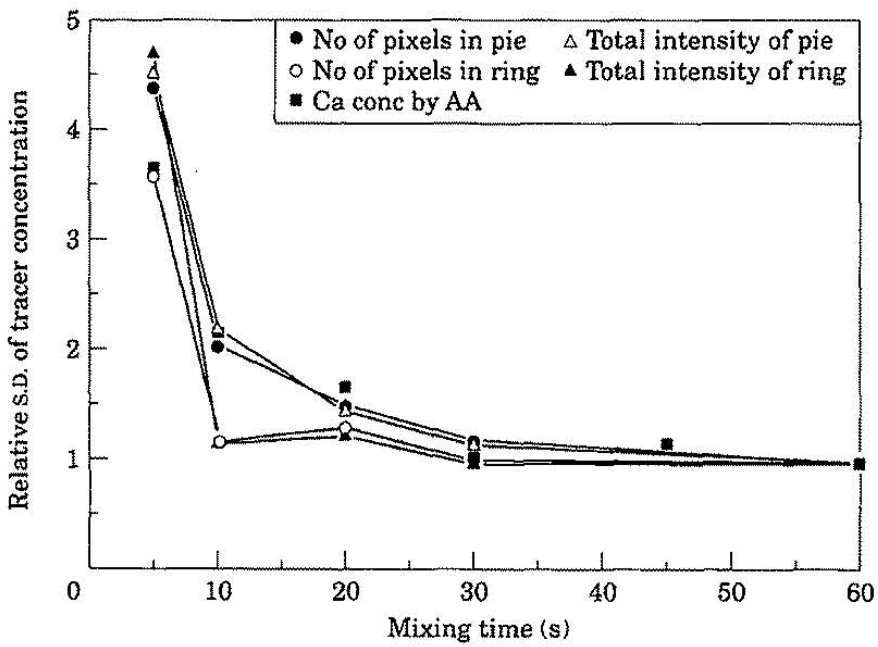
Contaminated Minford and Gallia soils excavated from cell #1 will be transported (within the source area) and placed in the test excavation in lifts consistent with the remedial design requirement. This test excavation will be used to refine the oxidant mixing technique. Each lift placed in the test excavation will be mixed with oxidant at the required ratio and physically evaluated (using “tracers” as described in subsequent paragraphs) to ensure that the mixing equipment and mixing duration result in thorough mixing of the oxidant within the lift. Differing mixing durations will be used for different lifts and soil characteristics to permit comparative evaluation. Additionally, depending upon soil moisture content, water may be added to certain lifts to determine the impact of higher moisture content on the mixing duration.

A minimum of three (3) samples will be collected from each lift to determine mixing efficiency. Physical “tracers” will be used to indicate the distribution of oxidant in the soil. Additionally, the test area will be sampled monthly for the first six (6) months of the IRM to evaluate the effectiveness of TCE removal in the Minford and Upper Gallia soils.

The lower one to two feet of the Gallia and the weathered Sunbury shale in Cell #1 will be mixed with oxidant in the bottom of Cell #1, as will be the case for all subsequent cells. A minimum of three (3) samples will be collected and physically evaluated, utilizing chemical tracers, to establish and refine the mixing technique for these soil horizons.

The approach for the determination of uniformity will be as outlined in *Evaluation of the Homogeneity of Stabilized/Solidified Wastes by a Video Imaging Technique*, (Waste Management & Research, 1995). A fluorescent tracer will be distributed on the surface of the lift in addition to the oxidant and activator. Mixing will then occur with the equipment described in Section 4 of the work plan. Over a series of discrete elapsed time mixing intervals, soil cores will be obtained over the cross-sectional area of the excavation cell to verify the horizontal and vertical uniformity of the mixing. It is anticipated that after several minutes of mixing, the tracer will be uniformly dispersed both horizontally and vertically within the lift, and a mixing time for each soil type will be established for the remainder of the IRM. A typical mixing curve from the referenced Waste Management & Research article is provided in Figure 4 for reference.

Figure 4
Typical Soil Mixing Curve



5. REMEDIAL DESIGN

This section provides the engineering basis for the design and additional detail on the implementation approach, including excavation and management of soils, storm water controls, groundwater controls, air controls, soil treatment, and the approach for backfill and site restoration. The specific engineering design is included in Appendix C (plan views, profiles, typical drawings, notes) and Appendix E (shoring design).

DOE has taken a conservative approach in the preparation of this work plan based on historical site investigations and prior process knowledge. The methodology outlined in this work plan will not change. However, upon receipt of ongoing analytical data, specific techniques may be refined for engineering controls, BMP, and oxidant mixing techniques. Any refinements to the IRM will be processed as field changes to this Work Plan and approved by Ohio EPA.

5.1 EXCAVATION AND TREATMENT OF SOILS

The design objectives for the excavation and management of soils are as follows:

- Excavated contaminated soils will remain within the defined source area.
- Excavated non-contaminated soils will remain within the project work area.
- Shoring design will accommodate the excavation.
- Dewatering prior to and during excavation will allow management of soils.
- Dewatering relief points will minimize the shoring required for the shoring design.

Appendix C identifies the excavation area, support area and facilities, and the footprint of planned excavation cells. Based upon preliminary design of the remediation, there are approximately 65 cells to be excavated. Actual cell dimensions and the resultant number of cells required are subject to revision based on field conditions as encountered. Changes to the cell design, location, and sequence, if necessitated by field conditions, will be made utilizing the approved field change process.

The general construction process is as follows:

1. Establish immediate work area boundaries and storm water controls.
2. Excavate the top 10 feet of soils and stockpile adjacent to the excavation (subject to analytical results).
3. Concurrently with Step 2, install shoring systems for the individual cell per the shoring design contained in Appendix E.
4. Install dewatering drive points, as determined by actual field conditions, to lower the free water within the excavation and maintain hydrostatic pressure relief outside the shoring as required by the Shoring Design.
5. Remove contaminated soils, in approximate lifts of two (2) feet, to the depth of the top of the higher permeable Gallia formation (approximately 28 feet bgs).
6. Place the soils, in approximate lifts of two (2) feet, in adjacent empty cell.
7. Treat each lift by thorough blending with oxidant at the prescribed oxidant ratio prior to placement of the next lift.
    - Note that for the first cell, the material will be removed and treated in a test excavation, located within the source area (Appendix C).

- Oxidant ratios will be pre-determined for each lift within each cell based upon sampling and analysis program results and bench scale studies.

8. Treat the Lower Gallia and weathered Sunbury Shale in place (approximately 28–31 feet bgs) by thorough blending with oxidant at the prescribed oxidant ratio.
9. Install a higher permeable layer, consisting of uniform coarse sand, in areas determined during remedial design to be advantageous to accelerate the long term groundwater cleanup.
10. Backfill the cell in lifts to within 8 feet of ground surface in accordance with Steps 6 and 7.
11. Backfill the remaining cell void with non-contaminated soils excavated in Step 2.
12. Concurrently with Steps 10 and 11, remove unnecessary shoring systems.

5.2 STORM WATER CONTROLS

A temporary eastern berm will be constructed to protect the excavation area from run-on and to contain potentially contaminated run-off within the work area. The berm layout design and engineering details are shown in Appendix C. In accordance with BMP, the berm design incorporates silt fencing on the outside berm perimeter and temporary seeding of the berm. The berm will be constructed of imported clean borrow material.

The overall design contains the direct precipitation and prevents runoff following a rain event. To minimize the area that requires collection of direct precipitation, the bermed area will be phased. Appendix C identifies the initial berm placement that incorporates the initial area of excavation and the temporary stockpile. The intermediate berm placement may vary in the field, but the overriding principal will be to contain water within the disturbed area and prevent runoff.

5.3 GROUNDWATER CONTROLS

In general, groundwater currently flows through the X-701B Gallia from west to east toward Little Beaver Creek where it is collected in the X-237 Interceptor Trench and treated in the X-624 Groundwater Treatment Facility prior to discharge through NPDES Outfall 0IO00000015. During implementation of the IRM, it will be necessary to remove (dewater) most of the stored groundwater within and in the immediate vicinity of each open excavation cell. Existing wells within and surrounding the source area will be monitored weekly throughout Phase I of the project to ensure that abrupt and unanticipated changes in groundwater flow do not occur during dewatering activities. Water level monitoring will be reduced to semi-monthly based on experience gained from the first six cells, if appropriate.

5.3.1 Groundwater Modeling

The hydraulic groundwater model is presented in Appendix D. DOE has taken a conservative approach in preparing the groundwater model based on historical site investigations and prior process knowledge. The methodology described in this work plan will not change. Based on observed field conditions, however, techniques may be refined for engineering controls, BMP, and oxidant mixing techniques. Any refinements to the IRM will be processed as field changes to this Work Plan and approved by Ohio EPA.

A numerical groundwater model has been developed to determine the hydraulic impact to groundwater flow from the IRM activities and to aid in IRM design. To accomplish this, an existing groundwater model has been refined and updated in the areas of the X-701B and 7-Unit Groundwater Plumes. Slug tests were performed on the selected wells within the X-701B Plume to refine the conductivity values for critical portions of the aquifer. The model has been calibrated against the most current water-level measurements for the area and previously completed pumping tests within the unit.

The objectives of the hydraulic groundwater modeling effort for this IRM are as follows:

- Evaluate transmissivity (product of hydraulic conductivity and thickness) focusing on the Gallia formation within the X-701B refined groundwater model to identify areas of uncertainty.
- Evaluate the various long term pumping tests conducted in the past to evaluate the anisotropy of the Gallia unit.
- Update/refine the existing X-701B and 7-Unit Groundwater model to:
  - Incorporate hydraulic conductivity and thickness based on re-assessment of long term pumping tests
  - Vertically divide the Gallia Formation in up to three layers (Lower Gallia contains over 80% of the transmissivity of the unit with the upper layers being one or two orders of magnitude lower) based on re-evaluation of the site geologic logs and testing
  - Calibrate the groundwater model using the most current water-level data collected during different stresses (e.g., 7 day constant rate test in 2003, operation and non-operation of interceptor trench, quiescent conditions).
- Run up to three simulations of the proposed dewatering system to verify the analog dewatering calculations
- Simulate the effect of X-701B dewatering activities on the 7-Unit Plume to ensure that there are no adverse unintended effects
- Simulate the effect of the engineered high permeability layer on the X-701B Plume to ensure that there are no adverse unintended effects

Building upon the hydraulic model, an existing mass transport model for the 7-Unit/X-701B Aquifer will also be refined and updated. The mass transport model will be used to evaluate the overall long-term impact of the IRM on the time required to achieve PRGs within the groundwater unit. The results from recent Geoprobe sampling and analysis event at X-701B will initially be loaded to simulate the pre-IRM conditions at the unit. A simulation will then be run within the mass transport model to predict the time to achieve PRGs without further remedial action. Then a range of anticipated post-IRM soil conditions will be loaded into the model, and the simulation repeated to forecast the time to achieve PRGs under those conditions. By comparing the time to achieve PRGs for the anticipated post-IRM conditions against the no-further-action scenario, DOE and Ohio EPA will gain a better understanding of the total life cycle cost for cleanup of the unit, and be able to make high quality cleanup decisions both during and after the IRM.

5.3.2 Dewatering Plan

Groundwater levels within the footprint of the individual excavation cells will be lowered to facilitate remediation of the X-701B Source Area. The specific dewatering objectives are to:

- provide sufficient water withdrawal so that the materials can be excavated from the cells; and
- remove water sufficiently so that mixing of the lowermost Gallia Aquifer sediments and weathered shale can be conducted.

The critical design determination is the quantity and rate of water withdrawal necessary to dewater the individual, and successive, excavated cells within the X-701B Source Area. The dewatering withdrawal rate is dependent on:

- hydraulic conductivity,
- aquifer thickness,
- storativity,
- porosity,
- pumping duration, and
- the effectiveness of the installed shoring piles in reducing the lateral groundwater flux from adjacent and/or upgradient groundwater sources.

Table 1 below provides a summary of the individual test analyses used to determine the effective transmissivity, as established by pressure transducers in various wells during a 7-day constant rate pumping test performed on Extraction Well 1 (EW-01) in 2003.

Based on data from the 2003 study, the following input parameters were used for the dewatering design:

Table 1 - X-701B Dewatering Design Parameters

Parameter	**Value**	**Comments**
Gallia transmissivity	100 ft^2/day (approximates 50 ft/day and a 2-foot thick layer)	Average value from 7-day aquifer test from surrounding wells with transducers using residual recovery analysis
Porosity	0.25	Literature value
Hydraulic head in Gallia above the top of Sunbury	18 feet	Assumes depth to water 12 feet and top of Sunbury 30 feet bgs
Storativity	0.001	Resolved from 7-day aquifer test
Cell size	40 ft x 40 feet	Working design size

Based on various dewatering scenarios, the expected rate for dewatering is 18 gpm if the shoring were not present and 4 gpm for having a completely effective barrier with the Shoring. The design basis for the piping for the treatment system is 20 gpm. Appendix C provides the configuration design for 2 extraction wells located inside each cell at opposite corners. Additionally, perimeter extraction wells may be installed to minimize the head difference between the inside and outside of the cell.

The screen section of the drive points will be either 20-slot (20 slots per inch) or 40-slot (40 slots per inch). The actual number of drive points, their location, and appropriate slot size will be determined by field conditions encountered during cell excavation.

The drive points will be installed with threaded and coupled steel pipe and completed to the top of the Sunbury Shale (base of the cell excavation, nominally 28-32 ft). Submersible electric pumps will be installed in each temporary extraction well. The outflow lines from these pumps will then be joined through a controllable collection header (manifold) that will allow the cumulative production from the dewatering wells to be managed.

Inflow from beneath the shoring and precipitation may necessitate the construction of a down-gradient collector sump to be operated prior to oxidant amendment of the targeted Lower Gallia and weathered top of the Sunbury shale. The collection header described above will have the capability to accept water from this sump as well as the drive points.

The collective water captured by the extraction wells and/or inner cell sump will be pumped through the manifold to a sediment filtration system consisting of bag filters located within the defined source area (see Appendix C). Solids collected from the bag filtration system will be returned to an active cell and blended with oxidant.

This sediment removal system within the source area will be followed by a DNAPL separator located outside the source area. The DNAPL separator will discharge to two or more frac tanks to provide flow equalization and final solids settling prior to discharge to the X-623 Groundwater Treatment Facility. Sediments and DNAPL, if removed outside the source area, will be containerized, characterized, and shipped off-site for treatment and disposal at an appropriately licensed facility.

5.3.3 Treatment

The existing X-623 Groundwater Treatment Facility will be used to treat regulated surface water and groundwater from the X-701B area prior to discharge through NPDES Outfall 0IO00000610. If groundwater volumes exceed the treatment capacity of X-623, other DOE groundwater treatment facilities may also be used to treat regulated surface water and groundwater from the X-701B area.

Surface water from X-701B will continue to be collected from the former X-701B Pond and other possible impoundments associated with the IRM. The surface water will be conveyed to X-623 Groundwater Treatment Facility (or other permitted groundwater treatment facilities) for treatment prior to discharge. Groundwater within, and in the vicinity, of each open excavation cell will be processed to remove suspended solids and DNAPL, and then conveyed to X-623 Groundwater Treatment Facility (or other permitted groundwater treatment facilities) for treatment prior to discharge.

Wastewater initially entering the X-623 Groundwater Treatment Facility will be collected in a 6,000 gallon stainless holding tank. From the tank, the wastewater is pumped through a roughing filter for removal of suspended solids. If necessary following filtration, a feed pump will inject caustic or acid to adjust the pH to an appropriate level. The filtered wastewater will then be delivered to an air stripper for primary removal of volatile organic compounds (VOCs). The volatile emissions from the air stripper will be routed through a regenerative vapor-phase carbon adsorption system to reduce the level of air pollutants. Air-stripped water will be delivered to a wet well and then to a liquid phase carbon adsorption system for secondary removal of VOCs. The treated wastewater will be discharged to a sanitary sewer and conveyed to the existing X-6619 Sewage Treatment Facility.

5.4 WELL ABANDONMENT

Figure 5 identifies the 63 groundwater wells that will be impacted during the excavation of the X-701B Area and the related construction activities associated with the establishment of the surrounding Work Areas. The wells shown on Figure 5 include five varieties of groundwater wells:

- Berea Sandstone Monitoring Wells,
- Integrated Groundwater Monitoring Plan (IGWMP) Gallia Aquifer Monitoring Wells,
- Non-IGWMP Gallia Aquifer Monitoring Wells,
- Minford Silt Monitoring Wells, and
- Gallia Aquifer Extraction/Recovery Wells.

Since excavation of the source area and the preparation of the defined work area will destroy the locations/functionality of these monitoring wells, they will be abandoned in accordance with State of Ohio 1996 Technical Guidance for the Sealing of Unused Wells. DOE will file the Ohio Department of Natural Resources (ODNR) Well Decommissioning Report for each abandoned well with the ODNR as required by Ohio Revised Code (ORC) 1521.05. The planned abandonment methods of these wells are as follows:

5.4.1 Berea Sandstone Monitoring Wells

Referring to Figure 5, there are three (3) Berea Sandstone monitoring wells that occur within the limits of the X-701B Source Excavation Area (X701B-97, X701B-98 and X701B-99). These monitoring wells were not historically impacted by the X-701B Source Area and are not part of the site IGWMP program.

As these three established monitoring wells are completed at depths greater than the planned excavation depth of the X-701B project, the wells require appropriate, documented abandonments to prevent the potential for cross contamination from the overlying contaminated soil and groundwater present in the Gallia Formation. The Berea wells will be abandoned in place by grouting from their respective total depths to an elevation within each well to greater than (above) the planned excavated floor elevation of the X701B source area remediation project floor elevation, nominally 638 ft. The well casings and related original well installations materials that extend above the planned X-701B Source Area excavation floor elevation will be removed during the excavation.

This well abandonment approach will ensure that the Berea well completions are grouted through the entirety of their individual completed screened sections, filter pack completion intervals, and the entire thickness of their individual sanitary well seals. Abandonment through grouting with bentonite will ensure that an impermeable barrier is placed through the entirety of the stratigraphic thickness of the relatively impervious Sunbury Shale, which stratigraphically separates the Gallia and Berea aquifers.

Alternative well abandonment techniques including over drilling, complete well string removal and ripping casing are precluded by the stainless steel construction of the monitoring wells and the potential for cross-contamination during abandonment.

5.4.2 IGWMP Gallia Aquifer Monitoring Wells

Referring to Figure 5, there are 11 Gallia Aquifer monitoring wells that are listed and regularly used for monitoring, analyses, and reporting under the IGWMP. Given their status and reporting value, the monitoring wells will be selectively abandoned based on their individual vulnerability as the excavation progresses. This approach will allow the IGWMP wells to be available for monitoring and reporting until such time that site work will reasonably cause their installations to be compromised. The impacted IGWMP monitoring wells immediately surrounding the source area will be abandoned during site preparation. Well removals will be documented in quarterly IGWMP reports. In consultation with OEPA, DOE will develop a schedule for IGWMP well replacement.

IGWMP monitoring wells located outside the source area excavation but within the work area will be abandoned through the removal of the above grade surface completion followed by physical pulling of the stainless steel well string. The open well bore will then be abandoned by grouting to nominally 3 feet below grade. The remaining surface void will be backfilled with clean fill materials.

5.4.3 Non-IGWMP Gallia Aquifer Monitoring Wells

Referring to Figure 5, 37 Non-IGWMP Gallia monitoring wells will be impacted by the IRM. Monitoring wells established outside the X-701B Source Excavation Area will be sequenced and abandoned in the same manner as the IGWMP monitoring wells. This approach will allow these wells to serve as substitute monitoring wells throughout site development and excavation.

The non-IGWMP Gallia monitoring wells that exist within the limits of the source area excavation will be fully abandoned through excavation. The wells are completed in the Gallia Aquifer, at depths less than the floor elevation of the source area cells.

5.5 MINFORD SILT MONITORING WELLS

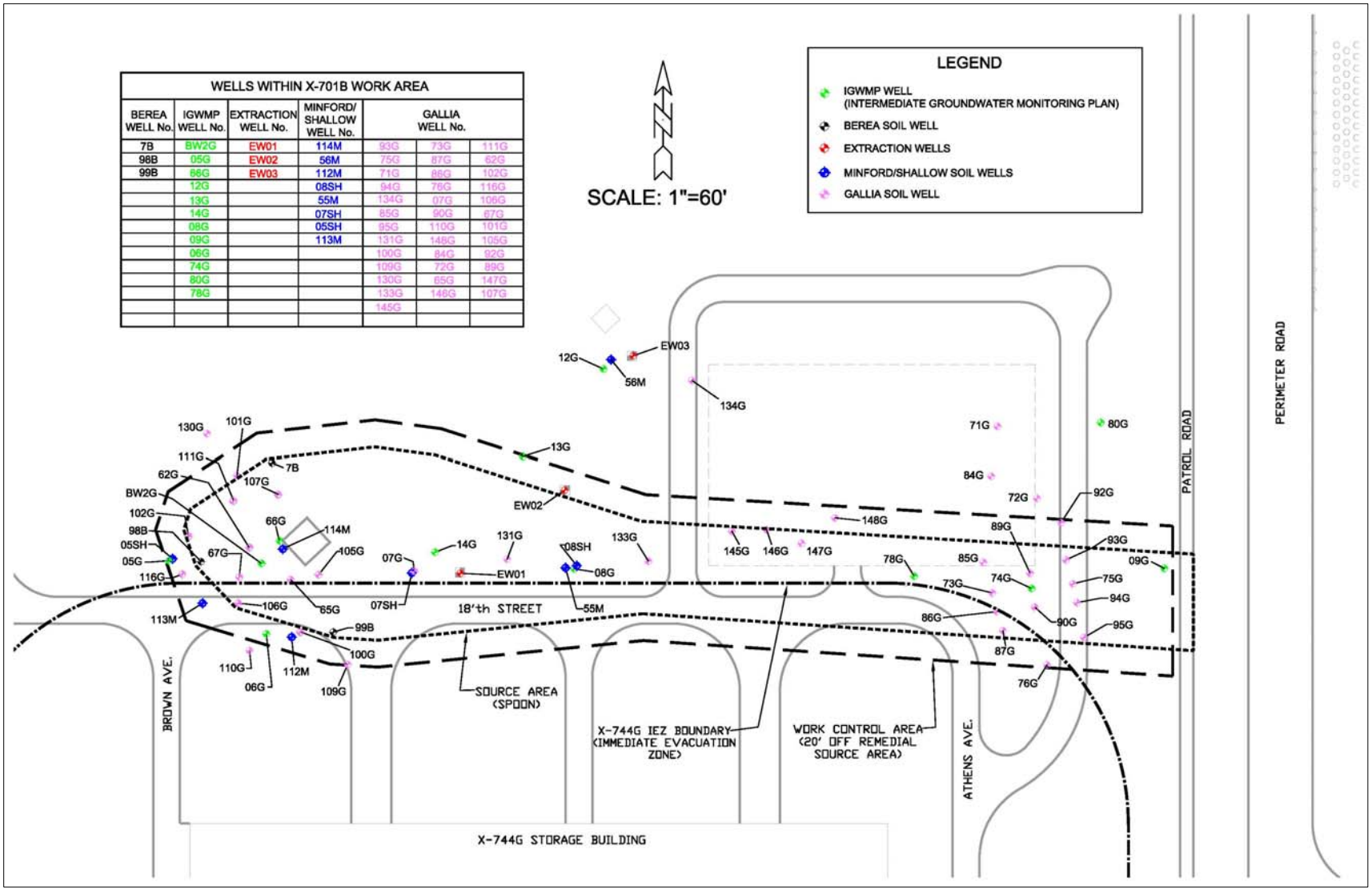
Referring to Figure 5, there are 8 shallow Minford monitoring wells completed to depths above the Gallia Aquifer. The Minford wells located outside the source excavation area will be abandoned by pulling and grouting as described in Sections 4.4.2 and 4.4.3 above. The Minford wells that occur within the excavation area will be abandoned by complete excavation.

5.5.1 Gallia Aquifer Extraction/Recovery Wells

Three (3) Gallia Extraction/Recovery Wells (EW, RW) are located within or near the western part of the X-701B Source Area. The extraction wells pump contaminated groundwater from the Gallia to the X-623 Groundwater Treatment Facility. Two of the extraction wells, EW-1 and EW-2, occur within the source excavation area and will be abandoned and their related subsurface infrastructures removed during excavation.

EW-3 is located north of the source area excavation area but within the Work Area. EW-1 has been of marginal value in groundwater extraction and will be removed during site preparation activities by pulling and grouting. Subsurface infrastructure associated with EW-3 will be plugged and abandoned.

Figure 5 - Well Abandonment



5.6 AIR CONTROLS

Due to the nature and extent of the hazardous constituents contained within the soils at X-701B, some of the constituents may be released to the air during the IRM activities. As a result, DOE has taken a conservative approach in the design of air controls based on historical site investigations and prior process knowledge. Engineering controls, resulting from the air model, include carbon filtration, limitation of cell dimensions, air monitoring requirements, and the excavation sequence.

The design of the air controls will be ongoing based upon analytical data generated during execution of the IRM. The design of these air controls is guided by U.S. Environmental Protection Agency (USEPA) BMP (Section 4.5.2), and will control air emissions to a level within regulatory limits without the special provisions of an Ohio EPA Air Permit.

5.6.1 Air Modeling

A numerical model has been used to forecast the overall rate and flux of hazardous constituent emissions as a result of the IRM activities. The numerical model also forecasts the dispersion of these emissions to onsite workers and the public and determines if the rate of air emissions will exceed established limits for un-permitted activities.

TCE within the X-701B Source Area soils is a Hazardous Air Pollutant (HAP), and will be managed accordingly. Based on historical soil and groundwater samples, it is anticipated that total TCE emissions from the IRM will not exceed 1 ton per year, therefore, the activities will be considered a “deminimis” under Section 3745-15-05 of the Ohio Administrative Code. Uranium, Technetium, Arsenic, Beryllium and Nickel have also been determined to be COCs within the X-701B Source Area soils and particulate emissions from the IRM activities have the potential to contain these constituents.

A technical investigation has been conducted of existing emissions estimation models/approaches to identify the best approach for calculating cross media contaminant transfer during IRM activities. The resultant modeling approach has received concurrence from Ohio EPA. Model runs utilizing historical soil and groundwater data indicate that Ohio EPA de minimis level(s) will not be exceeded.

As soil results from 2009 IRM design characterization activities at the X-701B Source Area become available, the results will also be factored into the model. If it is determined that the de minimis level(s) will be exceeded, then the IRM area source flux will be modeled using the USEPA AERMOD dispersion modeling program (or approved equivalent). The results from the downwind prediction will be compared to Ohio EPA TCE Maximum Allowable Ground Level Concentrations (MAGLC) and the Ohio EPA un-permitted limit for TCE (1 ton per year).

If the limits are exceeded, then mitigation technologies will be developed in accordance with the BMP identified within the USEPA publication EPA 530-R-97-007, BMP (BMPs) for Soils Treatment Technologies. The developed technologies will then be incorporated into the numerical model, and additional simulations will be run as the mitigation technologies are developed, until the results indicate that the IRM will remain within MAGLC and the un-permitted limit for TCE.

DOE will implement additional engineering controls, as necessary, based on air model results. Modifications to engineering controls will be made in accordance with the approved field change process. In addition, a copy of the air model will be provided to the Ohio EPA and included as an appendix to this Work Plan upon completion.

5.6.2 Best Management Practices

USEPA publication EPA 530-R-97-007 provides guidance on how to design and conduct soil remediation activities at RCRA and other hazardous waste sites so that transfers of contaminants from contaminated soil to other media (such as air, clean soil and ground water) are minimized. This publication does not direct or guide the selection of appropriate treatment technologies and is intended only to provide advice on the operational practices relating to prevention and control of cross-media contamination. If mitigating features are required as a part of this IRM for the control of hazardous emissions to air, then the design of the features will be guided by the BMPs within this publication.

The BMP guidance identifies both general and specific cross-media concerns for contaminants during treatment activities. The general concerns that are appropriate to air emissions for the X-701B IRM are identified below.

There is a risk of inaccurate site characterization with any soils treatment technology operation. This is particularly an issue at sites such as X-701B where there is the potential for DNAPL to be present within the subsurface. The actual soils encountered during excavation may not be like those that formed the basis for the remedial design. Additional contaminants may be encountered, the concentration of known contaminants may be higher than expected, or the percentage of the fine-grained fraction may be significantly greater than expected. To mitigate these concerns for the X-701B IRM, additional sampling and analysis has been conducted prior to the start of field work. Additionally, air, soil, and groundwater monitoring will be conducted on an ongoing basis during all phases of this IRM. The approved field change notice will be utilized if at any time during the project the analytical results drive a change in standard operating conditions.

There is a risk of fugitive dust emissions during many of the IRM activities. These include the mobilization and staging of equipment, clearing and grubbing, shoring installation, soil excavation, staging, and blending. The fugitive dust emissions may contain contaminants which could pose a threat to workers, public health, or the environment. To mitigate these concerns for the X-701B IRM, water misters will be utilized to keep the soils moist. Water misters will agglomerate small soil particles with larger particles or water droplets to reduce the fugitive dust emissions.

There is a risk that VOCs and/or semi-volatile organic compounds (SVOCs) may be volatized during the soil excavation, staging, and blending portions of the IRM activities and be released to the air. At X-701B, there is a particular concern with the VOC, TCE, which was identified in the Ohio EPA Decision Document for the unit as the principal contaminant of concern. Soil sampling, which was conducted during the previous oxidant injection activities, detected TCE concentrations as high as 10,000,000 ug/kg after the third injection event. TCE at this level indicates that some of the pore space within the subsurface soils contained DNAPL. To mitigate the concerns, a series of features have been incorporated into the design.

- Soil which is staged in piles during the IRM will be placed at a location and in a shape that minimizes the surface area that is exposed to wind. If soil sampling and air modeling indicate that the anticipated air releases from staged soil pile(s) will exceed regulatory limits, then a cover or physical barrier will be placed over the pile(s).
- The extent of the open excavation areas during the IRM will be limited to three (3) excavation cells at a given point in time. The excavation cells may vary in size, but most typically will be 30-38 ft on a side. This will minimize the size of the disturbed area for TCE releases over the course of the IRM, and enhance the IRM's ability to capture off gases from each source area.

- The extent of the high TCE containing soils which are exposed during the IRM will be limited to only one (1) excavation cell at a time. Soil sampling at the unit indicates that the highest levels of VOC contamination are contained within the weathered shale that resides at a depth of approximately 31 feet bgs, at the interface between the Gallia and Sunbury. To avoid volatilization of TCEs from these soils, they will not be excavated to ground surface prior to treatment. Instead, the soils will be blended in place with oxidant and then covered with a high permeability sand layer to facilitate future groundwater flow.
- If soil sampling and air modeling indicate that the anticipated air releases from the excavation cells will exceed regulatory limits, then additional engineering controls will be implemented to capture and treat the releases prior to discharge. The features may include a combination of water sprays, hoods, or enclosures. Misters will agglomerate small soil particles with larger particles or water droplets, cool the soil, and decrease the air-filled soil porosity to reduce VOC emissions. Exhaust ventilation systems may be installed to cause each excavation cell to act as a hood for VOC collection. If a ventilation hood approach is not feasible, then it may be necessary to install an enclosure over each excavation cell for VOC collection. Exhaust air which is collected from either a hood or enclosure design would be conveyed to an appropriate treatment system (such as activated carbon) prior to discharge.

5.7 SOIL TREATMENT

5.7.1 Technology Overview

The remediation of groundwater contamination by ISCO involves the delivery of oxidants directly into the contaminated media. The oxidant(s) react with the organic contaminants and naturally occurring molecules in the soil and groundwater to produce innocuous substances such as carbon dioxide, water, and in the case of chlorinated compounds, inorganic chloride. Contaminants amenable to treatment by ISCO include the following:

- benzene, toluene, ethylbenzene, and xylenes;
- petroleum hydrocarbons;
- chlorinated solvents, including TCE;
- polyaromatic hydrocarbons; and
- polychlorinated biphenyls (to a lesser degree)

There are two main advantages of using ISCO instead of other conventional treatment technologies. First, because the contaminant is destroyed in the subsurface, the volume of waste material generated is typically very small. Second, the treatment can be implemented over a much shorter time frame compared with other treatment technologies.

The advantages result in savings of materials, monitoring, and maintenance. The success of ISCO treatment depends on achieving adequate contact between the oxidant(s) and contaminants by the use of an efficient delivery system. In the previous remedial action at X-701B Source Area, oxidant was pumped into the contaminated media through hollow rods that were installed by direct push technology (DPT). This delivery system was only partially successful in achieving the required contact. The delivery approach for ISCO within this IRM involves the direct mixing of oxidant with contaminated media to achieve the maximum possible contact between oxidant and contaminant.

Four oxidants are commonly used for the remediation of contaminated soil and groundwater. The oxidants are permanganate, catalyzed persulfate, catalyzed hydrogen peroxide (CHP), and ozone. Combinations of these oxidants have also been effective in some applications. Each oxidant has advantages and disadvantages, and selection of the appropriate oxidant depends on site-specific conditions. Permanganate and persulfate are less reactive than CHP, and they will remain in the subsurface for longer periods of time. CHP reacts very aggressively and can in some cases facilitate increased mass transfer from DNAPL into the dissolved phase. However, CHP remains in the subsurface for only short periods of time, and may not penetrate fine grained material within the formation.

Catalyzed sodium persulfate (CSP) has been chosen as the primary oxidant for this IRM because of its relatively high oxidation potential and persistence in the subsurface. This persistence is an essential feature of the IRM because it will allow the oxidant to penetrate into the low permeability media which is present in portions of the X-701B Source Area. CSP has emerged as a cost-effective and viable oxidant for the treatment of organic contaminants in groundwater, soils, and sediments. With CSP, the natural oxidant demand is less than CHP, and the CSP process promotes the formation of a variety of free radicals (sulfate free radical SO4-• and hydroxyl free radical OH•). CSP has a relatively high stability under normal subsurface conditions and travels effectively through the subsurface into target contaminant zones.

Sodium persulfate has been successfully catalyzed (activated) by a variety of techniques, including chelated iron addition, heat addition, and alkaline addition. The addition of hydrated lime has been selected as the primary activation technique for this IRM because of its use at many commercial remediation sites where oxidant was successfully mixed into contaminated soils. It is anticipated that hydrated lime will be blended into the X-701B Source Area soils at a rate of approximately 1 pound per 10 pounds of sodium persulfate. However, the final rate will be determined during the treatment of the first six cells.

The stoichiometric formula for the destruction of TCE by sodium persulfate is provided below:

$$3NaS_2O_8 + C_2HCl_3 + 4H_2O \rightarrow 2CO_2 + 9H^+ + 3Cl^- + 3Na^+ + 6\ SO4_2^-$$

Where:

NaS_2O_8	=	sodium persulfate
C_2HCl_3	=	TCE
H_2O	=	water
CO_2	=	carbon dioxide
H+	=	hydrogen ion
Cl-	=	chloride ion
Na+	=	sodium ion
$SO4_2$-	=	sulfate ion

During the field implementation of the IRM, it may become apparent that CSP is not the most efficient oxidant to fully degrade contaminants within all portions of the X-701B Source Area. Therefore, additional oxidants, such as hydrogen peroxide, (or combination of oxidants) as identified above and activating techniques, chelated iron addition, heat addition, or alkaline, may be used to achieve the goals of the remedy. If, based on final TOD and sampling and analysis results, it is recognized that hydrogen peroxide becomes the oxidant of choice for the Weathered Top of Sunbury Shale; the specifications in appendix F will be implemented.

5.7.2 Total Oxidant Demand

One disadvantage of ISCO is that oxidants are non-selective in the subsurface. They will react equally well with any other molecules or ions they encounter if the thermodynamics and kinetics are favorable. As a result, the TOD is the sum of several competing factors, including the soil oxidant demand, contaminant oxidant demand, oxidant scavengers, and some inorganic constituents within the soil and groundwater. At the X-701B Source Area, past experience has indicated that the TOD will primarily be a function of TCE loading, soil type, and natural organic content within the unit.

Therefore, the IRM must add a sufficient quantity of oxidant to satisfy the TOD for each soil horizon. Previous measurements have indicated that the natural oxidant demand within the Gallia is on the order of 10 grams sodium persulfate per kilogram of soil. It is anticipated that the natural oxidant demand within the weathered shale (clay) at the Gallia-Sunbury interface could be higher because of its organic content. However, the TOD at the X-701B Source Area is probably most sensitive to the fraction of the pore space that is filled with TCE DNAPL. Table 2 shows the calculated ideal oxidant demand over a range of DNAPL saturation levels for a porosity of 50%. This porosity is a typical value for the weathered shale.

Based upon prior sampling results, it is anticipated that all of the soils at the X-701B Source Area are suitable for treatment with oxidant, and that the TOD for the soils will average 10 grams sodium persulfate per kilogram of soil.

Table 2 - Calculated Contaminant Oxidant Demand as a Function of Residual DNAPL Loading

% of Pore Space Filled with DNAPL	DNAPL Concentration (ug TCE/kg Soil)	Contaminant Oxidant Demand Per Stoichemitry (g/kg)
0.01%	41,430	0.23
0.05%	207,150	1.13
0.10%	414,299	2.25
0.50%	2,071,495	11.3
1%	4,142,991	22.5
5%	20,714,953	113
10%	41,429,906	225
20%	82,859,811	450
30%	124,289,717	676
40%	165,719,623	901
50%	270,149,528	1,126
60%	248,579,434	1,351
70%	290,009,340	1,577
80%	331,439,245	1,802
90%	372,869,151	2,027
100%	414,299,057	2,252

5.7.3 Delivery Methodology

Delivery of the oxidant to the TCE contaminant during the X-701B IRM is a three-step process. In general, the steps are bulk mixing, dissolution, and diffusion.

Bulk mixing of oxidant with soil will occur within each excavation cell for a lift of soil that is approximately three feet in un-compacted thickness. The sodium persulfate will be received in granular form and spread on top of the soil lift in quantities that satisfy the target TOD for the lift. Hydrated lime will be spread on the lift at an approximate ratio of 1 lb. hydrated lime to 10 lb. sodium persulfate to activate the persulfate. Bulk mixing will then be accomplished by utilizing a Terex Model WS60N (or equivalent) tilling/cutting attachment attached to large excavator such as a Komatsu PC-600. The mixing time which is required to achieve a uniform distribution of the oxidant and activator on a macro scale within a soil lift will be established during treatment of the test cell and Cell #1 described in Section 3.3.3 and applied throughout the cleanup.

As bulk mixing is completed for all regulated soils within the cell, the shoring will be removed to allow re-establishment of the water table. As the water table rises, oxidant and activator will dissolve and enter the dissolved phase within the pore space, where they will react with and destroy the TCE.

5.7.4 Construction of High Permeability Layer

Following the oxidant mixing of the lowermost Gallia sediments and the upper weathered surface of the Sunbury Shale, a nominal two foot (2') thick layer of washed, uniformly graded, coarse concrete sand will be placed over the amended sediments. The sand layer will enhance flushing of the source zone and the easterly down-gradient movement of groundwater toward the existing X-237 Groundwater Collection Trench. The lateral continuation and the maintenance of grade of the sand layer will be verified in the field by field surveying the upper elevation of the sand layer along all four sides of the cell.

After the sand layer has been placed and its lateral continuity and grade relative to adjacent cells verified, previously excavated source area sediments will be placed over the sand layer. The contaminated sediments will be amended with an oxidant by physical mixing within the cell and above the sand layer. During backfilling and mixing operations, care will be taken to minimize disruption of the underlying sand layer. The action will be visually monitored and recorded in the X-701B IRM field log book.

5.7.5 Site Restoration

The X-701B Source Area is partially located beneath the easterly limits of 18th Street just north of the X-744G building. Prior to the removal of the excavated area of 18th Street, a new access road will be constructed along the north side of the X-744G Building that will connect Brown Avenue to Athens Avenue. The area of the site where the existing section of 18th Street has been removed will not be reconstructed as a paved area. During excavation of the source area, it is anticipated that soils will swell by an approximate 15%. This, coupled with the import of sand materials for the construction of the high conductivity layer, will cause an excess of soils to be placed back on the area. A mound of the soils centered where 18th Street is presently located will be blended into the landscape and graded to shed water to the north and south. Water will be graded mostly to the north toward the existing drainage ditch. A smaller amount of water will flow to the south and catch basins on the north side of X-744G Building will collect the run off. Areas of the existing X-701B pond will contain some materials blended with the excavated soils within the source area and will be covered with the future installation of the proposed cap of the RCRA unit. The areas where soils have been backfilled, graded and otherwise disturbed will be seeded and protective mulch applied. Erosion control devices (silt fence and straw bales) will be left in place until a vegetative cover growth has been established.

6. MONITORING

6.1 SOURCE AREA MONITORING

The monitoring program for the X-701B IRM will include the collection of soil, groundwater, and air samples. The data produced will be used to optimize the remedial activities and to monitor the effectiveness of the IRM. All sampling will be conducted in accordance with the Quality Assurance (QA) section of this work plan.

The monitoring results from implementation of the IGWMP will be used for the assessment of any large-scale groundwater impacts resulting from the IRM activities. However, as described in Section 4.4.2, some IGWMP monitoring locations in the vicinity of the source area will be removed as a result of the IRM. Well removals will be documented in quarterly IGWMP reports. In consultation with Ohio EPA, DOE will develop a schedule for IGWMP well replacement, after completion of this project.

6.1.1 Sampling of First Six Cells

The purpose of for the first six cells is to determine the feasibility of and refine the approach for the IRM. As described below, the first six cells will be sampled for soil, groundwater, and air at a higher frequency than the remaining cells.

6.1.1.1 Soil Sampling

Soil samples will be collected from each of the first six cells after treatment is complete to verify the performance of the IRM. The samples will be collected approximately one, three, and six months following the removal of the shoring for each cell. The samples will be collected at approximately the center of the excavation cell, for the soil intervals and analytes defined in Table 3.

Table 3 - Source Area Soil Sampling for the First Six Cells

Analyte	Method	2 ft bgs	15 ft bgs	25 ft bgs	Below Low Perm Layer
TCE	SW-846 8260 with extraction Method 5035 modified	X	X	X	X
Uranium	Approved method per laboratory QA Plan	X	X	X	X
Technetium	Approved method per laboratory QA Plan	X	X	X	X
Total PCBs	SW-846 8082	X	X	X	X

6.1.1.2 Groundwater Sampling

Groundwater samples in the X-701B Source Area will be collected from the existing IGWMP Gallia wells at the frequency indicated in Table 4. As the IRM progresses, some of the IGWMP wells will be removed as part of the excavation process. The removed IGWMP wells will be replaced with wells as indicated in Table 6. If “New Well” is indicated in Table 6, the well will be installed at a location agreed to by DOE and Ohio EPA.

Table 4 - Source Area Wells for Groundwater Sampling

IGWMP Well	Frequency	Replacement Well
X701-02G	Quarterly	None
X701-05G	Quarterly	X701-03G
X-701-BW2G	Quarterly	New Well
X701-06G	Quarterly	X701-104G
X701-66G	Quarterly	New Well
X701-BW1G	Quarterly	None
X701-14G	Quarterly	New Well
X701-13G	Quarterly	New Well
X701-BW4G	Quarterly	None
X701-38G	Semi-Annual	None
X701-08G	Quarterly	New Well
X701-12G	Quarterly	None
X701-50B	Quarterly	None
X701-10G	Quarterly	None
X701-78G	Quarterly	New Well
X701-74G	Quarterly	X701-EW121G
X701-80G	Quarterly	None
X701-09G	Quarterly	X701-EW122G

All groundwater samples will be analyzed for the parameters indicated in Table 5.

Table 5 - Groundwater Analytical Parameters

Parameter	Method
TCE	EPA SW 846, Method 8260B
Hexavalent Chromium	EPA Method 7199, or 7196A
Technetium-99	Laboratory Specified Method
Total Uranium	Laboratory Specified Method
Sulfate	EPA Method 300.0

For the first three excavation cells, a new monitoring well will be installed at approximately the center of the cell after completion of the treatment and prior to removal of the shoring. The monitoring wells will be sampled monthly for the first six months after shoring removal, and every six months thereafter for the duration of the IRM. The wells will be analyzed for the parameters indicated in Table 5.

6.1.1.3 Air Sampling

Air samples will be collected to ensure that worker safety is maintained, and to verify that air emissions from the IRM activities are consistent with air modeling results and within approved regulatory limits.

6.1.1.3.1 TCE Sampling

Low volume personal breathing zone air monitoring, which follows NIOSH Method 1022, will be conducted on a cross-section of the workers performing the IRM activities. These monitors will be initially worn daily by 25% of the workforce until a negative assessment can be completed. If the negative assessment is successful, then the personal monitoring parameters for TCE may be changed to allow for confirmatory sampling until project completion.

Air monitoring for TCE will be conducted by Industrial Hygiene personnel at task-specific locations around the IRM. The monitoring will be accomplished with Photo Ionization Detectors (PIDs) at location(s) determined by Industrial Hygiene personnel.

Perimeter air monitoring for TCE will be conducted with data logging PIDs downwind and immediately outside the current IRM work area. The locations and frequency will be determined by Industrial Hygiene personnel.

Whole air (SUMMA) sampling stations will be installed at fixed locations downwind of the IRM and will collect air samples for analysis in accordance with EPA Methods TO-14A and TO-15. The locations and frequency of the sampling will be determined after completion of the Air Modeling described in the work plan.

6.1.1.3.2 Radiological Sampling

Buck low-volume personal breathing zone (BZ) air monitors will be worn by 25% of the workers to monitor for potential internal exposure.

Air monitoring for radionuclides will be conducted by Radiological Control personnel at task specific locations around the IRM. Monitoring will be accomplished with low volume air sample pumps with glass fiber filters, and the location(s) will be determined by Radiological Control personnel.

Perimeter air monitoring for radionuclides will be conducted with low volume air sample pumps with glass fiber filters placed along the project perimeter. The exact location(s) will be determined by Radiological Control personnel and will be established at sites where they are most likely to detect potential sources of contamination

6.1.2 Sampling for the Balance of Source Area Remediation

The balance of the source area remediation will expand the technology for the cleanup of the remainder of the X-701B Source Area developed during the installation of the first cells. As described below, soil, groundwater and air samples will be collected at a lower frequency than for the first six cells.

6.1.2.1 Soil Sampling

Soil samples will be collected to confirm the uniformity of mixing for oxidant, activator and soil. The samples will be collected at a rate of one lift per every ten excavated cells. The approach for determination of uniformity will be the same as that used for installation of the first six cells.

Soil samples will also be collected from completed excavation cells to verify the performance of the IRM. The samples will be collected at a rate of one excavation cell for every ten that have been completed and will be collected approximately six months following the removal of the shoring. The samples will be collected at approximately the center of the excavation cell for the same soil intervals and analytes as for the first six cells.

6.1.2.2 Groundwater Sampling

Groundwater samples in the X-701B Source Area will be collected from the same monitoring wells, at the same frequency, and analyzed for the same analytes as indicated for the first six cells.

At the rate of one per every ten excavation cells, a new monitoring well will be installed at approximately the center of the cell after completion of the treatment, and prior to removal of the shoring. The monitoring wells will be sampled monthly for the first six months after shoring removal, and every six months thereafter for the duration of the IRM. The samples from these wells will be analyzed for the same parameters as the other groundwater samples.

6.1.2.3 Air Sampling

Air samples will be collected to ensure that worker safety is maintained, and to verify that air emissions from the IRM activities are within approved regulatory limits, and consistent with the results from the air modeling (4.5.1).

6.1.2.3.1 TCE Sampling

Low volume personal breathing zone air monitoring, which follows National Institute for Occupational Safety and Health (NIOSH) Method 1022, will be conducted on a cross-section of the workers performing the IRM activities. These monitors will be initially worn daily by 25% of the workforce until a negative assessment can be completed. If the negative assessment is successful, then the personal monitoring parameters for TCE may be changed to allow for confirmatory sampling until project completion.

Air monitoring for TCE will be conducted by Industrial Hygiene personnel at task specific locations around the IRM. The real-time monitoring will be accomplished with PIDs at location(s) determined by Industrial Hygiene personnel.

Perimeter air monitoring for TCE will also be conducted with data logging PIDs downwind and immediately outside the current IRM work area. The locations and frequency will be determined by Industrial Hygiene personnel.

A whole air (SUMMA) sampling station will be installed at a fixed location downwind of the IRM and will collect air samples for analysis in accordance with USEPA Methods TO-14A and TO-15. The location and frequency of the sampling will be determined after completion of the Air Modeling described in section 4.4.1 of the work plan.

6.1.2.3.2 Radiological Sampling

Buck low-volume personal BZ air monitors will be worn by 25% of the workers to monitor for potential internal exposure.

Air monitoring for radionuclides will be conducted by Radiological Control personnel at task specific locations around the IRM. Monitoring will be accomplished with low volume air sample pumps, with glass fiber filters, and the location(s) will be determined by Radiological Control personnel.

Perimeter air monitoring for radionuclides will be conducted with low volume air sample pumps with glass fiber filters placed along the project parameter. The exact location(s) will be determined by Radiological Control personnel and will be established at sites where they are most likely to detect potential sources of contamination

6.2 DOWNGRADIENT MONITORING

Downgradient monitoring will be performed outside the X-701B Source Area and east of the plant perimeter road. The purpose of the downgradient monitoring is to provide a final monitoring buffer between the IRM activities, the environment, and the public.

6.2.1 Downgradient Groundwater Monitoring

Groundwater samples will be collected in accordance with the IGWMP from existing downgradient IGWMP wells through completion of the IRM. In addition, the downgradient IGWMP wells identified in Table 6 will be sampled quarterly throughout the IRM for the analytes listed in Table 5. Following completion of the IRM, groundwater monitoring will continue per the IGWMP.

Table 6 - Downgradient IGWMP Wells with Quarterly Sampling

X701-25G
X701-21G
X230J7-01GA
X701-127G
X230J7-02GA
X230J7-03GA
X701-128G
X230J7-04GA
X701-20G
X701-19G
X701-16G
LBC-PZ06G
X701-24G
X701-15G

6.2.2 Downgradient Air Monitoring

When excavation cells in the eastern end of the X-701B Source Area are being treated, a whole air (SUMMA) sampling station will be established at a fixed location downwind of the IRM to measure TCE. The sampling station will collect samples for analysis in accordance with USEPA Methods TO-14A and TO-15. The location and frequency of the sampling will be determined after completion of the Air Modeling described in Section 4.5.1 of the work plan.

Radiological ambient air monitoring stations for PORTS will provide downgradient monitoring for radionuclides during the IRM. Radionuclides monitored by the monitoring stations include Uranium (U) and Technetium-99 ($Tc\text{-}_{99}$). The monitoring stations will continue to be operated in accordance with regulatory requirements.

6.3 SAMPLE MANAGEMENT

All sampling and data management activities including field chain-of-custodies, labeling of sample containers, and laboratory chain-of-custodies will be performed in accordance with the Project Environmental Measurements System (PEMS) standards. Verification and validation of generated data will be performed on 5% of the samples in accordance with established PEMS procedures.

7. SCHEDULE AND MILESTONES

The proposed milestones for the project are presented in this section of the work plan. The actual milestones will be highly variable; there fore the milestones are provided for non-enforceable, informational purposes only.

7.1 INVESTIGATION SCHEDULE

Initiation of field activities is contingent upon Ohio EPA approval of the Work Plan. Additional time to complete the IRM may be needed based on circumstances, such as, inclement weather or discussions with Ohio EPA regarding overall approach.

7.2 INVESTIGATION MILESTONES

Proposed milestones to track progress are outlined in Table 7.

Table 7 - Milestones for the X-701B IRM

Milestone	Action Date
Initiate field investigation (groundwater sampling activities)	60 calendar days after Ohio EPA approval of the work plan
Completion Report	90 calendar days after completion of field work

8. WASTE MANAGEMENT

All waste from this project will be managed in accordance with applicable federal, state, and DOE site requirements. The management of wastes may include the collection of wastes, characterization of wastes, and management of the 90-day RCRA waste storage area. All wastes will be characterized by analysis or process knowledge prior to shipment to appropriate treatment and or disposal facilities. Both liquid and solid waste will be generated during this interim remedial action.

8.1 LIQUID WASTE

Liquid waste streams will include:

- decontamination water
- precipitation water and groundwater that accumulates within open excavations
- well development water, and
- surface water collected within the X-701B Pond and/or within the bermed interior of the X-701B Source Area.

Liquid wastes will be treated at existing, on-site groundwater treatment facilities and/or sent to an appropriately off-site facility for treatment and disposal. Liquid wastes that will be treated at the X-623 Groundwater Treatment Facility or other on-site treatment facility will pass through a sediment removal system and DNAPL separator prior to introduction into the treatment facility.

Appendix C, Interim Remedial Measure Design, includes the process flow diagram for liquids collection and treatment. Estimated liquid waste volumes are presented in Table 7.

8.2 SOLID WASTE

Solid wastes will include:

- contaminated soils
- sediment from the liquid separator system
- contaminated personal protective equipment (PPE)
- non-contaminated packaging materials and expendables
- miscellaneous piping and equipment removed during site preparation

Minimal solid waste will be generated during soil /oxidant blending, as most of the soil will be returned back to the area from which it was removed. PPE used during the waste generation processes (i.e. disposable safety suits, gloves, etc.) will be decontaminated to a RCRA-clean standard per the Ohio Administrative Code (OAC) 3745-270-45 and surveyed by site radiological personnel. If radiological contamination is found the waste will be containerized and sent to an approved off-site facility for disposal. PPE meeting radiological off-site release criteria will be disposed at a sanitary landfill. Packaging materials and expendables meeting radiological off-site release criteria will be disposed at a sanitary landfill. Estimated waste volumes are presented in Table 7.

8.3 WASTE SAMPLING

Samples will be collected in accordance with applicable procedures and will be analyzed to determine treatment and disposal requirements. Specific waste characterization requirements, including sample collection and analytical methods will be dependent on the waste acceptance criteria for receiving facilities. Laboratories used for characterization will be certified as required by the receiving facility and applicable state/federal regulations.

8.4 SPECIAL WASTE STREAMS

Several special waste streams exist, or have the potential to exist, during the project. In consultation with Ohio EPA, DOE will address these circumstances as described in the following subsections.

8.4.1 DNAPL Remediation / Settled Solids

DNAPL has been encountered during operation of the ongoing X-701B groundwater extraction and treatment systems. Historical sampling data suggests that DNAPLs, where present, are in the weathered Sunbury Shale.

The planned excavation technique will enhance the release of DNAPL from the weathered shale. Installation of shoring sections as well as mechanical oxidant mixing in the bottom of each cell will release the DNAPL from pore spaces. Where encountered, free phase DNAPL will be collected in sumps at the excavation bottom and pumped to the DNAPL separator. The DNAPL will be collected, drummed, and sent off-site for treatment and disposal.

Solids will settle at several points within the water management system. A bag filtration system, located within the source area, will remove the bulk of potentially contaminated solids. Filtered solids will be removed from this unit and returned to the excavation for direct-mix oxidant treatment. Solids removed from the storage/flow equalization frac tanks, if located outside the source area, will be sampled, characterized, and disposed off-site. Solids removed at the X-623 Groundwater Treatment Facility will be managed in accordance with the current practice.

8.4.2 Radiological Contamination Remediation

Radiological contamination, including Tc^{99} and U, potentially exist within the planned excavation area. Previously performed surface surveys will be utilized to identify clearly defined surface contamination areas. The areas will be removed and disposed prior to excavation of underlying cells.

The sampling and analysis program will be used to identify subsurface radiological contamination areas. Contamination levels and alternative disposition pathways will be assessed based upon sample results. Alternative disposition pathways include:

- direct blending with surrounding soils during ISCO,
- relocation to designated cells beneath the future X-701B Pond cap, and
- off-site disposal,

8.4.3 Metals Remediation

Although the focus of this IRM is TCE remediation, excavations may encounter metals which exceed PRGs for identified metals COCs. The sampling and analysis program includes identification of metals contamination areas. Metals contamination levels and alternative disposition pathways will be assessed, based upon sample results. Alternative disposition pathways include relocation to designated cells beneath the future X-701B Pond cap or off-site disposal.

8.5 ESTIMATED WASTE VOLUMES

Table 7 presents estimated waste volumes for each of the waste streams described above.

Table 8- X-701B Estimated Waste Volumes

Waste Type	Estimated Quantity	Disposition
Decon Water	500 Gal	X-623 Groundwater Treatment Plant
Dewatering	2.9 Million Gal. (@ estimated rate of 10 GPM.)	X-623 Groundwater Treatment Plant
Settled Solids / DNAPL	2,200 Cubic Feet	Treatment and Disposal at Clive, Utah
PPE	14,400 Cubic Feet	Disposal at Clive, Utah
Packaging Materials	16,200 Cubic Feet	Pike Sanitation
Removed Piping and Equipment	3,440 Cubic Feet	Disposal at Clive, Utah

9. ENVIRONMENT, HEALTH, AND SAFETY

9.1 ENVIRONMENT SAFETY AND HEALTH

The Environment, Safety and Health (ES&H) Program is designed to minimize the number of injuries and illnesses, with an ultimate goal of zero accidents and injuries. The appropriate supervision, training, and PPE will be provided to keep employees safe. Management and staff share responsibility for health and safety, and all levels are accountable for specific health and safety activities. Full participation by, and cooperation with, all employees are crucial to the overall success of the ES&H Program for this project. Principles that will be adhered to during the performance of the work include the following:

- Occupationally caused injuries and illnesses are preventable.
- Preventing occupationally caused injuries and illnesses is one of the highest responsibilities of DOE and LATA Parallax Portsmouth, (LPP).
- Providing safe working conditions in the office and in the field is a priority.
- Employees have a right to information and training.
- Working safely is a condition of employment and is a shared responsibility between management and staff.
- The project cannot succeed unless injuries and exposures are mitigated, managed, and prevented.

Safety is the responsibility of every employee. Ultimately, however, the successful implementation of the ES&H Program depends on the integrated activities of managers, health and safety staff, and employees. Through oversight and coordination of all health and safety functions, compliance will be achieved with all applicable health and safety regulations.

A primary consideration for all operations is the health and safety of its personnel. The protection of the general public and the environment is also an important consideration in developing and implementing the ES&H Program. The application of standardized health and safety procedures by trained personnel reduces the possibility of injury or exposure.

Manager and employee cooperation is required in all health and safety matters. The objective is a Health and Safety Program that reduces the number of accidents, injuries, and illnesses to a minimum.

The Integrated Safety Management System (ISMS) integrates safety into management and work practices at all levels so that missions are accomplished efficiently while protecting the worker, the public, and the environment. Those involved with this action must be committed to this system and must recognize that it is fundamental to successful execution of work. ISMS provides a formal, organized process to ensure the safe conduct of work. The principles of ISMS will be integrated into all environmental, safety, and health programs performed on site.

10. QUALITY ASSURANCE

DOE will provide the appropriate resources to facilitate quality work. The QA Program includes a framework for achieving quality, contains explanations of various elements that may be applicable to project work, and includes procedures to effectively implement the elements. Inclusion of the applicable quality elements and procedures during project planning helps build quality into the project. Certain quality procedures assist in properly dealing with problems if they arise during project activities. The key quality elements are planning the project, qualification of personnel, technical review of project work, procurement of technical services and measurement and test equipment, assessment of work, and rapid correction of problems.

The QA Program also includes QA staff that is available to provide information and guidance in quality matters and to assist in meeting QA requirements. QA and project staff shares a common goal to achieve high quality project products and results. The QA staff will work to customize the QA procedures to identify the quality measures that will be most helpful to this project. A QA staff member will work with the project team to achieve these common goals in this regard.

QA/QC measures will be communicated to the project team through the planning documents, procedures, work instructions, and through training and orientation meetings. Readiness assessments will verify that adequate QA/QC controls are in place and project staff are trained and qualified.

During project execution, the adequacy of QA/QC measures will be assessed by employees, management, and independent reviewers to determine if the scope of work and governing documents are being implemented effectively. All workers are responsible for identifying, reporting, and suggesting improvements to work processes and solutions to qualify problems. If necessary, measures will be modified using the change control process and communicated to the project team. Lessons learned and other feedback will be provided to foster continuous improvement.

10.1 PROJECT MANAGEMENT

The DOE Project Manager is responsible for ensuring that all subcontracts are managed / administered properly and that the flow-down of contract requirements occur and enforced. It is also the responsibility of the Project Manager to enforce full implementation of project QA and QC procedures. DOE is authorized to make QA decisions on all work elements and is responsible for reviewing QA project plans and auditing QA/QC performance for this project. DOE ensures proactive implementation of QA/QC procedures and policies, quality in all planning and deliverables, and documentation and implementation of any corrective actions. DOE also works with all project personnel to ensure understanding and implementation of QA procedures and protocols and ensures that project staff receives required training and training records are current.

10.2 PROCEDURES

An established QA Program will be applied to all activities in a manner consistent with the nature of the work performed and the requirements applicable to each work activity. The most current version of applicable procedures will be utilized in the field.

In addition, supplementary project-specific procedures will be developed or adopted from other sources to meet special project needs.

10.3 QA/QC MEASURES

Field QC measures will include samples collected or prepared in the field during sampling activities and submitted to the laboratory to assess the quality of the sample collection process, sample handling and shipment, and sample analysis (total measurement error). For purposes of this plan, field QC samples include field duplicates, rinseate samples, field blanks, and trip blanks.

- Field Duplicates (soil and groundwater) – One duplicate for each analytical batch or for every twenty samples, whichever is fewer. Field duplicates will be analyzed for the same set of analytical parameters as the non-QC samples being collected. The purpose of field duplicates is to determine precision that is a function of variance in sample composition, sampling techniques and analytical techniques. Duplicate samples will be collected in the same manner as regular samples. Field duplicates will not be collected for soil samples that are collected to measure the extent to which oxidant and activator are uniformly distributed within a soil lift.
- Rinseate Samples (soil and groundwater) – One rinseate for every thirty samples that involves non-dedicated sampling equipment. Rinseate samples will be analyzed for the same set of analytical parameters as the non-QC samples being collected. The purpose of rinseate samples is to verify the effectiveness of the decontamination procedure and to verify that cross-contamination is not occurring. Rinseate samples will not be collected for soil samples that are collected to measure the extent to which oxidant and activator are uniformly distributed within a soil lift.
- Field Blank Samples (groundwater only) – One field blank for each analytical batch or for every thirty samples, whichever is fewer. Field blank samples will be analyzed for the same set of analytical parameters as the non-QC samples being collected. The purpose of field blanks is to verify that the presence of a given analyte in a sample is not due to a source of external contamination (e.g., potable water used in the decontamination process, airborne contamination from an adjacent facility or operation, etc.).
- Trip Blank samples (groundwater only) – One trip blank for each shipment of TCE samples only. Trip blank samples will be analyzed for the same set of analytical parameters as the non-QC samples being collected. The purpose of trip blanks is to ensure that the presence of TCE in a given sample is not due to cross-contamination from another more highly contaminated TCE sample that is placed in the same cooler.

For purposes of this plan, laboratory QA measures are those checks that an analyst routinely runs to determine the precision and accuracy of the analytical methods and equipment (method error). Laboratory QA measures typically include blanks, standards, duplicates, standard reference materials, and standard additions (matrix spikes). The QA measures will be specified in the contracts with the analytical laboratories that perform the analyses.

11.REFERENCES

Ohio EPA (Ohio Environmental Protection Agency) 2003. *Decision Document for the X-701B SWMU in Quadrant II of the US DOE Portsmouth Facility, Piketon Ohio.* December.

Ohio EPA (Ohio Environmental Protection Agency) *Consent Decree, Article X, Additional Work*

Ohio EPA (Ohio Environmental Protection Agency) 2003 *Decision for the X-701B SWMU in Quadrant II of US DOE Portsmouth Facility, Piketon Ohio*

Waste Management and Research 1995, *Evaluation of Homogeneity of Stabilized/Solidified Wastes*

APPENDICES

Appendix A
Summary of Historic Soil Sampling Data

Appendix A - Trichloroethene in Soil
Summary of Historic Soil Sampling Data

Soil Sampling Location	Height Above Sunbury (ft)	Units For All Results	Phase II Baseline	Phase IIb	Phase IIc	Phase IId	Phase IIe	Phase IIf	Most Recent Sample Less Than PRG ?	Overall Percent Reduction	Overall Increase
S-01	5'-10'	ug/kg	360	8.8	61	418	14	1.8	Yes	99.5%	
S-02	5'-10'	ug/kg	71	0.29	4.0	5.0	0.65	0.52	Yes	99.3%	
S-03	5'-10'	ug/kg	2,242	790	2,150	600	1,045	820		63.4%	
S-04	5'-10'	ug/kg	5,651	100	180	14	6.8	270		95.2%	
S-05	5'-10'	ug/kg	87	1.5	33	62	2.4	0.88	Yes	99.0%	
S-06	5'-10'	ug/kg	63	1.5	1.0	0.86	1.8	0.54	Yes	99.1%	
S-07	5'-10'	ug/kg	1,050	9.5	240	28	74	25	Yes	97.6%	
S-08	5'-10'	ug/kg	22,000	920	7,100	10,000	480	500		97.7%	
S-09	5'-10'	ug/kg	715	0.97	4,200	4.3	37	4.7	Yes	99.3%	
S-10	5'-10'	ug/kg	10,700	260	1,400	3.5	150	670		93.7%	
S-11	5'-10'	ug/kg	14,300	2.3	38	33	110	2,200		84.6%	
S-12	5'-10'	ug/kg	1,600	26	1,500	44	100	120		92.5%	
S-13	5'-10'	ug/kg	13,300	480	3,900	7,200	490	550		95.9%	
S-14	5'-10'	ug/kg	3,900	2,400	9,100	6,800	3,100	260		93.3%	
S-15	5'-10'	ug/kg	4,150	1.2	1,060	395	260	340		91.8%	
S-16	5'-10'	ug/kg	75	0.90	23	8,100	40	33	Yes	56.0%	
S-17	5'-10'	ug/kg	30,000	56	9,800	1,700	9,900	1,400		95.3%	
Overall	5'-10'	ug/kg	7,848	298	2,143	1,602	782	400		94.9%	
S-01	1'-5'	ug/kg	233	5.0	16	4.6	8.6	0.81	Yes	99.7%	
S-02	1'-5'	ug/kg	159	5.0	5.5	4.1	1.8	9.4	Yes	94.1%	
S-03	1'-5'	ug/kg	510	110	7.5	30	120	120		76.5%	
S-04	1'-5'	ug/kg	1,901,112	1.5	75	2,915	3.2	137		100.0%	
S-05	1'-5'	ug/kg	205	3.4	12	48	12	18	Yes	91.4%	
S-06	1'-5'	ug/kg	12,840	14	15	10	140	3.2	Yes	100.0%	
S-07	1'-5'	ug/kg	270	5.8	112	6.3	4.1	18	Yes	93.4%	
S-08	1'-5'	ug/kg	5,950	16	62	9.7	150	197		96.7%	
S-09	1'-5'	ug/kg	32,750	5.7	7,040	40	293	573		98.2%	
S-10	1'-5'	ug/kg	445	2.9	2,720	4.2	35	15	Yes	96.7%	
S-11	1'-5'	ug/kg	375	8.6	5.0	1.9	41	3.1	Yes	99.2%	
S-12	1'-5'	ug/kg	175	59	56	23	379	8.6	Yes	95.1%	
S-13	1'-5'	ug/kg	157	15	24	31	26	36	Yes	77.4%	
S-14	1'-5'	ug/kg	11,733	228	18,338	24	360	29	Yes	99.8%	
S-15	1'-5'	ug/kg	870	5.1	12	9.5	16	73		91.6%	
S-16	1'-5'	ug/kg	61,750	13	2,431	2,853	85	32	Yes	99.9%	
S-17	1'-5'	ug/kg	20,425	43	8.0	85	103	9.2	Yes	100.0%	
Overall	1'-5'	ug/kg	239,697	32	2,292	313	122	81		100.0%	
S-01	0'-1'	ug/kg	5,100	11,000	21	370,000	8,843	19,000			3.7
S-02	0'-1'	ug/kg	1,400	5.0	9.0	48	23,383	78		94.4%	
S-03	0'-1'	ug/kg	38,500	910	62,500	2,348	51,750	24,000		37.7%	
S-04	0'-1'	ug/kg	14,540	58	190,000	12,000	250,000	80,000			5.5
S-05	0'-1'	ug/kg	145,000	150	21,000	257,000	692,500	253,850			1.8
S-06	0'-1'	ug/kg	45,500	64	630	28,000	90,000	770		98.3%	
S-07	0'-1'	ug/kg	62,000	32	705,000	1,150,000	118,500	42,000		32.3%	
S-08	0'-1'	ug/kg	83,500	53	4,200	430,000	490	44,000		47.3%	
S-09	0'-1'	ug/kg	50,000	310	315,000	213,000	8,000	1,800		96.4%	
S-10	0'-1'	ug/kg	57,000	130,000	215,000	110,000,000	270,000	230,000			4.0
S-11	0'-1'	ug/kg	110,000	340,000	400	14,000,000	130,000	140,000			1.3
S-12	0'-1'	ug/kg	16,000	500,000	148,200	95,000	440,000	430		97.3%	
S-13	0'-1'	ug/kg	17,000	480	10,845	110,000	970	8,100		52.4%	
S-14	0'-1'	ug/kg	285,000	220,000	24,500	540,000	99,000	1,500		99.5%	
S-15	0'-1'	ug/kg	113,500	55,000	102,000	280,000	22,000	335,000			3.0
S-16	0'-1'	ug/kg	235,000	1,000,000	2,800	82,000	660,000	550,000			2.3
S-17	0'-1'	ug/kg	53,500	90,000	8,900	150,000	410,000	209,000			3.9
Overall	0'-1'	ug/kg	79,265	138,121	137,848	5,639,643	186,184	136,869			1.7

- Less Than or Equal to 100 ug/kg
- 100 - 1,000 ug/kg
- 1,000 - 10,000 ug/kg
- 10,000 - 100,000 ug/kg
- 100,000 - 1,000,000 ug/kg
- Greater Than or Equal to 1,000,000 ug/kg

Appendix B
Sampling and Analysis Plan Summary for Remedial Design

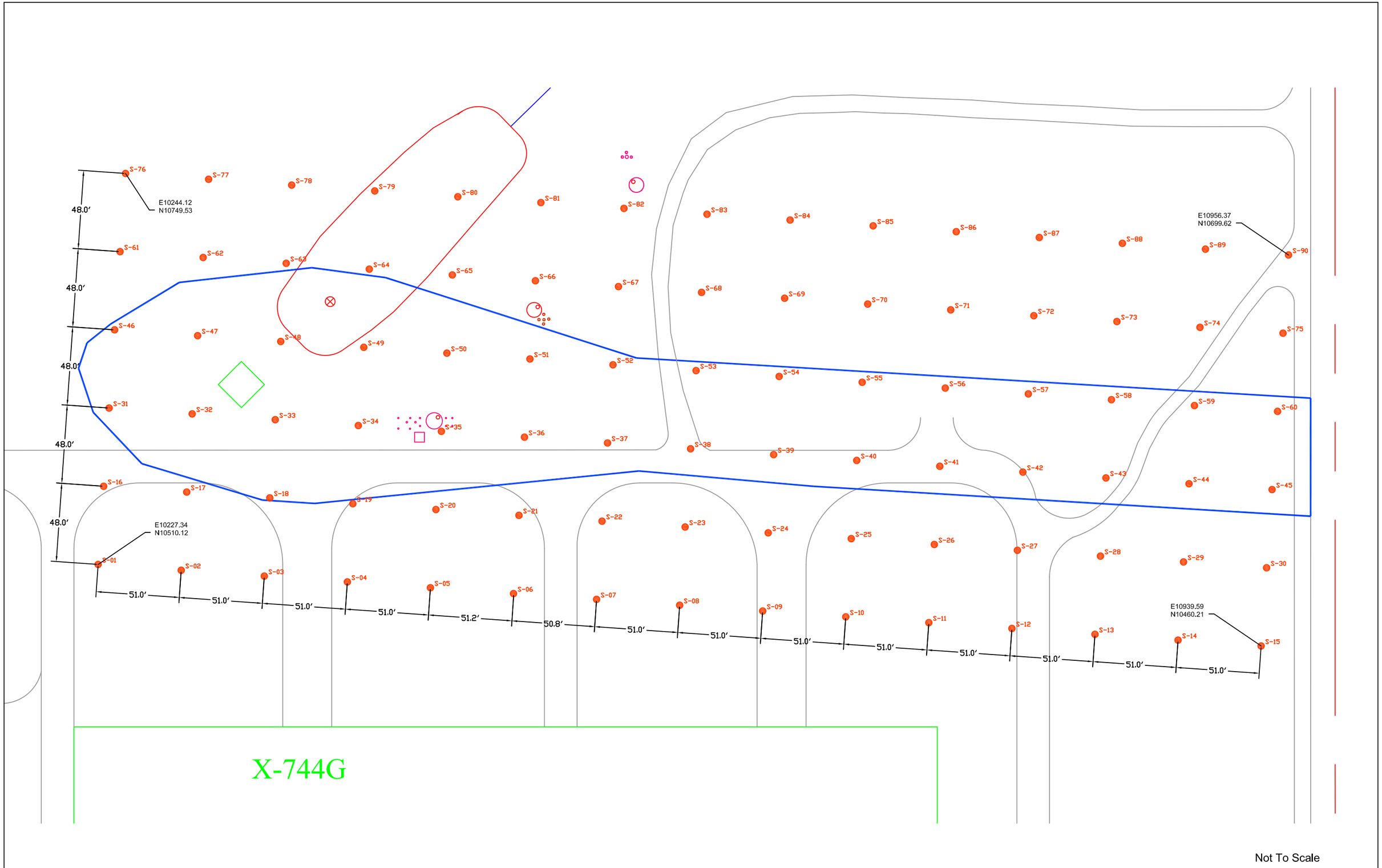


Figure 2
X-701B Soil Sampling Plan

X-701B Interim Measure

Preliminary Soil Characterization Data
August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT01	2							
	15				0.016	3.4	220	14.8
	25						230	
	AWS						270	16.0
	WS						270	22.1
DPT02	2							
	15							
	25							15.1
	AWS							18.8
	WS							19.7
DPT03	2							
	15							11.5
	25							
	AWS							19.6
	WS							19.7
DPT04	2							
	15						210	
	25				0.017	2.9	300	12.9
	AWS						600	17.7
	WS						22,000	31.0
DPT05	2							
	15							
	25							
	AWS							
	WS							
DPT06	2							
	15						240	
	25						260	13.0
	AWS						200	19.3
	WS						220	19.2
DPT07	2							
	15						240	14.5
	25						2,600	
	AWS				0.14	4.8	240	18.0
	WS						6,500	21.7
DPT08	2							
	15							
	25							12.9
	AWS							18.6
	WS							26.9
DPT09	2							
	15							
	25							
	AWS							
	WS							
DPT10	2							
	15						200	
	25						420	14.2
	AWS						910	17.3
	WS				0.056	39	5,800	25.3
DPT11	2							
	15						240	14.2
	25						430	
	AWS						290	18.8
	WS						430	23.9
DPT12	2							
	15						220	
	25						1,400	14.2
	AWS						2,300	23.4
	WS						110,000	29.4
DPT13	2							
	15							
	25							
	AWS							
	WS							
DPT14	2							
	15							
	25							
	AWS							

X-701B Interim Measure

Preliminary Soil Characterization Data

August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT14	WS							
DPT15	2							
	15							15.4
	25							
	AWS							11.0
	WS							24.9
DPT16	2							
	15							
	25							15.7
	AWS							15.4
	WS							32.6
DPT17	2							
	15							11.7
	25							
	AWS							17.1
	WS							29.7
DPT18	2							
	15						220	
	25						230	10.9
	AWS						220	16.4
	WS						96,000	25.4
DPT19	2							
	15							14.8
	25							
	AWS							19.0
	WS							24.3
DPT20	2							
	15							
	25							
	AWS							
	WS							
DPT21	2							
	15							
	25							
	AWS							
	WS							
DPT22	2							
	15						240	
	25						45,000	14.0
	AWS						7,600	14.5
	WS				0.18	16	83,000	27.5
DPT23	2							
	15							
	25							
	AWS							
	WS							
DPT24	2							
	15							
	25							
	AWS							
	WS							
DPT25	2							
	15				0.083	3.3	220	14.2
	25						29,000	
	AWS						57,000	17.5
	WS						92,000	21.9
DPT26	2							
	15						1,600	
	25						31,000	23.6
	AWS						81,000	17.3
	WS						880,000	18.4
DPT27	2							
	15							
	25							
	AWS							
	WS							
DPT28	2							
	15							
	25							

X-701B Interim Measure

Preliminary Soil Characterization Data

August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT28	AWS							
	WS							
DPT29	2							
	15							14.3
	25							
	AWS							18.5
	WS							19.4
DPT30	2							
	15							
	25							14.1
	AWS							17.5
	WS							23.1
DPT31	2							
	15						190	12.0
	25						260	
	AWS				0.14	9.0	32,000	16.2
	WS						1,300,000	24.9
DPT32	2							
	15							
	25							11.2
	AWS							20.1
	WS							24.2
	SS							41.4
DPT33	2				2.5	3.5		
	15						1,100	13.7
	25						590	
	AWS						9,500	18.0
	WS						140,000	22.2
DPT34	2							
	15							
	25							15.1
	AWS							19.8
	WS							21.5
DPT35	2							
	15						250	13.8
	25						190	
	AWS						27,000	17.0
	WS						110,000	28.8
DPT36	2							
	15							
	25							15.1
	AWS							19.2
	WS							23.2
	SS							44.7
DPT37	2							
	15							
	25							
	AWS							
	WS							
DPT38	2							
	15							
	25							15.2
	AWS							18.9
	WS							30.6
	SS							38.1
DPT39	2							
	15						1,150	15.5
	25						15,000	
	AWS						1,700,000	15.3
	WS						1,400,000	26.3
DPT40	2							
	15							
	25							17.1
	AWS							14.9
	WS							27.8
	SS							44.5
DPT41	2							
	15						3,800	14.8
	25						27,000	

X-701B Interim Measure
Preliminary Soil Characterization Data
August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT41	AWS						130,000	15.7
	WS						390,000	21.3
DPT42	2							
	15							
	25							
	AWS							
	WS							
DPT43	2							
	15							15.9
	25							
	AWS							19.2
	WS							34.5
DPT44	2							
	15							
	25							
	AWS							
	WS							
DPT45	2							
	15							15.4
	25							
	AWS							18.3
	WS							29.2
DPT46	2							
	15						190	
	25						35,000	14.1
	AWS				0.15	11	820	20.3
	WS						1,200	26.7
DPT47	2	12	0.74	17				
	15							10.0
	25							
	AWS							17.6
	WS							20.8
DPT48	2	10	0.69	33	347	20		
	15						680	
	25						240	12.7
	AWS						19,000	17.9
	WS						67,000	23.4
DPT49	2	9.8	0.82	21	9.9	4.5		
	15						450	13.0
	25						36,000	
	AWS						4,500	15.4
	WS						18,000	20.7
DPT50	2							
	15							
	25							16.2
	AWS							20.0
	WS							23.5
	SS							46.7
DPT51	2							
	15						170	14.4
	25						4,350	
	AWS						12,000	16.3
	WS						170,000	15.0
DPT52	2							
	15							
	25							12.6
	AWS							19.6
	WS				0.32	12		21.6
	SS							44.9
DPT53	2	8.9	0.49	16	0.62	3.1		
	15						230	14.1
	25						14,000	
	AWS						36,000	18.3
	WS						69,000	21.3
DPT54	2	4.2	0.84	41				
	15							
	25							16.5
	AWS							19.0
	WS							27.5

X-701B Interim Measure

Preliminary Soil Characterization Data

August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT55	2	7.0	0.80	30				
	15							15.8
	25							
	AWS							21.3
	WS							46.0
DPT56	2	8.5	0.80	26				
	15							
	25							14.5
	AWS							15.7
	WS							34.6
DPT57	2	9.6	0.66	18				
	15							14.4
	25							
	AWS							16.6
	WS							31.1
DPT58	2	10	0.62	16				
	15							
	25							15.1
	AWS							17.3
	WS							31.1
DPT59	2							
	15							
	25							
	AWS							
	WS							
DPT60	2							
	15							
	25							12.5
	AWS							18.5
	WS							24.4
DPT61	2							
	15				0.32	8.1	260	14.1
	25						37,000	
	AWS						420	19.0
	WS						290	18.9
DPT62	2	11	0.65	20				
	15							
	25							12.1
	AWS							24.3
	WS							30.4
DPT63	2	11	0.51	10	16	2.5		
	15						210	14.5
	25						660	
	AWS						1,200,000	18.0
	WS						360,000	18.2
DPT64	2	3.7	0.16	7.9	24	1.4		
	15							
	25							13.8
	AWS							17.7
	WS							17.1
DPT65	2	7.4	0.88	27				
	15							11.9
	25							
	AWS							21.9
	WS							21.9
DPT66	2							
	15							
	25							17.7
	AWS							18.1
	WS							19.9
DPT67	2							
	15							13.1
	25							
	AWS							16.4
	WS							21.2
DPT68	2	8.8	0.85	29				
	15							
	25							13.3
	AWS							17.6

X-701B Interim Measure
Preliminary Soil Characterization Data
August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT68	WS							19.7
DPT69	2	9.0	0.83	27				
	15							14.8
	25							
	AWS							18.0
	WS							24.9
DPT70	2	22	0.72	18				
	15							
	25							14.1
	AWS							14.5
	WS							19.0
DPT71	2	6.8	0.72	12				
	15							15.4
	25							
	AWS							14.5
	WS							27.3
DPT72	2	11	0.65	11				
	15							
	25							14.1
	AWS							14.0
	WS							34.0
DPT73	2	10	0.76	15				
	15							14.8
	25							
	AWS							18.7
	WS							25.3
DPT74	2							
	15							
	25							
	AWS							
	WS							
DPT75	2							
	15							13.7
	25							
	AWS							18.4
	WS							23.2
DPT76	2							
	15							
	25							16.1
	AWS							16.6
	WS							22.6
DPT77	2							
	15						340	13.8
	25						1,400	
	AWS						270	16.8
	WS						230	20.8
DPT78	2							
	15							
	25							
	AWS							
	WS							
DPT79	2	8.7	0.53	28	47	3.5		
	15							13.8
	25							
	AWS							18.7
	WS							23.9
DPT80	2	2.0	0.040	2.7	3.6	1.1		
	15							
	25							14.9
	AWS							17.3
	WS							22.9
DPT81	2	6.8	0.65	15				
	15							15.8
	25							
	AWS							17.5
	WS							22.7
DPT82	2							
	15						220	
	25						445	13.2

X-701B Interim Measure

Preliminary Soil Characterization Data

August 4, 2009

		Arsenic	Beryllium	Nickel	Technetium-99	Uranium	Trichloroethene	2-d PS TOD
Location	Adjusted Horizon	mg/kg	mg/kg	mg/kg	pCi/g	ug/g	ug/kg	g/kg
DPT82	AWS						700	16.1
	WS						8,800	26.0
DPT83	2	12	0.71	23				
	15							13.0
	25							
	AWS							16.1
	WS							22.0
DPT84	2	9.9	0.66	12				
	15							
	25							11.7
	AWS							15.5
	WS							25.5
DPT85	2	7.2	0.63	21				
	15							14.6
	25							
	AWS							15.0
	WS							24.8
DPT86	2	9.3	0.97	20				
	15							
	25							16.4
	AWS							16.5
	WS							21.1
DPT87	2	19	0.79	25				
	15							16.5
	25							
	AWS							15.4
	WS							27.7
DPT88	2	8.0	0.69	13				
	15							
	25							15.1
	AWS							17.3
	WS							24.5
DPT89	2							
	15							
	25							
	AWS							
	WS							
DPT90	2							
	15							
	25							14.2
	AWS							13.8
	WS							32.2

X-701B Interim Action

Preliminary Soil Characterization Data
August 4, 2009

Trichloroethene

	15' bgs	25' bgs	Above Weathered Shale	Weathered Shale
	ug/kg	ug/kg	ug/kg	ug/kg
DPT01	220	230	270	270
DPT04	210	300	600	22,000
DPT06	240	260	200	220
DPT07	240	2,600	240	6,500
DPT10	200	420	910	5,800
DPT11	240	430	290	430
DPT12	220	1,400	2,300	110,000
DPT18	220	230	220	96,000
DPT22	240	45,000	7,600	83,000
DPT25	220	29,000	57,000	92,000
DPT26	1,600	31,000	81,000	880,000
DPT31	190	260	32,000	1,300,000
DPT33	1,100	590	9,500	140,000
DPT35	250	190	27,000	110,000
DPT39	1,150	15,000	1,700,000	1,400,000
DPT41	3,800	27,000	130,000	390,000
DPT46	190	35,000	820	1,200
DPT48	680	240	19,000	67,000
DPT49	450	36,000	4,500	18,000
DPT51	170	4,350	12,000	170,000
DPT53	230	14,000	36,000	69,000
DPT61	260	37,000	420	290
DPT63	210	660	1,200,000	360,000
DPT77	340	1,400	270	230
DPT82	220	445	700	8,800

Maximum	3,800	45,000	1,700,000	1,400,000
Average	553	10,294	132,914	208,221
Minimum	170	190	200	220

Appendix C
Interim Remedial Measure Design

Appendix D
Groundwater Calculations

Dewatering and Construction Evaluation at the Proposed X-701B Excavation Area

Excavation and treatment of soil is proposed to remediate trichloroethene (TCE) in the subsurface at X-701B. Dewatering has been proposed for the excavation and a sand layer is planned to be placed in the excavation when it is backfilled to facilitate, in summary, groundwater movement in the area. A numerical groundwater model has been developed to evaluate impacts of the proposed dewatering activities and the post construction stratigraphy.

Purpose

The objectives of the evaluation were to:

- Construct a calibrated, three-dimensional numerical model in MODFLOW2000 that can be used to simulate pre and post construction stratigraphy in addition to features during construction.
- Using steady-state simulations and advective transport, evaluate the proposed dewatering activities and post-excavation stratigraphy to estimate if:
    - The 7-Unit plume will migrate toward the construction area during dewatering activities
    - Dewatering will cause water levels to drop in adjacent finished cells, potentially exposing the oxidant-treated soils to air and the oxidant to leach from the treated soil into the excavation pit where dewatering is occurring.
    - Adding a sand layer above the treated/mixed soil in the excavation will cause the X-701B plume to extend to areas not previously contaminated
- Prepare a memorandum that summarizes the area-specific conceptual model and numerical model construction, and reviews the results of the simulations.
- Prepare a report that details the model construction, calibration, and verification and discusses the evaluation simulations.

This memorandum summarizes the area-specific conceptual model and numerical model construction, and reviews the results of the simulations. A detailed report is planned to be prepared and submitted.

Conceptual Model

The main components of a conceptual model are 1) hydrostratigraphy, 2) groundwater sources and sinks, and 3) groundwater flow directions. The conceptual model for X-701B is summarized below and more detailed information is presented in previous reports.

Hydrostratigraphy

Beneath the X-701B TCE area, the Minford clay and silt overlays the Gallia member. The Gallia member is a sandy silt approximately two to eight feet thick. In addition, the Gallia exhibits a fining upward sequence with the lower portion being the most conductive and the upper portion being the least conductive. The fining upward sequence of hydraulic conductivity was observed during the Intera aquifer performance test (APT) investigation. The Sunbury Shale is approximately 10 to 15 feet thick and lies beneath the Gallia. The majority of the flow within the bedrock occurs within the upper 25 feet of the Berea Sandstone, a fine-grained sandstone lying beneath the Sunbury Shale. The lower 10 feet of the Berea has numerous, interlayered shale laminations. The Bedford Shale sits beneath the Berea formation and is approximately 100 feet thick.

Aquifer Hydrogeologic Properties

The Gallia is the most hydraulically conductive geologic unit and provides a primary groundwater flow and contaminant migration pathway. The overlying Minford silt and clay has, in general, a lower hydraulic conductivity than the Gallia.

The Berea sandstone is the uppermost bedrock water-bearing unit. Hydraulic conductivity in the Berea is greater than the hydraulic conductivities of the shales lying above and below it.

The Minford clay member, Sunbury Shale, and Bedford Shale act as confining or semi-confining units. The Minford clay member forms a semi-confining layer above the Gallia, although to some extent, the upper Minford may be in hydraulic communication with the Gallia. The Sunbury Shale, when greater than four feet thick, forms a semi confining or confining layer above the Berea Sandstone that also restricts the downward migration of groundwater and contaminants from the Gallia to the Berea. The Bedford Shale below the Berea is the lowest confining layer in the groundwater flow system due to its great thickness and shale composition.

Groundwater Recharge and Discharge

In the X-701B area, the main source of recharge to the aquifer system is precipitation. A site-wide groundwater model included recharge rates of 2 to 3 inches per year across most of the site except for upland areas (CDM, 2007). During the steady-state flow calibration of the X-701B model, it was found that a recharge rate of 1.75 inches per year best fit the measured water levels collected in January 2009. In addition, two concrete water storage basins located adjacent to the X-633 Cooling Towers provide recharge.

Groundwater discharges to the East Drainage Ditch, Little Beaver Creek, X-700 and X-705 sumps, and the X-624 extraction wells.

Groundwater Flow Directions

Groundwater in the unconsolidated deposits generally moves toward one of the surface drainage features onsite. A groundwater divide oriented in the north/south direction is located between the 7-Unit plume and the X-701B plume. The groundwater on the west side of the divide flows toward the sumps in the X-700 and X-705 buildings. In the Berea Sandstone, the groundwater gradient is generally to the east and is not controlled by the shallower drains or sumps. The vertical gradient between the Gallia member and the Berea Sandstone is downward in the X-701B area, which is typical of most of the main plant area.

Numerical Groundwater Model

The numerical model was developed from information and data used to construct the conceptual model. The six main components of developing a numerical model are: developing a conceptual model and parameter estimates, choosing a model code, defining a model grid, assigning boundary conditions, performing a model calibration, and conducting a sensitivity analysis to confirm the final model parameters.

Model Code

The flow code MODFLOW2000 (Harbaugh et al 2000) and the particle pathline (advective transport) code MODPATH (Pollack, 1989) were used to perform the modeling activity. The groundwater modeling package Groundwater Vistas, Version 5.29, (Environmental Simulations, Inc. 2004) was used as the graphical user interface to pre- and post-process the model files.

Model Area and Grid

The numerical model domain represents approximately 635 acres located in Pike County, Ohio. The model extends vertically from the bottom elevation of 500 ft to an elevation of 770 ft. The lateral extent of the model was chosen so that standard hydrogeological boundaries (e.g. a significantly large creek, or a groundwater divide) could be used as model boundaries and so that the boundaries are located at significant distances where they would not adversely impact water levels near the X-701B plume. The model horizontal coordinate system is the plant coordinate system. The vertical coordinate system is National Geodetic Vertical Datum (NGVD 1929).

The model is horizontally discretized to a uniform grid size of 5 feet surrounding the area of proposed excavation. The grid size expands to a maximum size of 20 feet outside of the construction area. The model is comprised of 285 rows (4500 ft) and 447 columns (6120 ft). The grid spacing is shown on **Figure 1**.

Model Stratigraphy

The model was vertically discretized into ten layers to represent the X-701B hydrostratigraphy. The layers are presented in **Figure 2**.

- Model Layer 1 - Minford Member
- Model Layer 2 - Gallia Member (lowest K)

- Model Layer 3 - Gallia Member (lowest K)
- Model Layer 4 - Gallia Member (higher K)
- Model Layer 5 - Gallia Member (higher K)
- Model Layer 6 - Gallia Member (highest K)
- Model Layer 7 – Sunbury Shale
- Model Layer 8 - Berea Sandstone (lower sandy facies)
- Model Layer 9 - Berea Sandstone (shaley facies)
- Model Layer 10 - Bedford Shale

In some areas of the model, unconsolidated units are not deposited and bedrock extends to the land surface (Cuyahoga Shale). In these areas, this rock unit is represented throughout Layers 1 through 6.

Where layers have been incised by a gulley or stream, the lithology present at the drainage feature is the alluvium found in the field at that location. For example, where the Little Beaver Creek has cut into Layer 1, the lithology at the creek in Layer 1 is the alluvium that surrounds the water body, not the Minford clay/silt or Cuyahoga Shale.

The top elevation of Layer 1 is the surface topography. The top elevations of Layers 2, 7, and 8 were assigned based on site well boring logs. The Gallia member was split into five layers to accommodate current and future stratigraphy. The average Gallia thickness within the model throughout the excavation area is 6.5 feet. Layer 2 – 1.5 ft, Layer 3 – 1 ft, Layer 4 – 1 ft, Layer 5 – 1 ft, and Layer 6 – 2 ft. This vertical discretization allows for the current known stratigraphy and the proposed stratigraphy to be simulated. The Gallia member exhibits a fining upward sequence with Layer 6 being the most conductive and Layer 2 being the least conductive.

Boundary Conditions

Boundary conditions were added to the model to account for areas where groundwater enters or leaves the system. The three types of boundary conditions used in numerical modeling are specified head, specified flux, and mixed boundary conditions. All three types are used in the X-701B model. In MODFLOW, specified head is referred to as constant head. The specified flux boundary condition was used to represent recharge (a positive flux) and pumping wells (a negative flux). Head dependent (or mixed) boundary conditions were used to represent drains and general head boundaries.

Specified Head Boundaries

A constant head boundary is used to represent Holding Pond X-230J7. The surveyed water elevation of the pond is 649.97 ft NGVD.

Specified Flux Boundaries

Recharge was applied using a sub-regional model approach. Large areas of similar units and topography are assigned a recharge value associated with that unit and topography. The recharge values used in the model are consistent with the values used in previous models. Recharge rates of 1.5 to 1.75 inches per year are applied throughout Layer 1; the lower value being assigned to the less permeable Cuyahoga shale. Also, recharge was increased at three areas at the north edge of the model to simulate water loss at the three cooling towers in this area. The water loss rate is unknown, therefore, recharge was adjusted until estimated

groundwater levels in nearby wells agreed with measured values to the best extent possible. The final water recharge rate at each tower is 3.5 gpm.

Five extraction wells are simulated in the model. The X-700 and X-705 sumps were represented by extraction wells and extracted approximately 3,800,000 gallons from January until June 2009. In addition, the X624-NPW and X624-SPW extraction wells are the only other wells in the model domain that were in operation during the January 2009 synoptic water level event. These wells are located in a groundwater collection trench approximately 200 feet west of Little Beaver Creek. The trench runs in the north/south and east/west directions and is simulated in the model using a zone of high hydraulic conductivity. Flow rates for the extraction wells were obtained from monthly flow data and were incorporated in the model.

Mixed Boundaries

General Head Boundaries (GHB) were assigned to the north, south, east, and west model boundary in all layers. The elevations of the boundaries were estimated by extrapolating from water elevations in nearby stream and monitoring wells.

Drains were assigned to represent Little Beaver Creek and the East Drainage Ditch. The drain elevations are based on site topographic contours.

Flow Model Calibration

A steady state flow model calibration was performed by comparing the computed groundwater levels with field measurements collected in January 2009. This data set was selected because a complete set of X-701B wells was gauged during this event. It can be noted that the calibration contains a mix of simulated water levels that are greater than and less than the measured values, indicating an accurate steady state solution.

Figure 3 shows observed water level measurements compared to the predicted water level measurements. If a model is perfectly calibrated, the points would lie on a 45 degree line bisecting the graph. As shown in the figure, all points are near the line, which indicates reasonable calibration.

The model was considered calibrated when the residual mean and residual standard deviation was within five percent and 10 percent, respectively, of the observed range in heads and the computed potentiometric surface was equivalent to the observed surface. The residual mean is -0.36 (four tenths of one percent of the range in heads) and the residual standard deviation is approximately six percent of the range in heads. Also, the model-estimated potentiometric surfaces for the Gallia member (Layers 2 through 6) and the Berea Sandstone (Layer 8) are similar to the potentiometric surface developed from data collected in the field.

Figure 4 shows a compilation of hydraulic conductivity values derived from historical APTs. The hydraulic conductivity values within the model were adjusted to reflect the historical data to improve model calibration by refining the modeled conductivity.

During model development and calibration, several sensitivity analyses were performed to understand the model characteristics. The analyses identified that the model is sensitive to

recharge. Small recharge changes (less than 1.0 in/yr) result in dramatic (several feet) groundwater water level changes. The model is also sensitive to drain elevations and the Berea Sandstone conductivity.

Simulations

Simulation Set 1 – Evaluation of Dewatering Effects on the 7-Unit Plume

The first set of simulations evaluated the dewatering of a single excavation pit and its effects on the 7-Unit plume. In the model, dewatering points were placed within the excavation pit closest to the 7-Unit plume. The dewatering point was set approximately 1.5 feet above the top of Sunbury Shale to represent the water level during dewatering. Particle pathlines were generated starting from the eastern edge of the 7-Unit plume at the base of the Gallia to evaluate any changes to the hydraulic gradient due to dewatering. The travel times associated with the pathlines were reported to determine the duration of each particle path.

In the first simulation (Sim 1a), no horizontal flow barrier representing shoring panels around the excavation pit was assigned in the model. This simulation represented the worst case scenario of the wall offering no hydraulic control. The results of this simulation are shown on **Figure 5**. The particle flowpaths indicate that the particle placed along the edge of the 7-unit plume that is closest to the X-701B extraction area would be captured after approximately 180 days. The other two particles were not captured by X-701B dewatering. One was captured by the X-705 sump, while the other moved downward into the Sunbury, and crossed this unit in approximately 30 years, before entering the Berea and moving eastward. Groundwater movement through the Sunbury is nearly straight down due to the low hydraulic conductivity of the unit and the high vertical gradient across the unit.

In the second simulation (Sim 1b), a horizontal flow barrier was placed on all four sides of the dewatering pit to represent the shoring panels. The conductivity of the barrier was set at 1 ft/day. If the panel vendor provides a conductivity, that value can be used in the model in a subsequent simulation. The results of this simulation are shown on **Figure 6.** The particle flowpaths did not vary substantially from the flowpaths in Sim 1a, but the travel time of the captured particle increased from 180 to 224 days due to the effects of the simulated shoring panel (a decreased horizontal gradient between the 7-unit plume and the excavation pit).

The results of Sim 1b (shown on Figure 6) indicate that dewatering activities will affect the water level in adjacent cells, but may not reduce the level in the adjacent cells to the point where the bottom three feet of oxidant-treated soil would be exposed to air. In Sim 1b, the water level just outside of the shoring panel, is at approximately 644 ft NGVD, while the top elevation of the treated soil layer is slightly lower at 643 ft NGVD.

Simulation Set 2 – Evaluation of the Effect of Post-Excavation Stratigraphy on the X-701B Plume

The second set of simulations evaluated the long-term effects of the post-excavation backfill materials, including a conductive sand layer, on the groundwater flow field in the vicinity of the

X-701B plume. For evaluation, particle flowpaths were generated starting at the base of the Gallia near the X-701B plume source area.

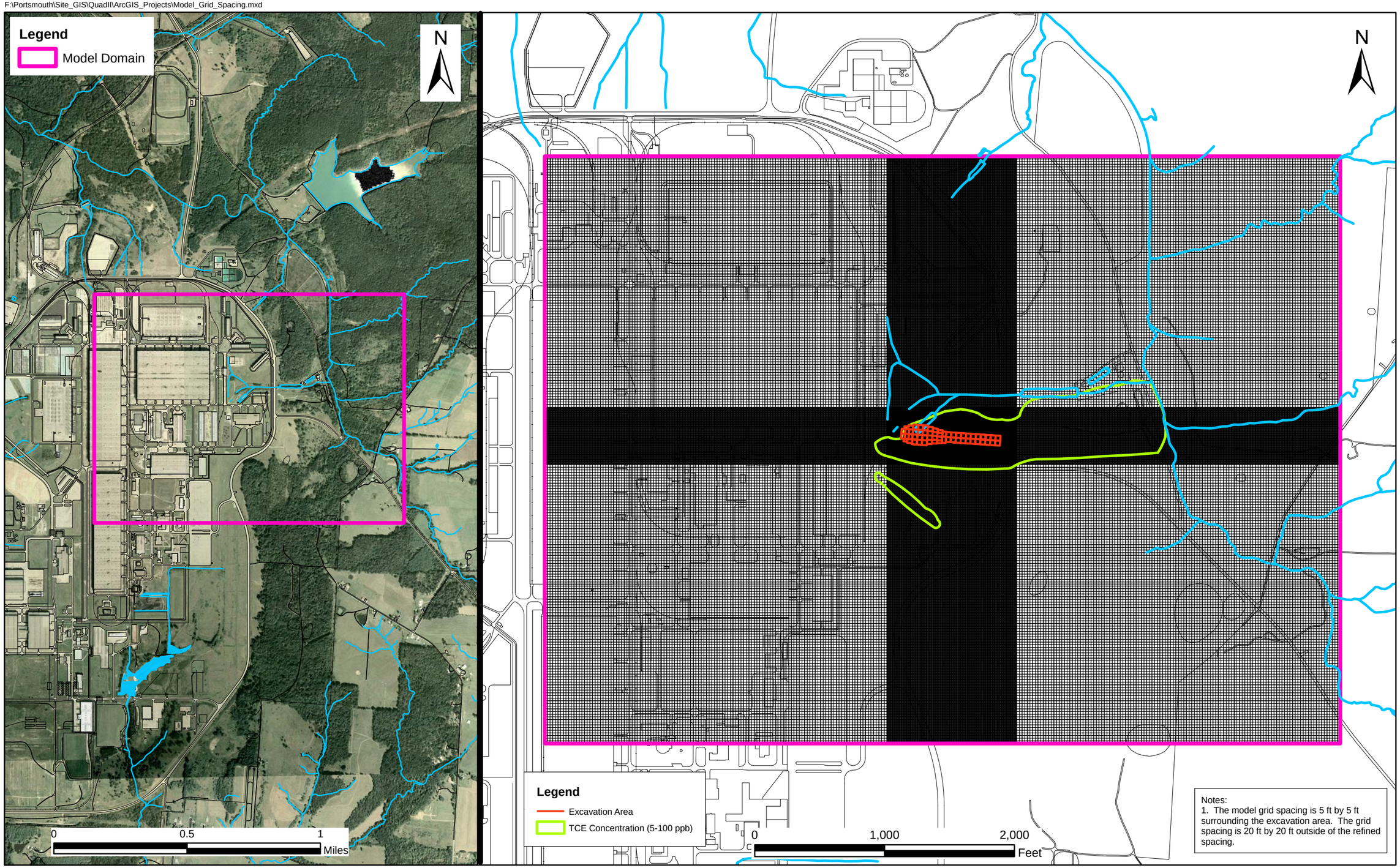
In the first simulation (Sim 2a), the current (pre-excavation) stratigraphy was used as a baseline condition. The results of this simulation are shown in **Figure 7**. All three particle flowpaths move eastward and in a slight counterclockwise direction, before moving downward into the Sunbury before reaching the eastern extent of the excavation area. The middle particle, started near the west end of the excavation area, moves down into the Sunbury the quickest after traveling the shortest distance east.

In the second simulation (Sim 2b), the model stratigraphy was changed across the entire excavation area to reflect future stratigraphy. The bottom three feet of Gallia (*i.e.*, Layers 5 and 6) was replaced with a mixture of Gallia material. The mixing of high and low conductive material will most likely lower the average hydraulic conductivity. The hydraulic conductivity for the lower three feet of the Gallia was simulated at 15 ft/day. Two feet of sand was placed above the lower three feet of mixed material (Layers 3 and 4). The purpose of the sand layer, in summary, is to facilitate groundwater movement. The conductivity of the sand layer was simulated at 100 feet/day. A conductivity value of 100 ft/day was used to represent the sand. If the supplier provides a different conductivity value for the material, that value can be used in a subsequent simulation. The material above the sand layer (*i.e.,* Layer 2) represents a predominantly silt unit and was modeled with a hydraulic conductivity of 1 ft/day. If conductivities of the new stratigraphic units are provided, those values can be used in subsequent simulations. The results of this simulation are shown on **Figure 8**. The groundwater flowpaths are not substantially different from the baseline simulation. In Sim 2b, there is a slight compression of groundwater flowpaths in a north-south direction; that is, flowpaths move toward the excavation area. This is likely due to the installation of the conductive (100 ft/day) sand layer which serves as a conduit for enhanced groundwater flow along the central axis of the X-701B groundwater plume. Comparison of the two simulations suggests that the changed post-excavation stratigraphy is not likely to significantly alter the flow field at the site. Therefore, the plume would not likely be subjected to spreading in the north-south direction. The new flow field may even help to contain the plume within its current north and south borders.

Model Functionality and Limitations

The model was developed to evaluate the dewatering activities and the proposed new stratigraphy at the X-701B area. The model structure is sufficient for these evaluations and will allow new data to be incorporated, when available, to refine the model. Additional data could be used to refine the hydrostratigraphic characteristics and decrease the uncertainty of the model. This memorandum provides a summary of the model development and simulations. A report is planned to be prepared to comprehensively document the model construction, functionality and limitations, and the simulation results.

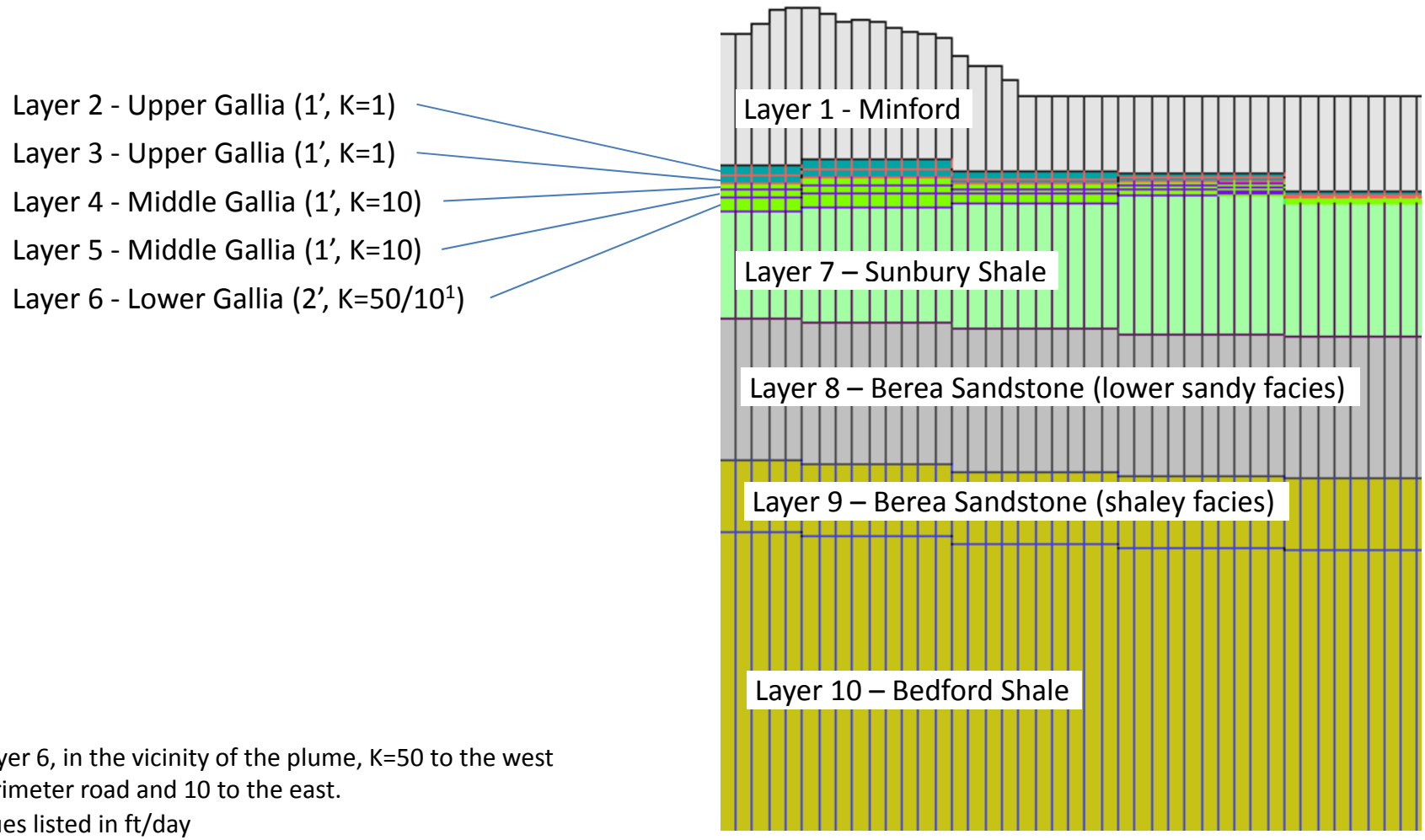
F:\Portsmouth\Site_GIS\QuadIII\ArcGIS_Projects\Model_Grid_Spacing.mxd



CDM

Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

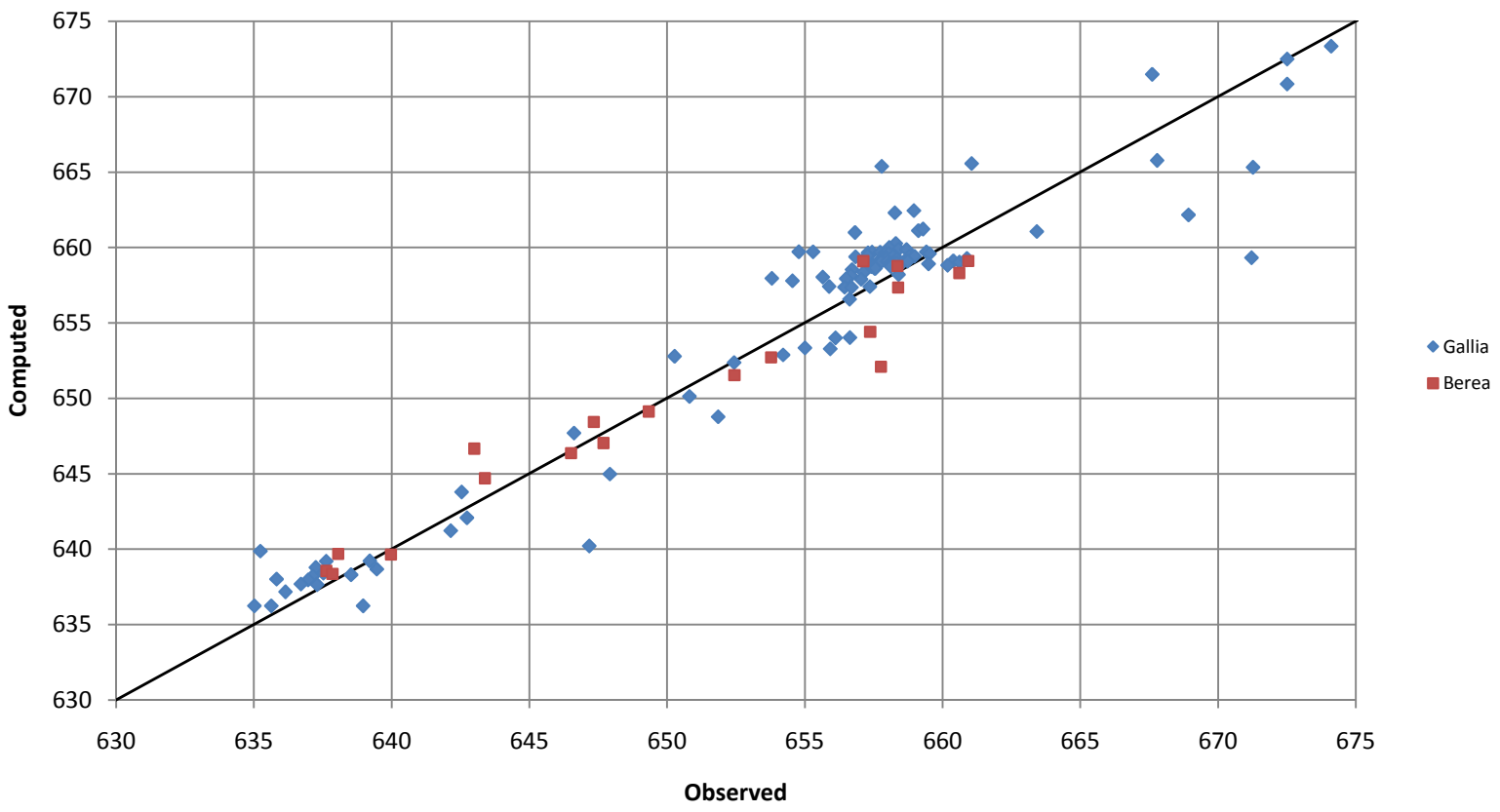
Figure 1
Model Grid Spacing



[1]In Layer 6, in the vicinity of the plume, K=50 to the west of perimeter road and 10 to the east.
K values listed in ft/day

CDM

Figure 2 – Model Stratigraphy



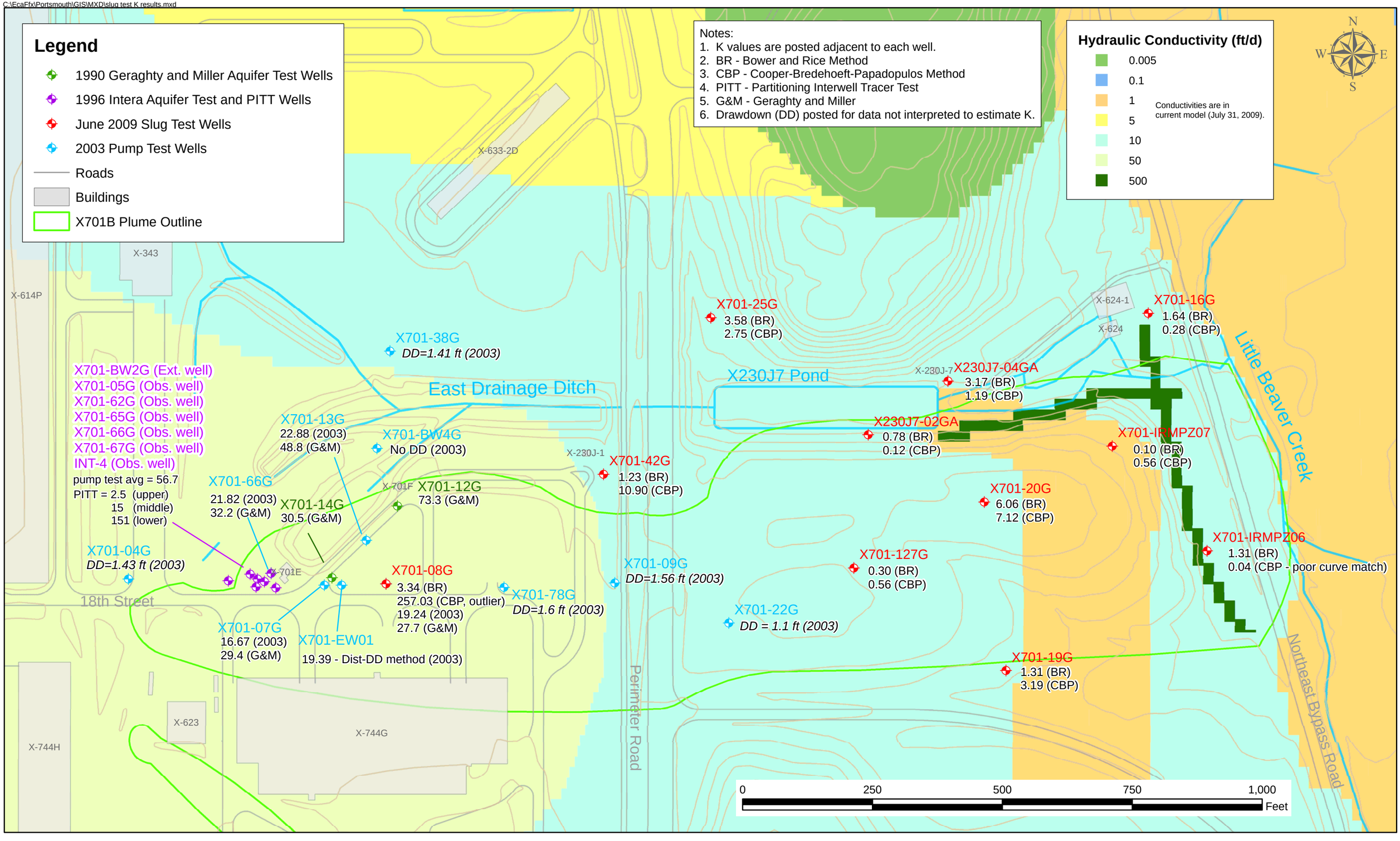
Residual Mean = -0.36
Residual Standard Deviation = 2.57
Residual Sum of Squares = 870.53
Absolute Residual Mean = 1.85
Minimum Residual = -7.58
Maximum Residual = 11.91
Observed Range in Head = 40.65
Residual Standard Deviation / Range = 0.06

Figure 3
Calibration Results
(Computed vs. Observed
Target Values)

CDM

Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

C:\EcaFfx\Portsmouth\GIS\MXD\slug test K results.mxd



CDM

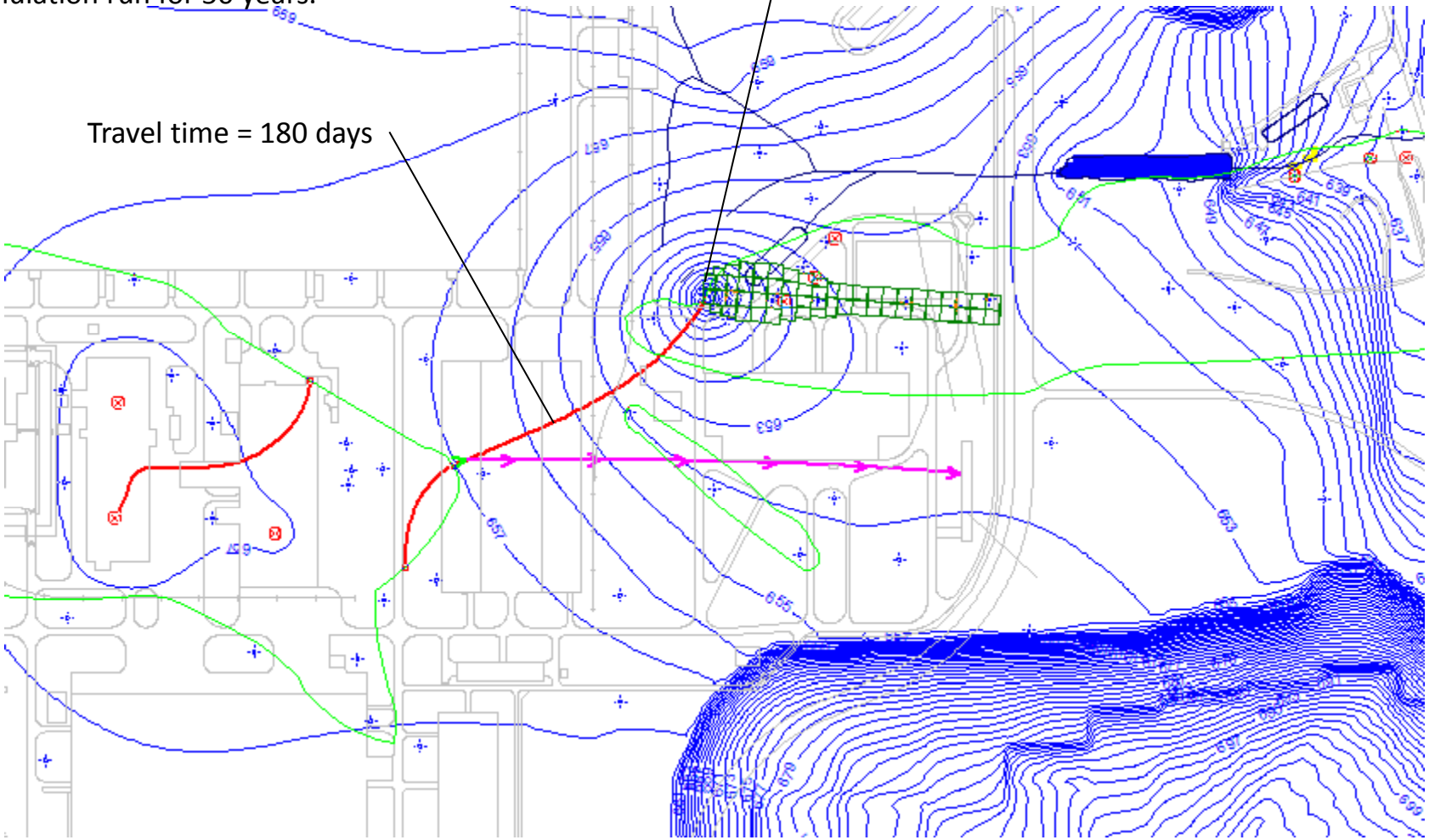
Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

Figure 4
Gallia Hydraulic Conductivity Compilation

Drain in excavation pit set = 641.5 ft

3 particles placed on 7-unit plume edge
Flowpath arrows placed at 5-yr intervals.
Simulation run for 50 years.

Travel time = 180 days



CDM

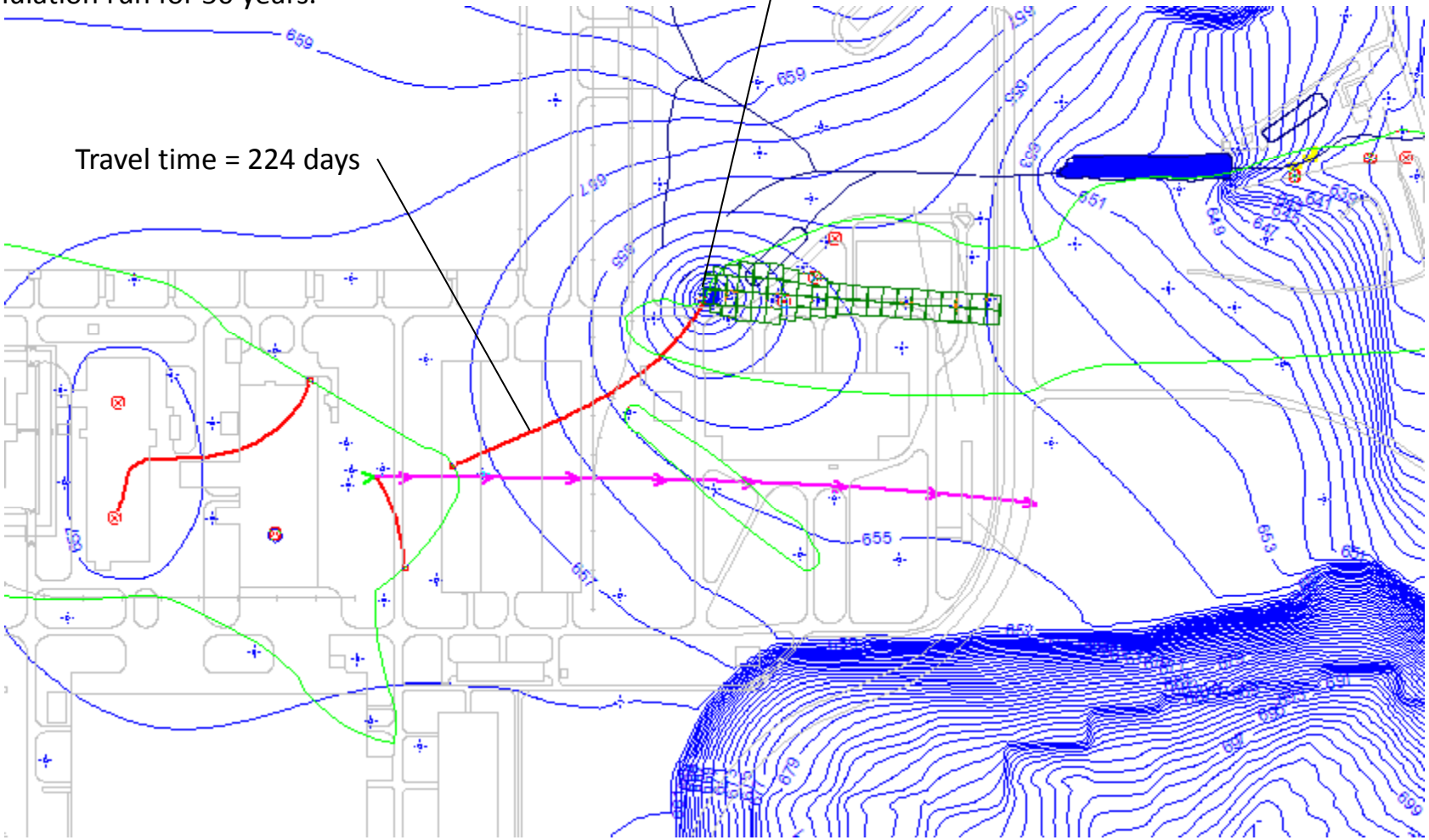
No shoring panels
6 dewatering points near excavation pit corners

Figure 5 – Sim 1a
Gallia (Layer 6)
Plan View

Drain in excavation pit set = 641.5 ft

3 particles placed on 7-unit plume edge
Flowpath arrows placed at 5-yr intervals.
Simulation run for 50 years.

Travel time = 224 days



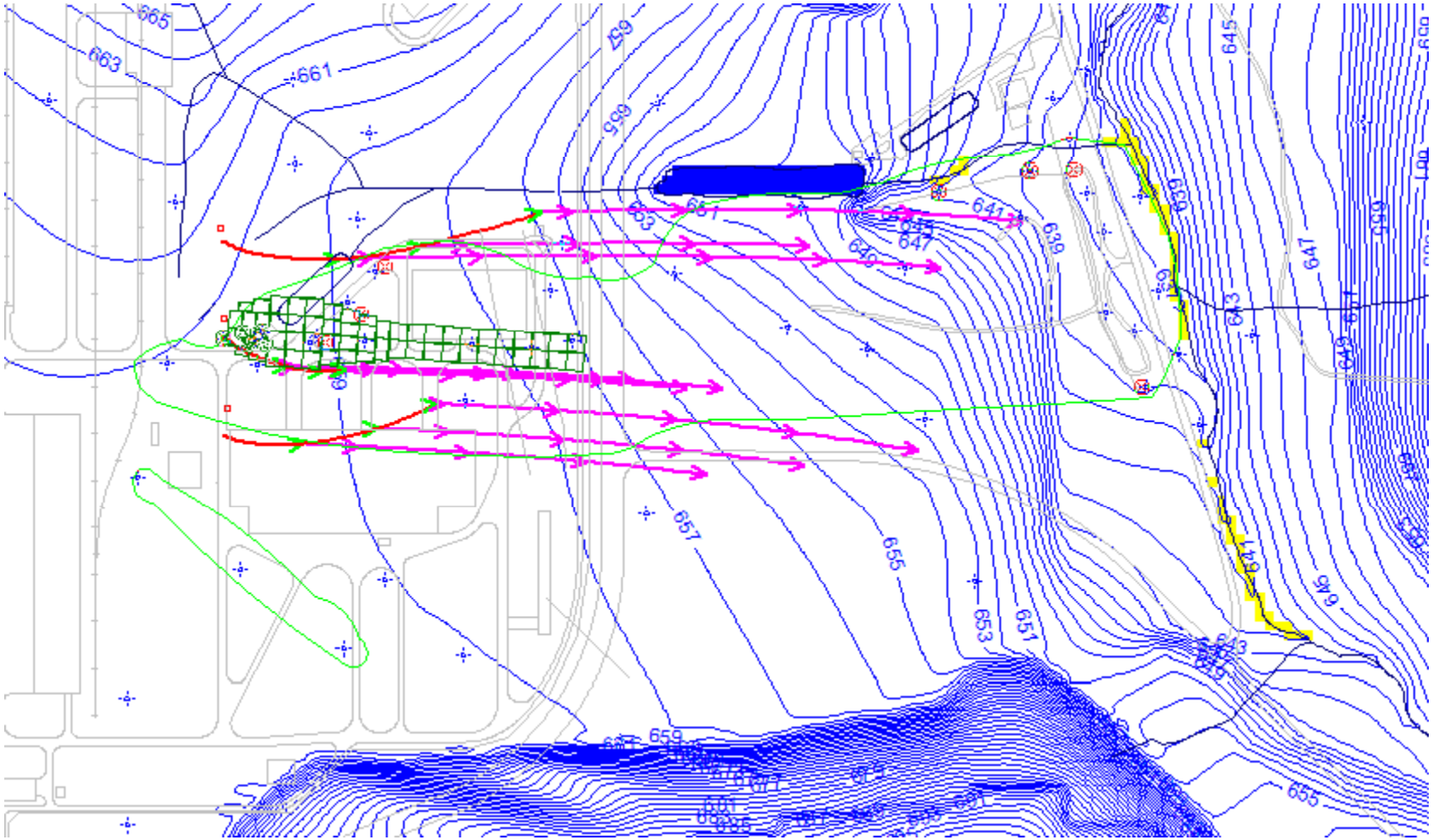
CDM

Shoring panel K = 1 ft/day (thickness = 0.5 ft)
6 dewatering points near excavation pit corners

Figure 6 - Sim 1b
Gallia (Layer 6)
Plan View

Particles placed at 3 locations near
X701-B source area. Placed at 3 elevations
spanning layer 6.

Flowpath arrows placed at 5-yr intervals. Simulation run for 50 years.



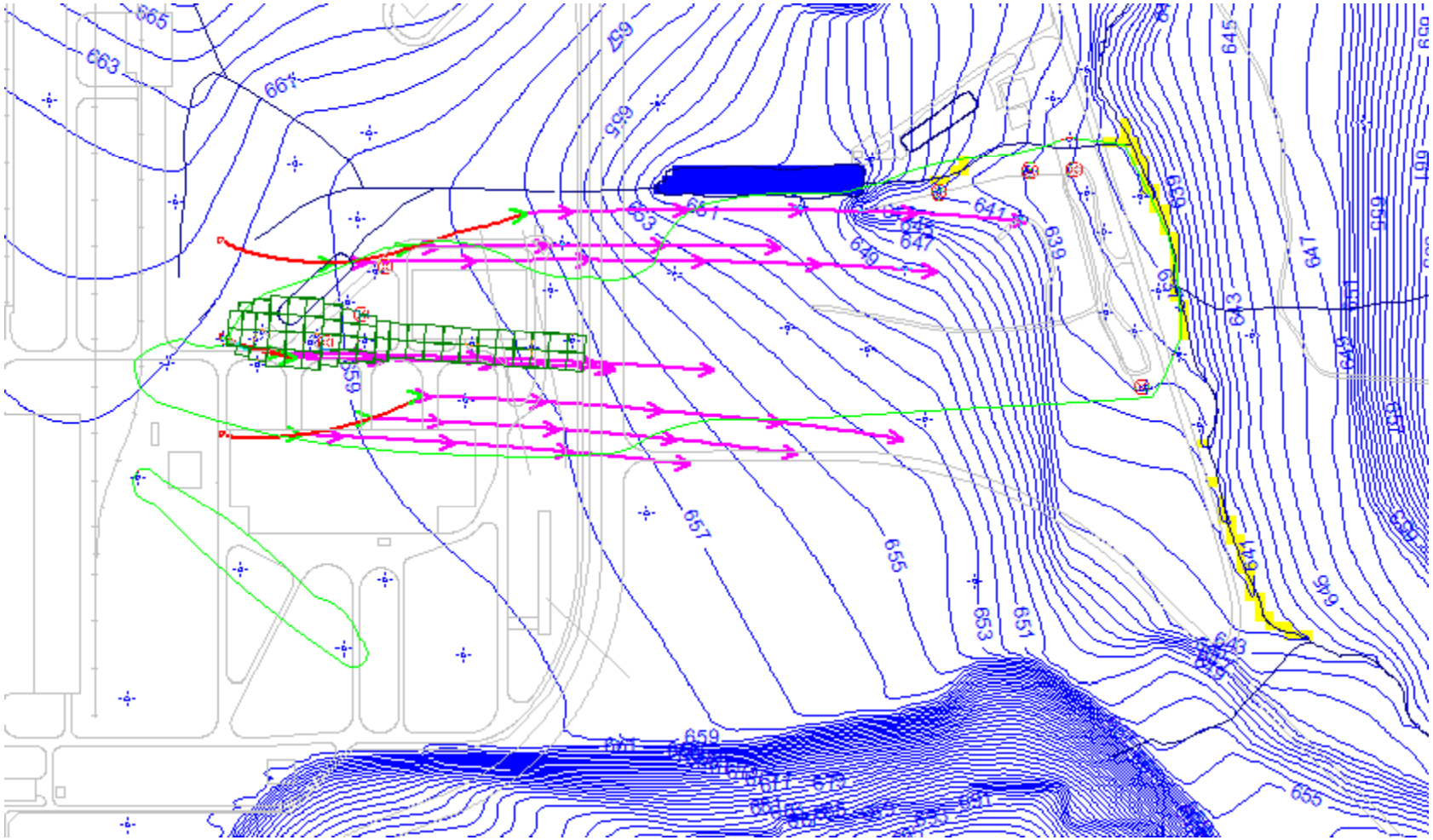
CDM

Current (pre-excavation) site stratigaphy used

Figure 7 - Sim 2a
Gallia (Layer 6)
Plan View

Particles placed at 3 locations near
X701-B source area. Placed at 3 elevations
spanning layer 6.

Flowpath arrows placed at 5-yr intervals. Simulation run for 50 years.



CDM

Future stratigraphy placed across excavation area
Including 100 ft/day sand layer.

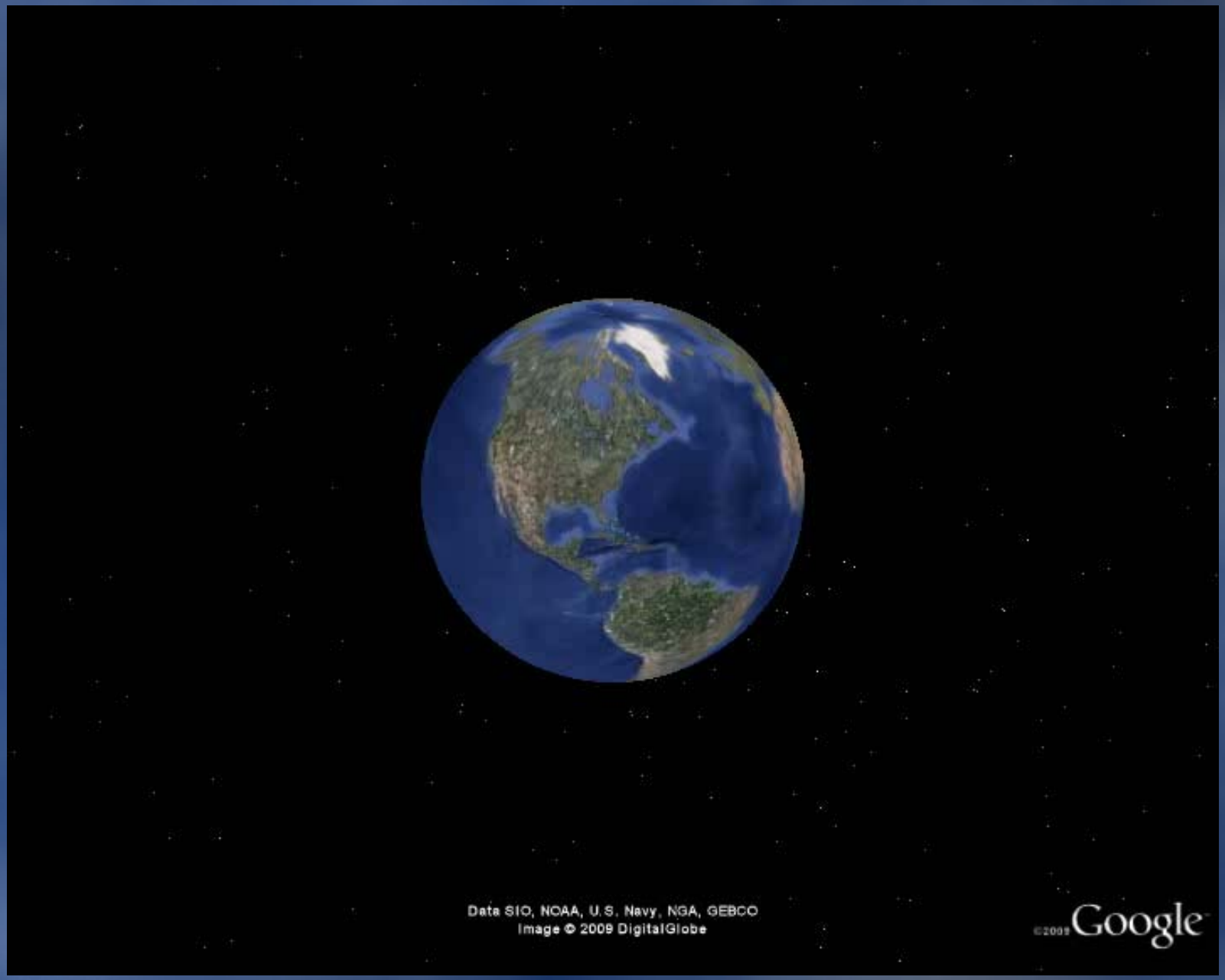
Figure 8 - Sim 2b
Gallia (Layer 6)
Plan View

Quadrant II - X701B
GW Flow Model

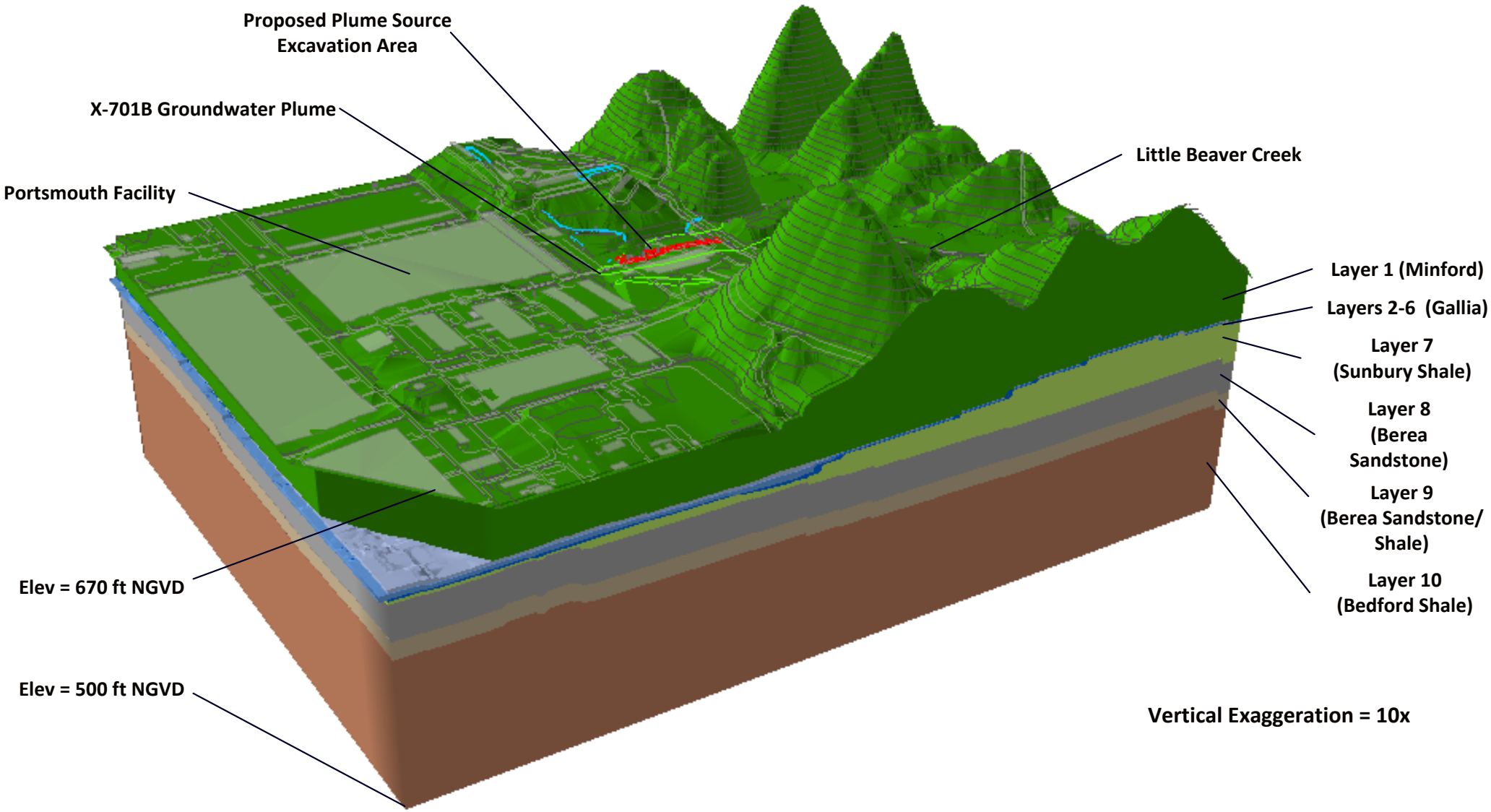
Evaluation of Proposed Dewatering Activities and Backfill Stratigraphy

August 4, 2009

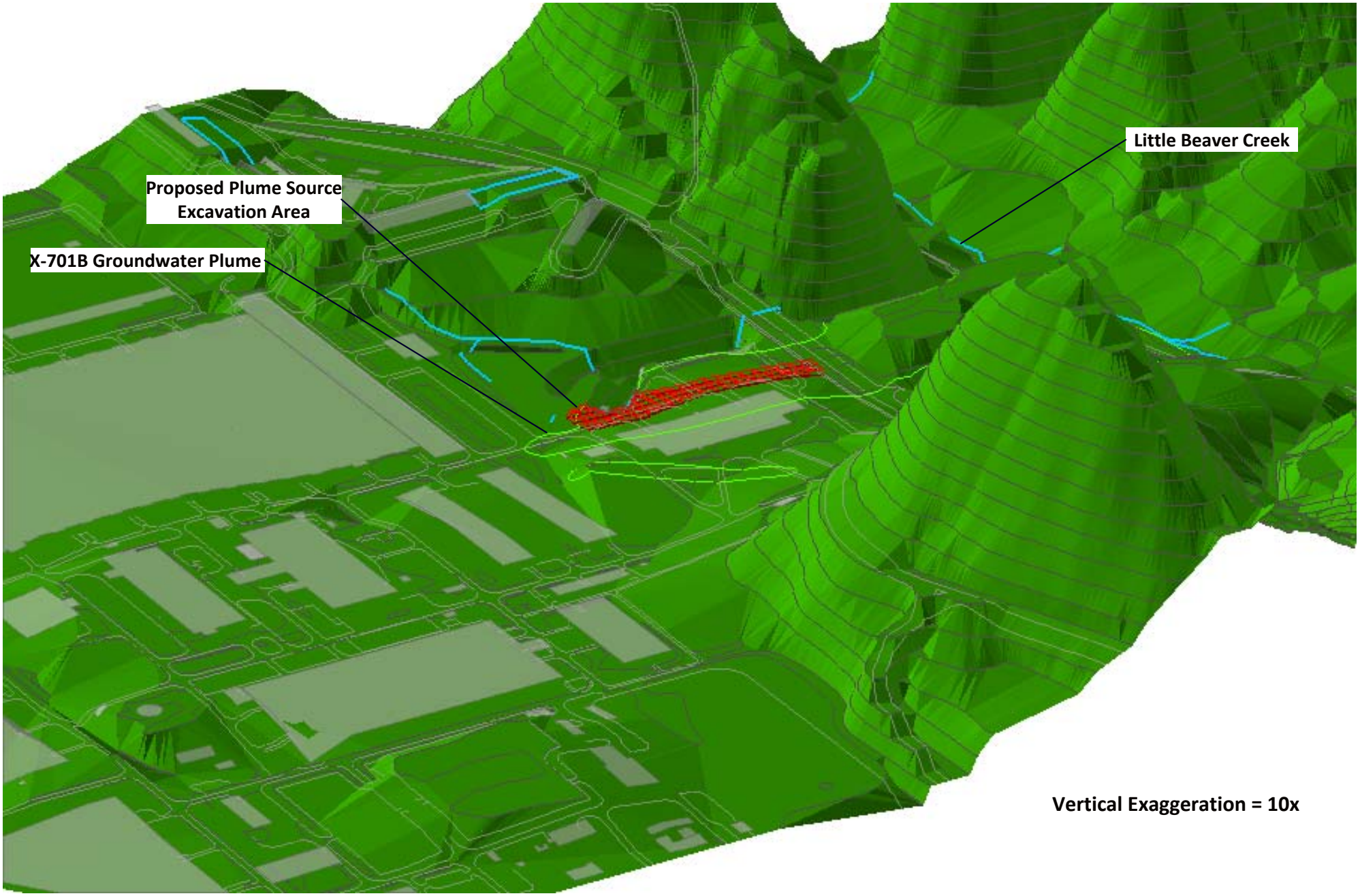
Quad II/701B Study Area Location



Quad II/701B Study Area

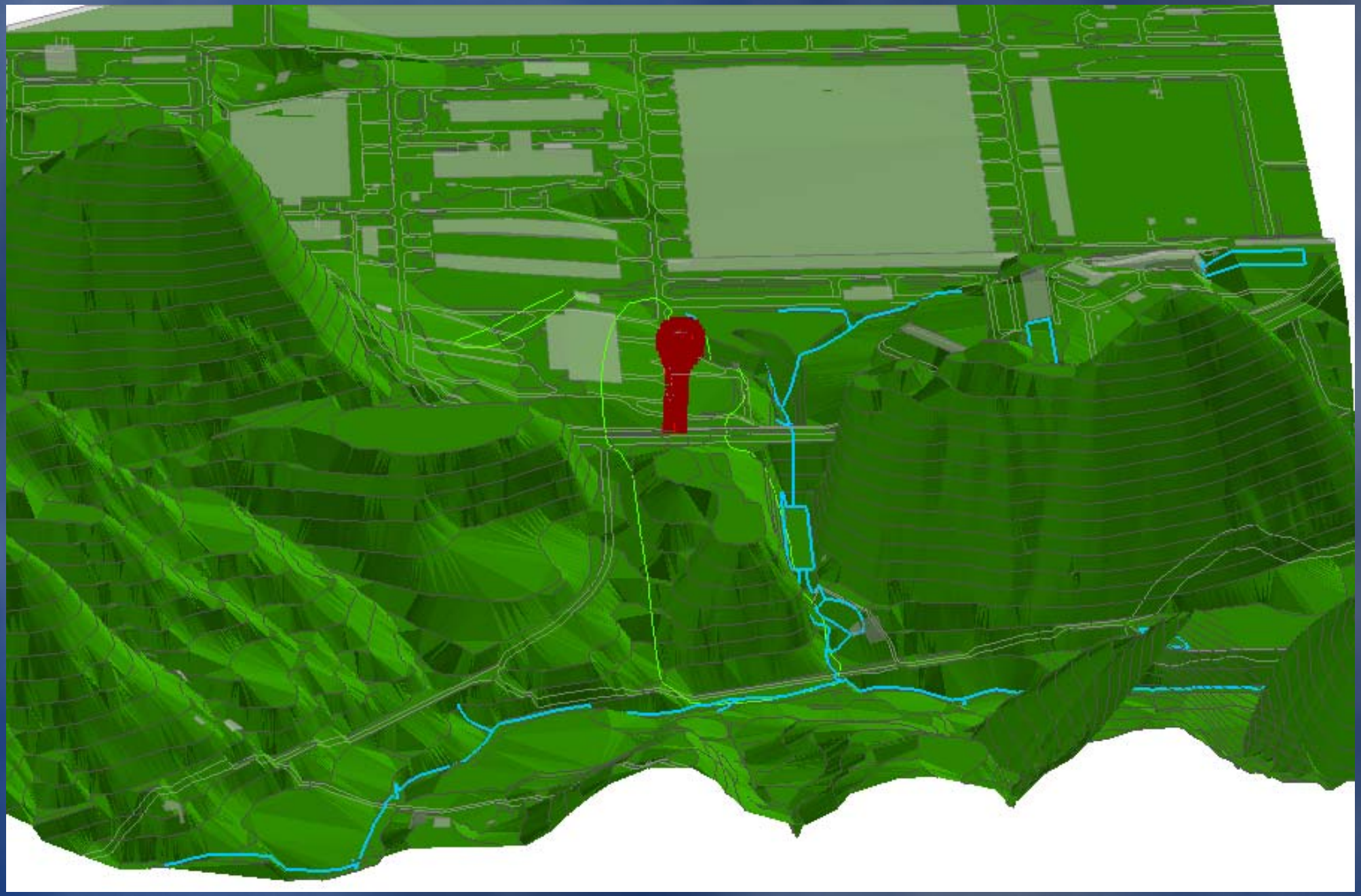


Quad II/701B Study Area Features and Land Surface
View Northeast



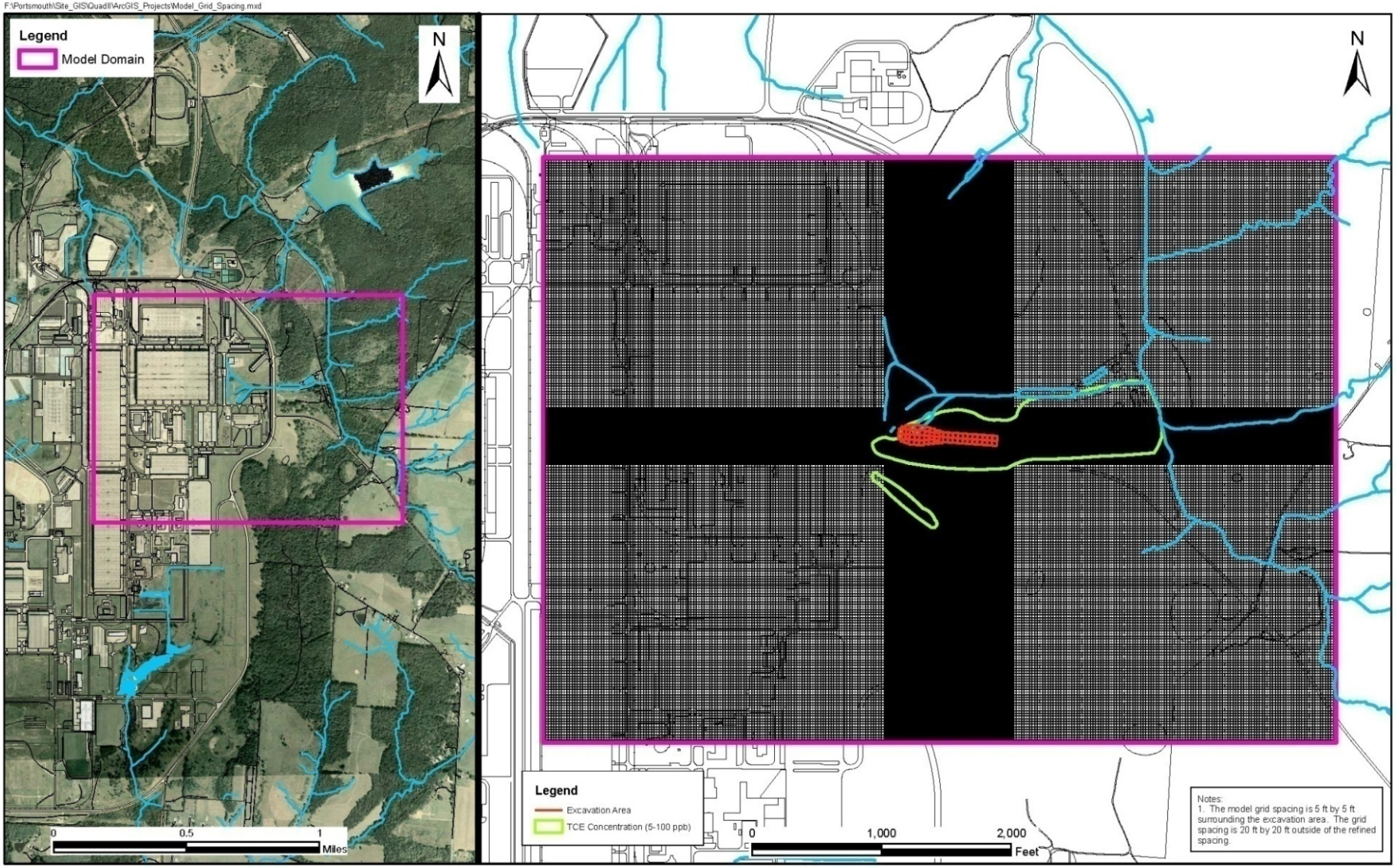
Quad II/701B Study Area Features and Land Surface
View South

Quad II/701B Study Area Features and Land Surface
View West



Model Grid Spacing

F:\Portsmouth\Site_GIS\Quadlll\ArcGIS_Projects\Model_Grid_Spacing.mxd

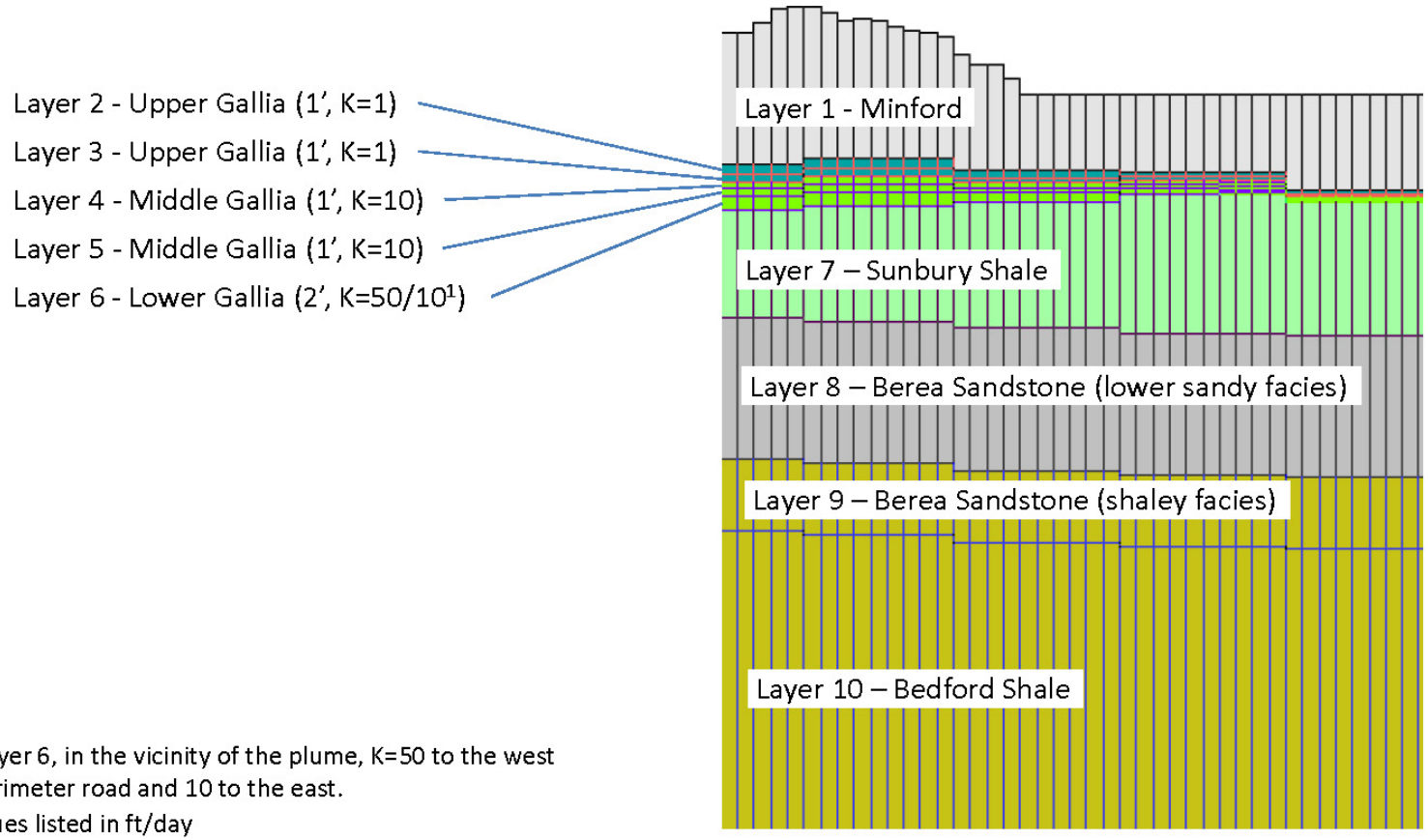


CDM

Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

Figure 1
Model Grid Spacing

Quad II/701B Numerical Model Stratigraphy

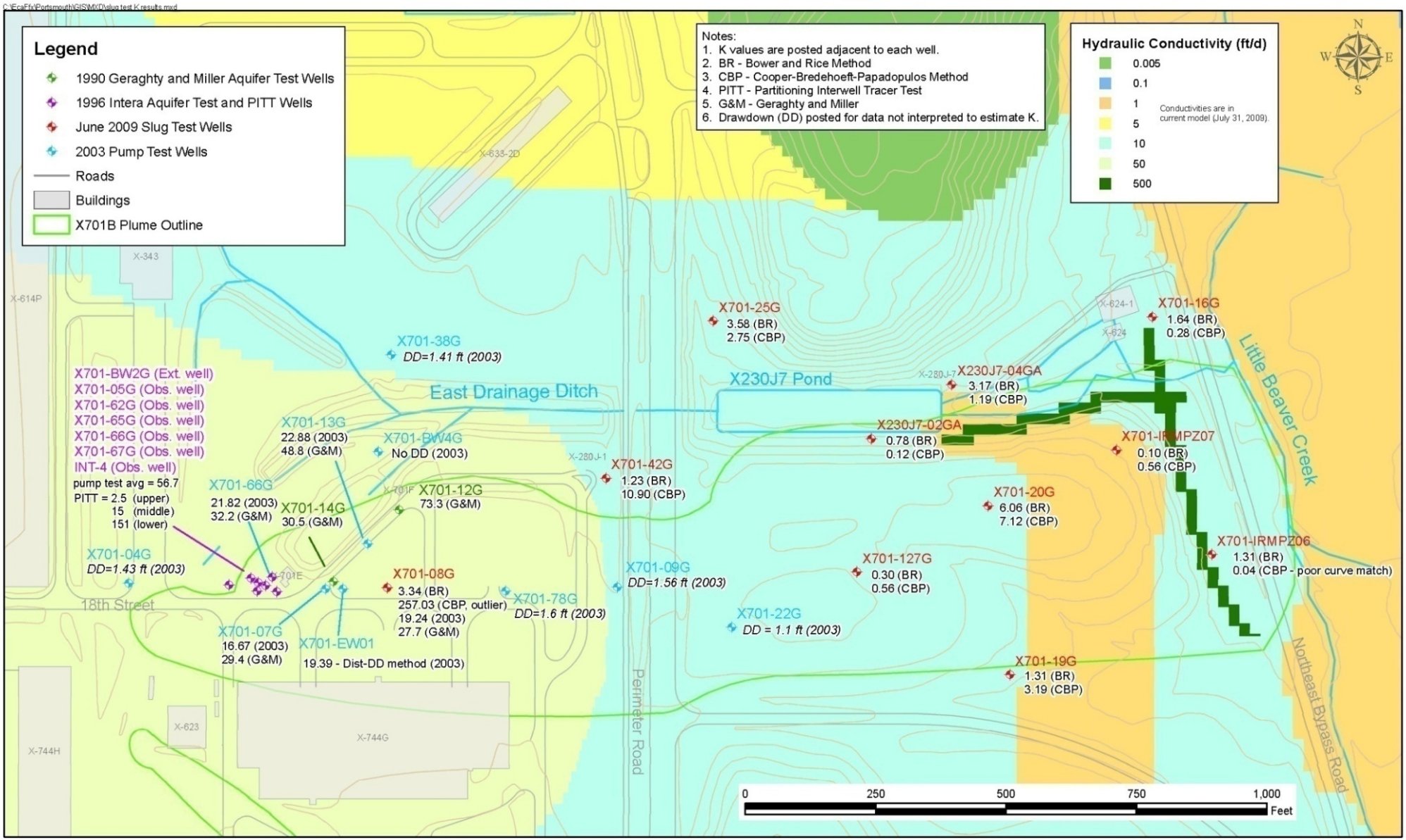


[1]In Layer 6, in the vicinity of the plume, K=50 to the west of perimeter road and 10 to the east.
K values listed in ft/day

CDM

Figure 2 – Model Stratigraphy

Gallia Hydraulic Conductivity Compilation

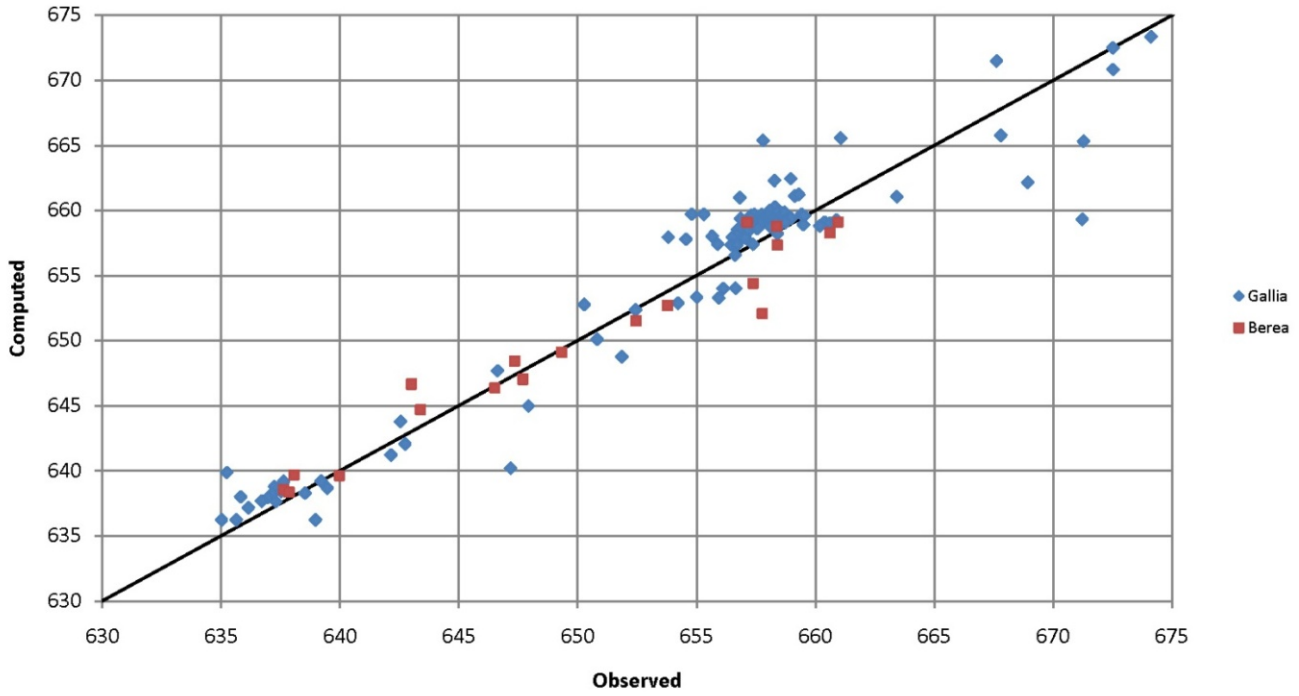


CDM

Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

Figure 4
Gallia Hydraulic Conductivity Compilation

Calibration Results Summary



Residual Mean = -0.36
Residual Standard Deviation = 2.57
Residual Sum of Squares = 870.53
Absolute Residual Mean = 1.85
Minimum Residual = -7.58
Maximum Residual = 11.91
Observed Range in Head = 40.65
Residual Standard Deviation / Range = 0.06

CDM

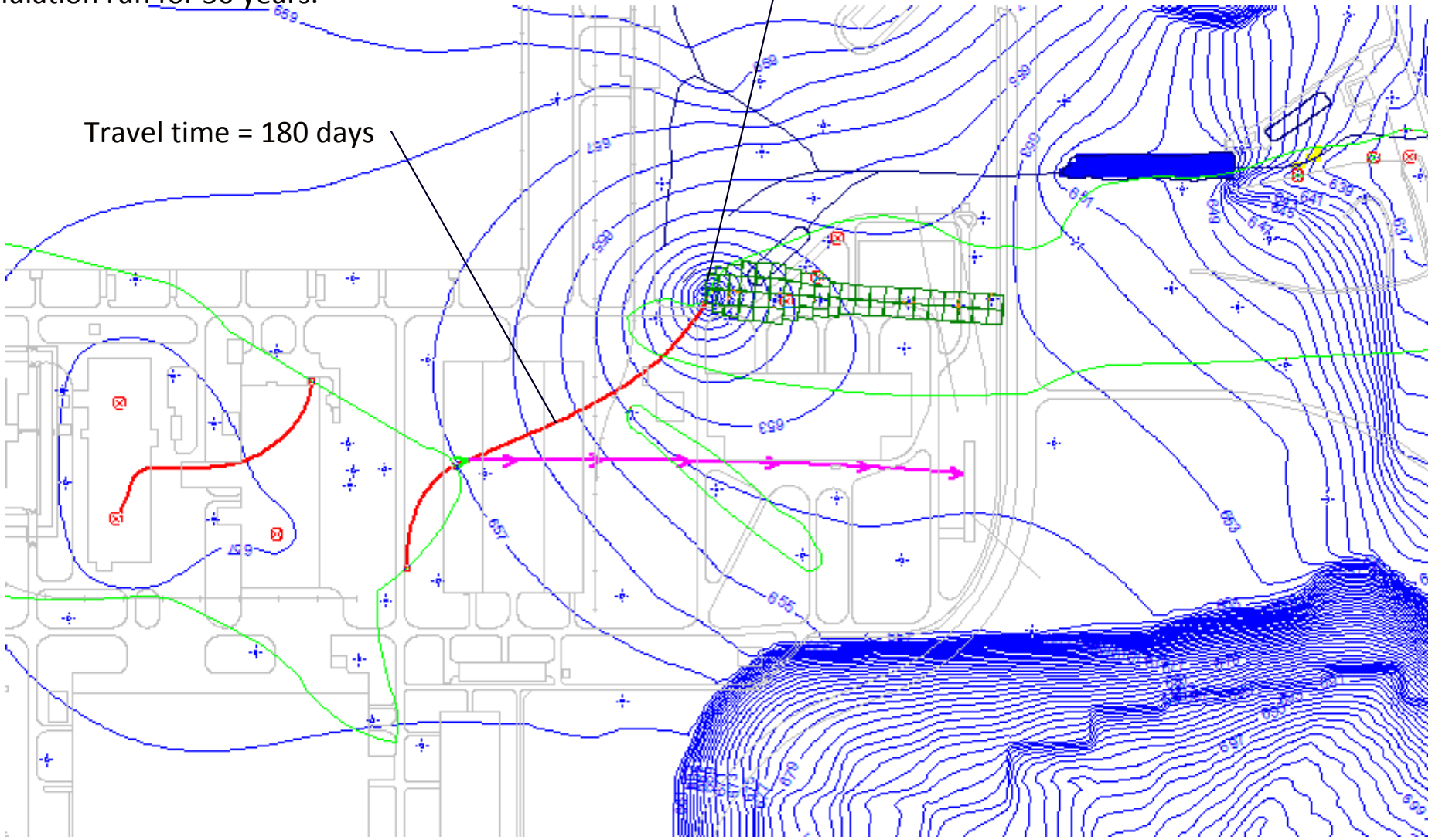
Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

Figure 3
Calibration Results
(Computed vs. Observed
Target Values)

3 particles placed on 7-unit plume edge
Flowpath arrows placed at 5-yr intervals.
Simulation run for 50 years.

Water level in excavation cell 641.5 ft (i.e., depth of water in Gallia Member approximately 1.5 ft)

Travel time = 180 days



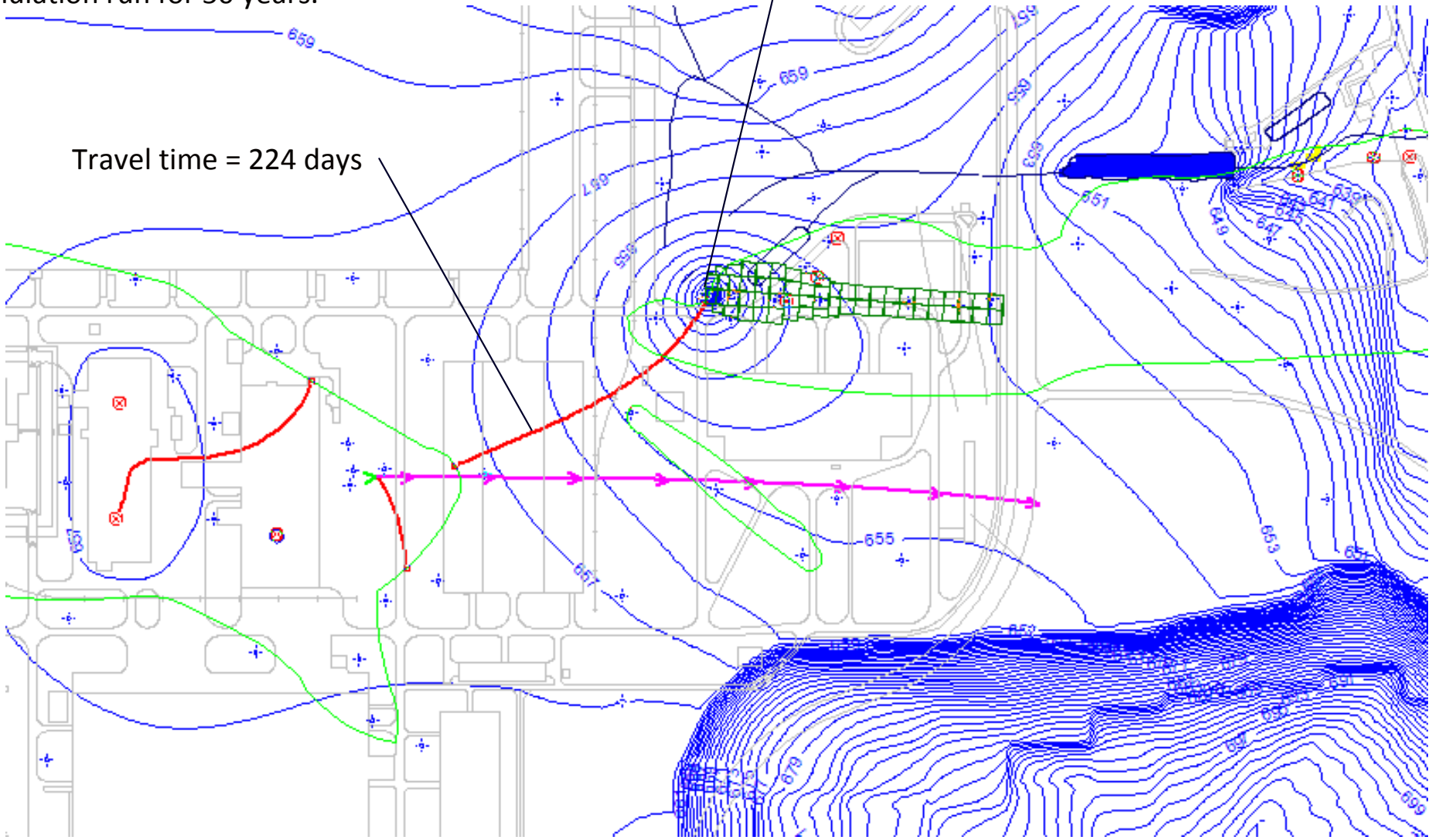
No shoring panels
6 dewatering points near excavation walls

Figure 5 – Sim 1a
Gallia (Layer 6)
Plan View

Water level in excavation cell 641.5 ft

3 particles placed on 7-unit plume edge
Flowpath arrows placed at 5-yr intervals.
Simulation run for 50 years.

Travel time = 224 days

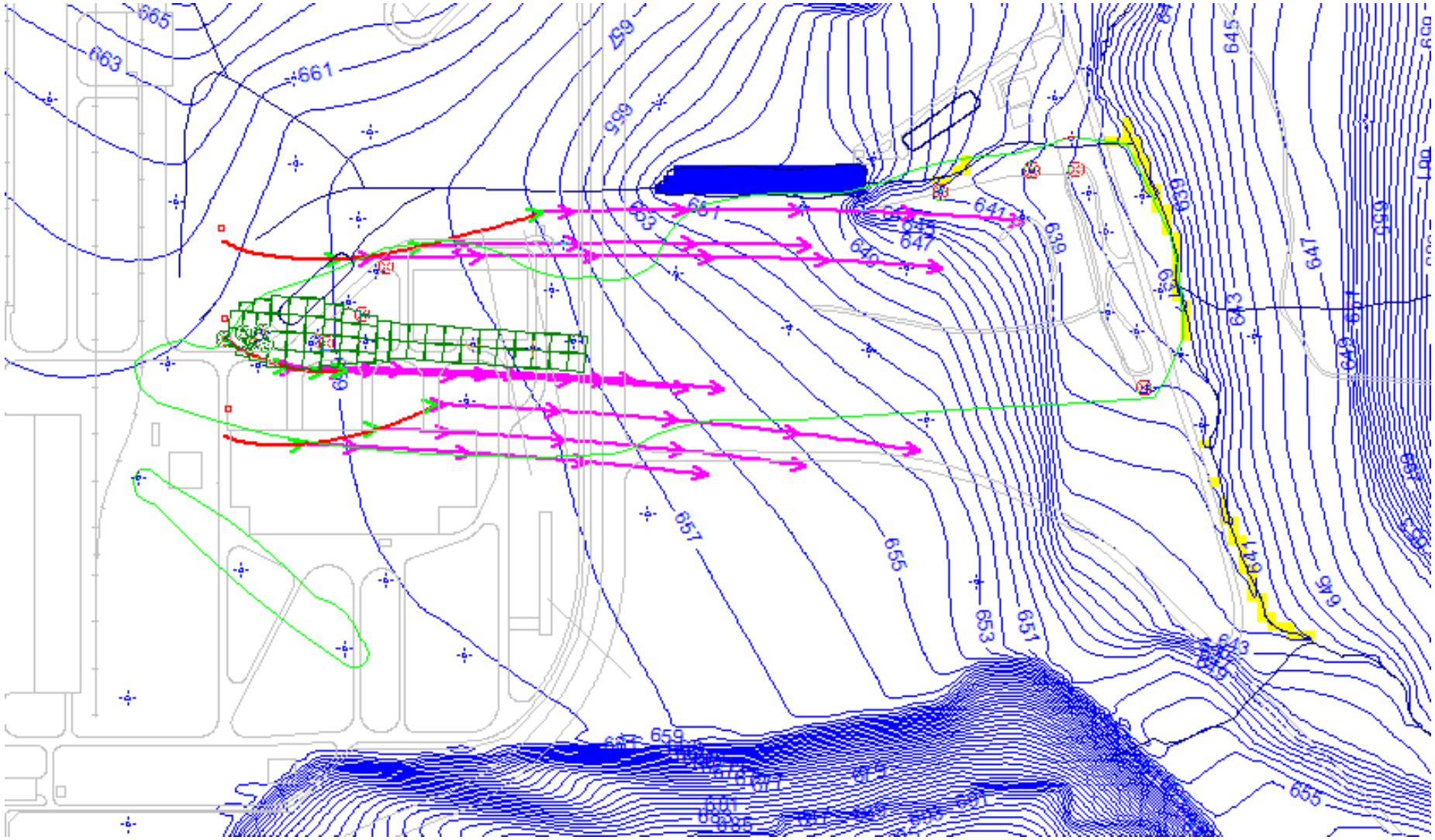


Shoring panel K = 1 ft/day (thickness = 0.5 ft)
6 dewatering points near excavation walls

Figure 6 - Sim 1b
Gallia (Layer 6)
Plan View

Particles placed at 3 locations near
X701-B source area. Placed at 3 elevations
spanning bottom of the Gallia Member

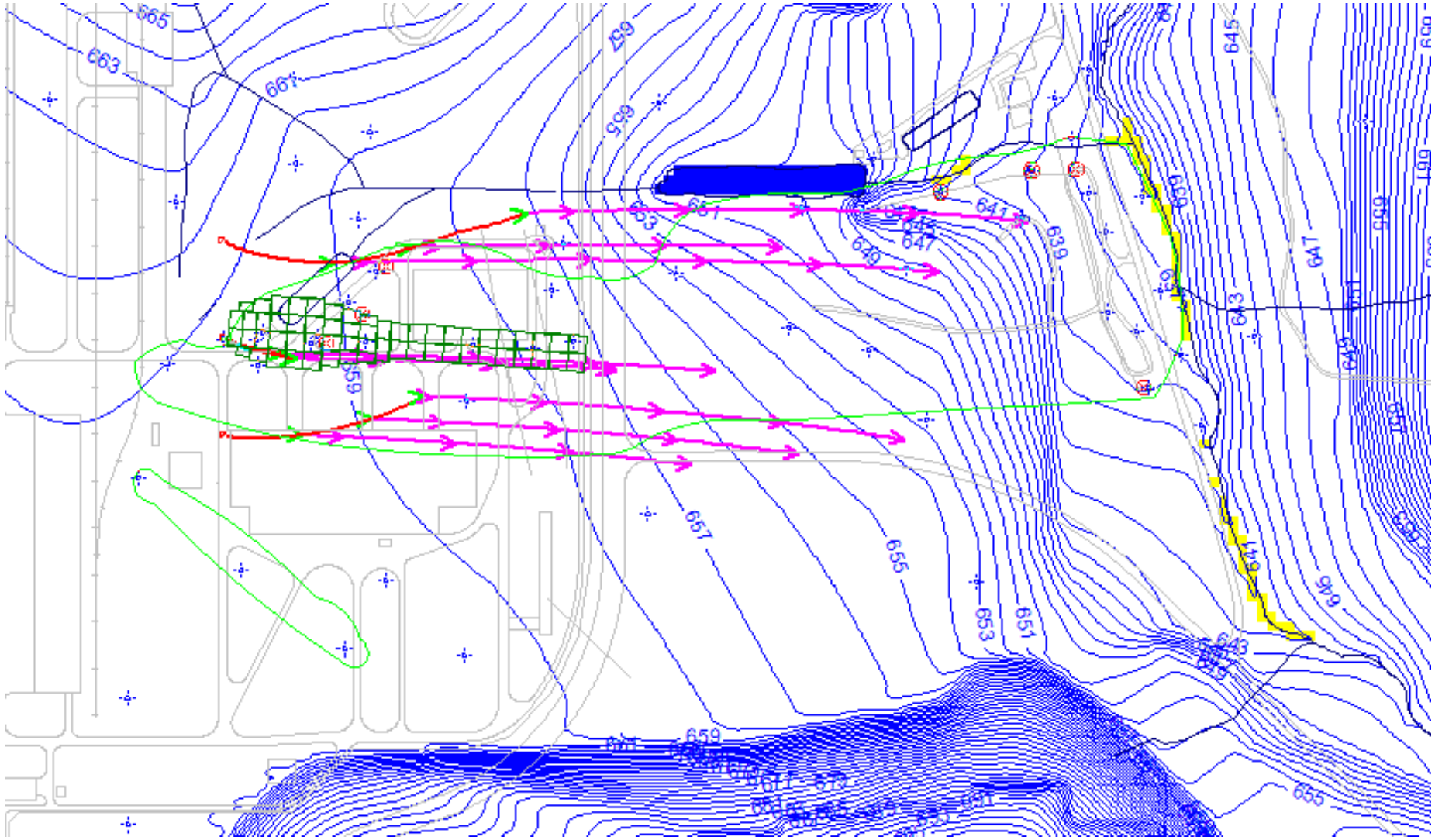
Flowpath arrows placed at 5-yr intervals. Simulation run for 50 years.



Current (pre-excavation) site stratigraphy used

Figure 7 - Sim 2a
Gallia (Layer 6)
Plan View

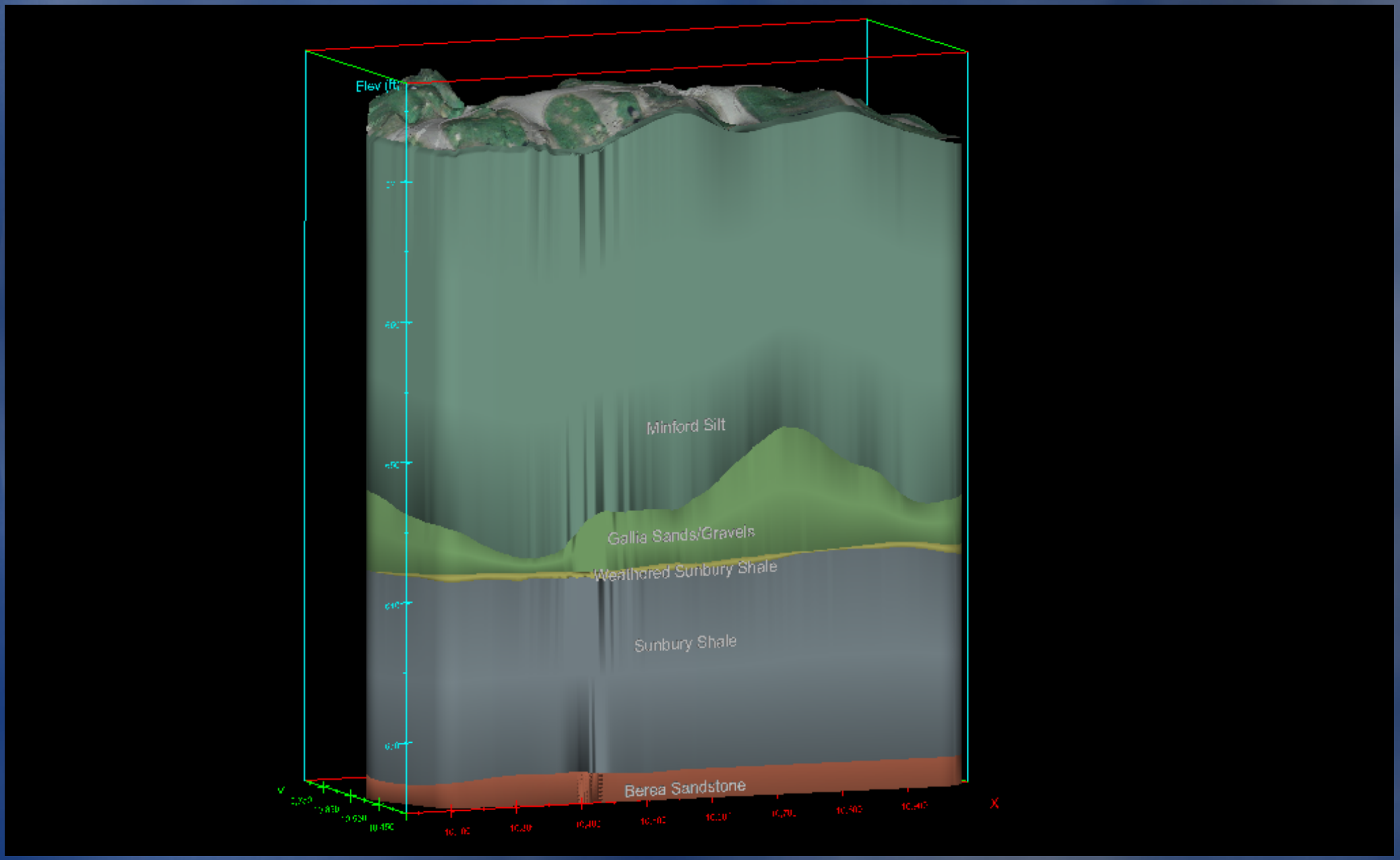
Particles placed at 3 locations near
X701-B source area. Placed at 3 elevations
Spanning bottom of Gallia Member.
Flowpath arrows placed at 5-yr intervals. Simulation run for 50 years.



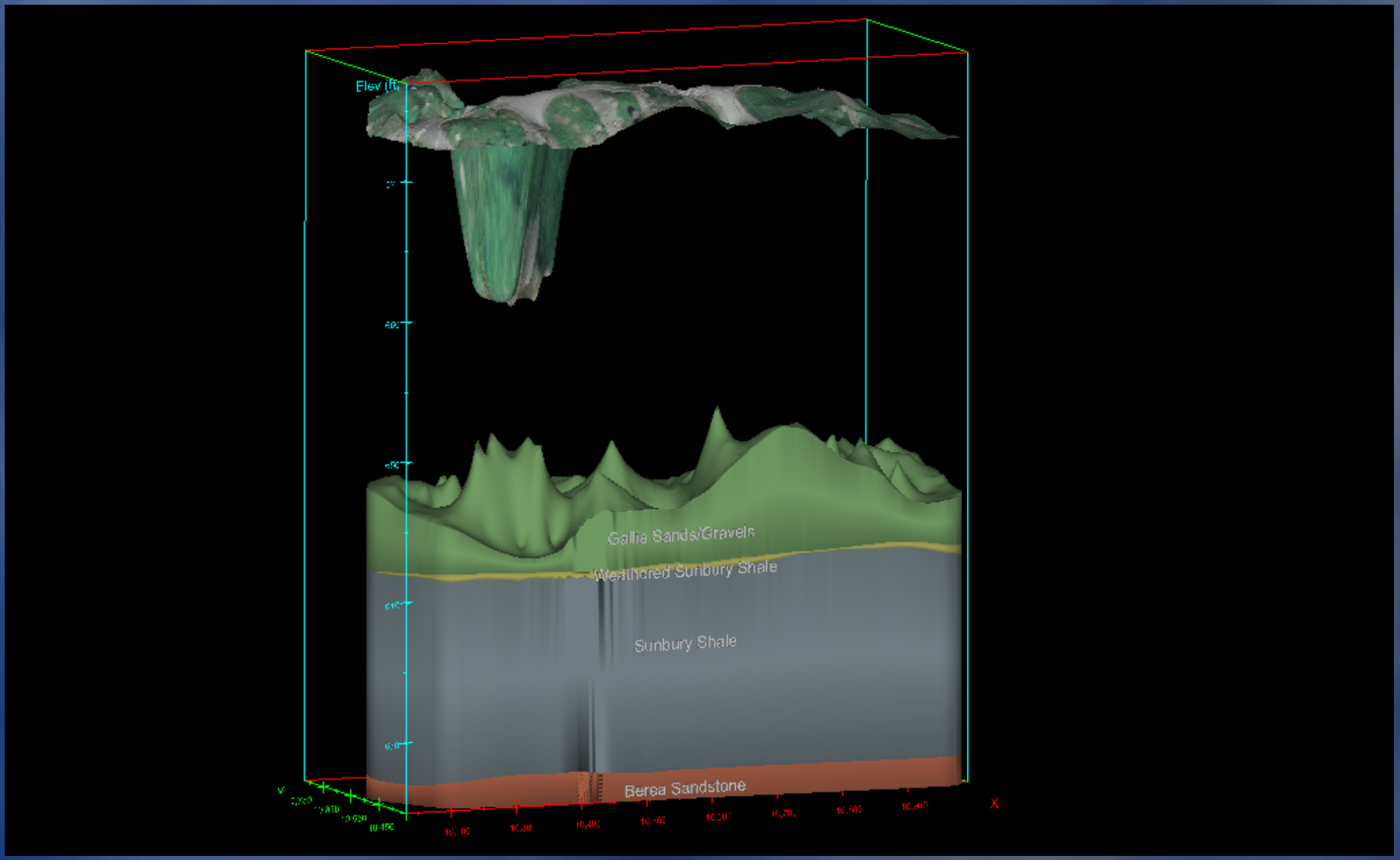
Future stratigraphy placed across excavation area
Including 100 ft/day sand layer

Figure 8 - Sim 2b
Gallia (Layer 6)
Plan View

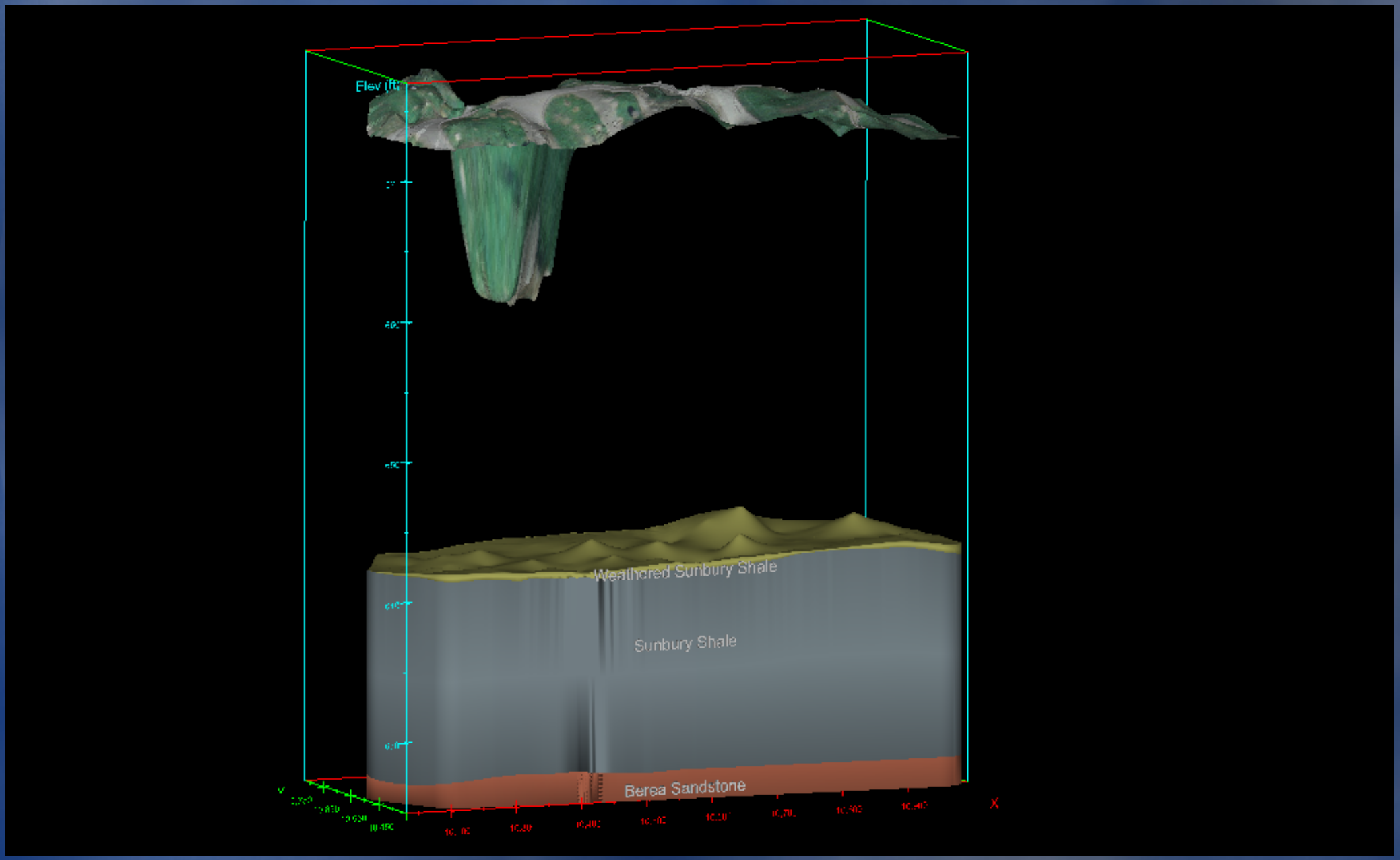
Stratigraphy in Vicinity of Proposed Excavation



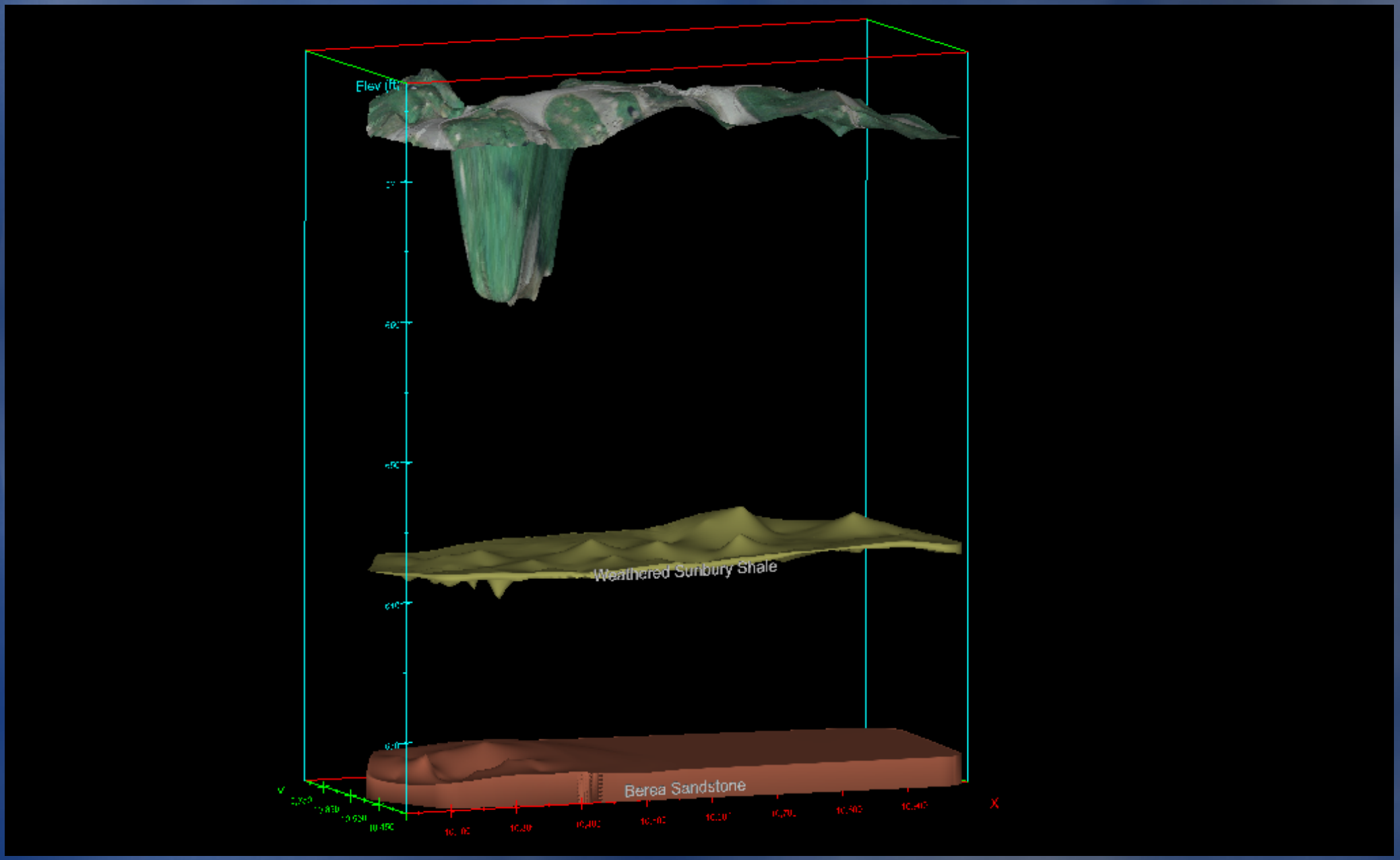
Stratigraphy in Vicinity of Proposed Excavation



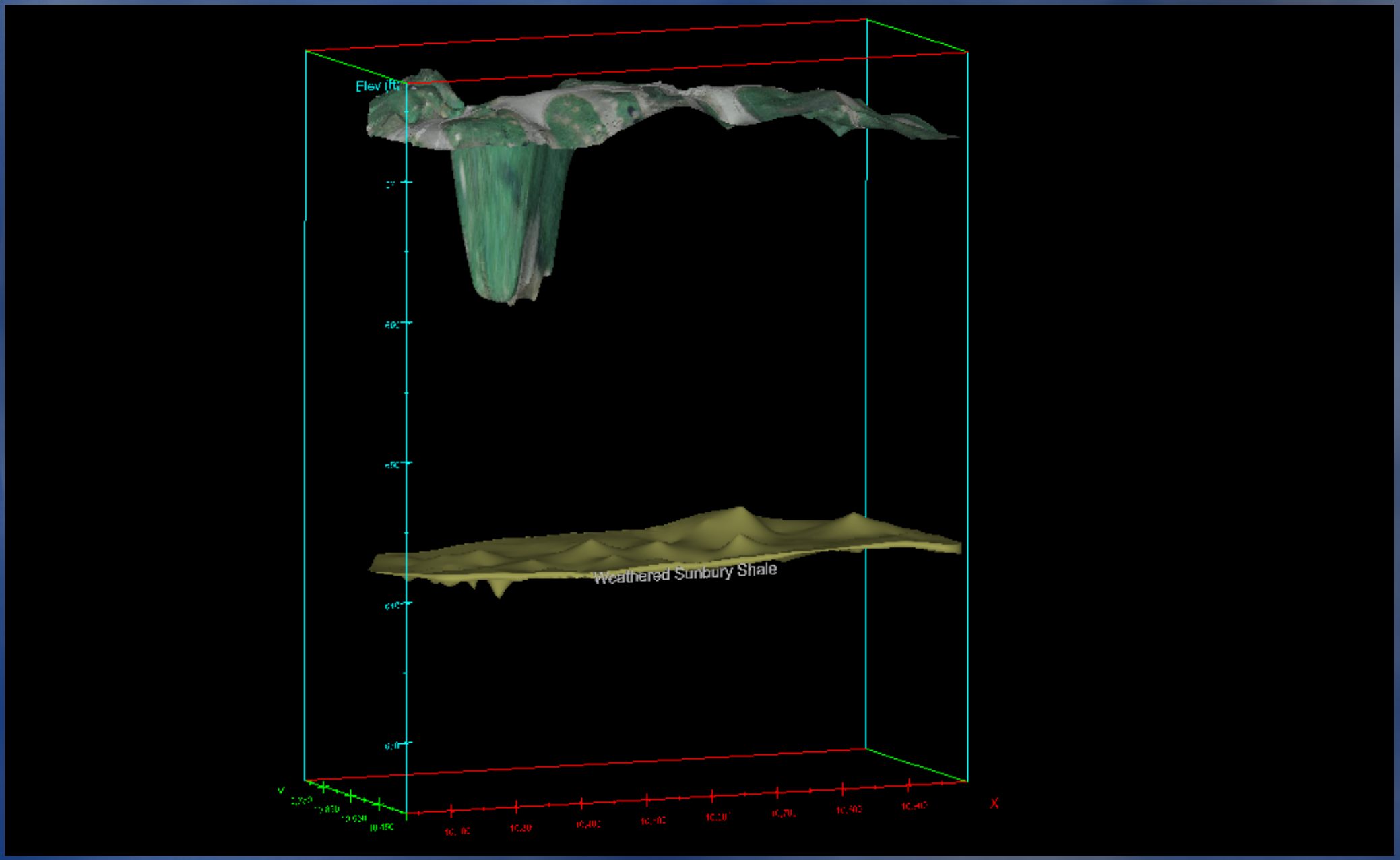
Stratigraphy in Vicinity of Proposed Excavation



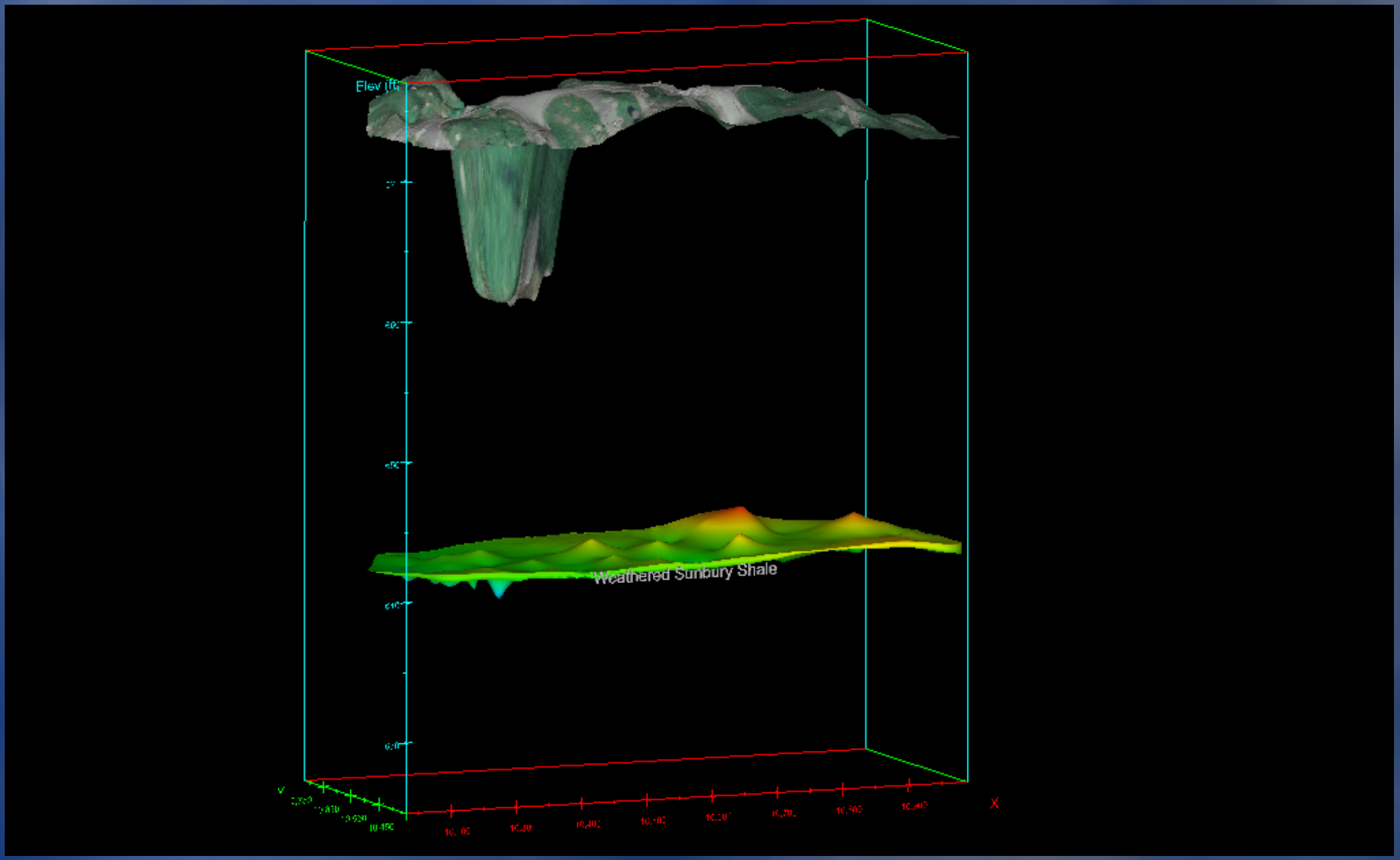
Stratigraphy in Vicinity of Proposed Excavation



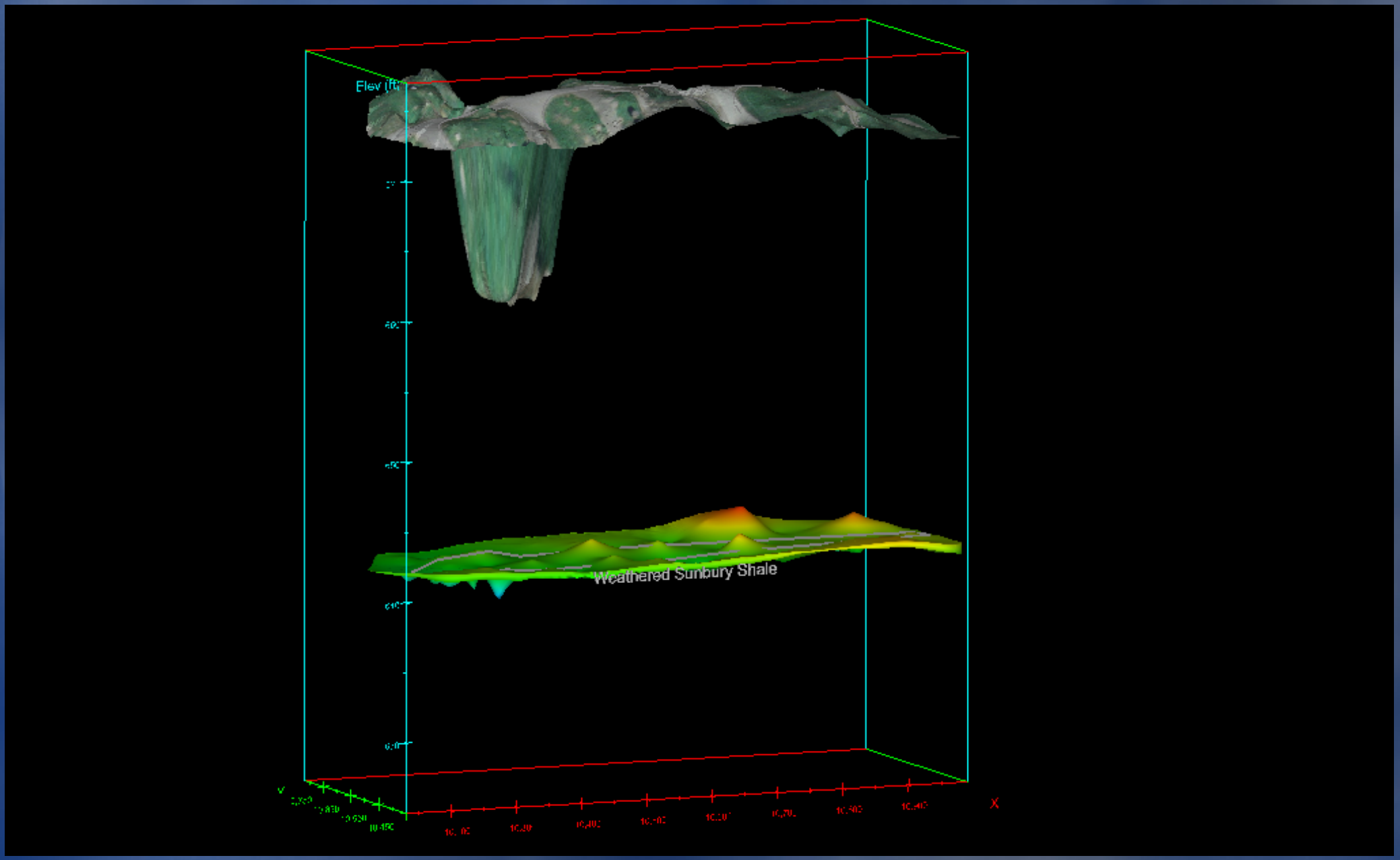
Stratigraphy in Vicinity of Proposed Excavation



Stratigraphy in Vicinity of Proposed Excavation



Stratigraphy in Vicinity of Proposed Excavation



Appendix D
Dewatering Calculations for the X-701B excavation

The groundwater levels within the footprint of the individual excavation cells will need to be lowered to facilitate the excavation. The critical design question is the quantity and rate of water withdrawal to dewater the excavation. This appendix provides the calculations that were used to support the dewatering design.

From a design perspective, the critical question is the predicted minimum and maximum flow rate required to dewater an individual cell. The first step is to evaluate the hydraulic testing from long term constant rate tests. Attachment 1 to this appendix provides a summary of the individual test analysis to determine the effective transmissivity as determined by pressure transducers in various wells during the 7 day constant rate test of EW-01 in 2003. These values which represent a weighted average of the aquifer properties in the vicinity of the X701B Source Area were used to perform the dewatering calculations.

The following input parameters were used for the dewatering design:

Parameter	Value	Comments
Gallia transmissivity	100 ft2/day (approximates 50 ft/day and a 2 foot thick layer)	Average value from 7 day aquifer test from xx surrounding wells with transducers using residual recovery analysis
Porosity	0.25	Literature value
Hydraulic head in Gallia above top of Sunbury	18 feet	Assumes depth to water 12 feet and top of Sunbury 30 feet bgs
Storativity	0.001	Resolved from 7 day aquifer test
Cell size	40 ft x 40 feet	Maximum worst case cell size

The Theis non equilibrium equation was used to determine the resulting drawdown from a constant withdrawl over time for an extraction point. The principal of superposition was used to allow for individual well points at various spacing. The Theis equation for drawdown is:

s=114.6Q W(u)/T
u= 1.87 r2S/(Tt)
W(u) =W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….)[1]

Where:

s= drawdown, feet
Q= flow rate, gpm
W(u) well function equation
T = transmissivity, gpd/ft
t= time since pumping started, days

The following spreadsheets provide a layout of the various designs considered for a given flow rate. The spreadsheets calculate drawdown at various distances from the pumping well for given aquifer parameters and a prescribed time. The design goal was to have a drawdown no more than 16 feet (2 foot of freeboard in the dewatering point to prevent breaking suction) and substantive dewatering of the formation within the excavation cell.

[1] This is the Taylor series expansion of the well function from Groundwater and Wells, Driscoll, 2nd Edition, pg 261.

A summary of the findings are listed below.

Scenario	Shoring effectiveness (a)	Flow rate (gpm/point)	Total dewatering (gpm) (b)	Comments
4 points on each side edge of the cell.	0%	4.5	18	Used to determine high end flow rate
8 points around perimeter of cell	0%	2.2	17.6	Used to determine high end flow rate
1 point center of excavation	100%	3.3	3.3	Not selected due to construction issues
1 point 3 foot from corner of excavation	100%	3.1	3.1	Opposite corner not dewatered
2 points in opposite corners of excavation	100%	1.9	3.8	Improves drawdown at corners. Selected for design

a) shoring effectiveness 0% assumes shoring not present to prevent infiltration of surrounding water; 100% effective is simulated by "image" wells to simulate barrier.
b) dewatering calculations are based on 3 days of operations

Ports 701B dewatering Calculations

Theis non equilibrium equation

Input
calculated

s=114.6Q W(u)/T (1)
u= 1.87 r2S/(Tt) (2)

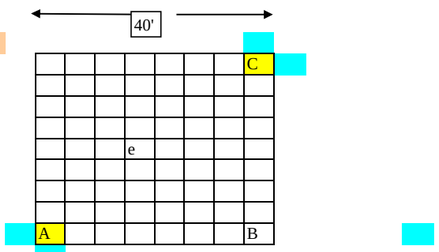
W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….) (3)

exponentional intergral approxmiated by an infinite series (Driscol, pg 261)
Using only first 3 terms in calculations below

s = drawdown, feet	see below	feet			
Q = pumping rate, gpm	see below	gpm	see below	gal/yr	
T = transmissivity, gpd/ft (k * 7.48)	881	gpd/ft	118	ft^2/day	Avg from 7 day constant rate test
K = T/B, hydraulic conductivity, ft/day	79	ft/d	2.8E-02	cm/s	
B = aquifer thickness, feet)	1.5	ft	does not affect calculation because use T		
u =	see below				
r = distance from center of well, feet	see below	ft			
S - coefficient of storage (dimesionless)	0.002	based on EW-01 7 day constant rate test 2003			
t = time since pumping began, days	see below	days			
porosity	0.3	unitless			

Time 3 days

		1.9	gpm		v=Ki/phi	wells 2	total flow 3.8	
Distance East from center of well (ft)			Drawdown (ft)	Gradient (ft/ft)	Velocity (ft/day)	Drawdown Point E (center)	Drawdown Point A/C (corner)	Drawdown Point B (other corner)
r	u	w(u)	s			13.86	16.67	12.80
0.25	8.84E-08	1.57E+01	3.87				3.87	
2	5.66E-06	1.15E+01	2.84	-0.5874	-1.54E+02			
3	1.27E-05	1.07E+01	2.64	-0.2004	-5.25E+01			
4	2.26E-05	1.01E+01	2.50	-0.1422	-3.72E+01			
6	5.09E-05	9.31E+00	2.30	-0.1002	-2.62E+01		4.60	
10	1.42E-04	8.29E+00	2.05	-0.0631	-1.65E+01			
15	3.18E-04	7.48E+00	1.85	-0.0401	-1.05E+01			
20	5.66E-04	6.90E+00	1.71	-0.0284	-7.44E+00			
25	8.84E-04	6.45E+00	1.60	-0.0220	-5.77E+00	3.19		
30	1.27E-03	6.09E+00	1.51	-0.0180	-4.71E+00	6.02		
37	1.94E-03	5.67E+00	1.40	-0.0148	-3.87E+00			2.80
40	2.26E-03	5.52E+00	1.36	-0.0128	-3.36E+00			2.73
43	2.62E-03	5.37E+00	1.33	-0.0137	-3.58E+00			3.98
45	2.87E-03	5.28E+00	1.31	-0.0121	-3.16E+00			1.31
50	3.54E-03	5.07E+00	1.25	-0.0106	-2.78E+00		1.25	
55	4.28E-03	4.88E+00	1.21	-0.0094	-2.46E+00		4.83	
60	5.09E-03	4.71E+00	1.16	-0.0086	-2.24E+00	4.65		
63	5.62E-03	4.61E+00	1.14	-0.0080	-2.09E+00			
70	6.93E-03	4.40E+00	1.09	-0.0074	-1.94E+00			
74	7.75E-03	4.29E+00	1.06	-0.0068	-1.78E+00		2.12	
80	9.06E-03	4.14E+00	1.02	-0.0064	-1.67E+00			
85	1.02E-02	4.02E+00	0.99	-0.0059	-1.55E+00			1.99
90	1.15E-02	3.90E+00	0.96	-0.0056	-1.46E+00			
100	1.42E-02	3.69E+00	0.91	-0.0051	-1.35E+00			
110	1.71E-02	3.51E+00	0.87	-0.0046	-1.21E+00			
120	2.04E-02	3.34E+00	0.82	-0.0042	-1.10E+00			
130	2.39E-02	3.18E+00	0.79	-0.0039	-1.01E+00			
140	2.77E-02	3.04E+00	0.75	-0.0036	-9.34E-01			
150	3.18E-02	2.90E+00	0.72	-0.0033	-8.66E-01			
200	5.66E-02	2.35E+00	0.58	-0.0027	-7.13E-01			
250	8.84E-02	1.93E+00	0.48	-0.0021	-5.38E-01			
300	1.27E-01	1.61E+00	0.40	-0.0016	-4.24E-01			
350	1.73E-01	1.34E+00	0.33	-0.0013	-3.44E-01			
400	2.26E-01	1.12E+00	0.28	-0.0011	-2.84E-01			
500	3.54E-01	7.84E-01	0.19	-0.0008	-2.18E-01			
550	4.28E-01	6.54E-01	0.16	-0.0006	-1.69E-01			
600	5.09E-01	5.42E-01	0.13	-0.0006	-1.45E-01			
700	6.93E-01	3.62E-01	0.09	-0.0004	-1.16E-01			



Assume well 3 foot from corner
Dewatering well
Image well

Ports 701B dewatering Calculations

Theis non equilibrium equation

Input
calculated

s=114.6Q W(u)/T (1)
u= 1.87 r2S/(Tt) (2)

W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….) (3)
exponentional intergral approxmiated by an infinite series (Driscol, pg 261)
Using only first 3 terms in calculations below

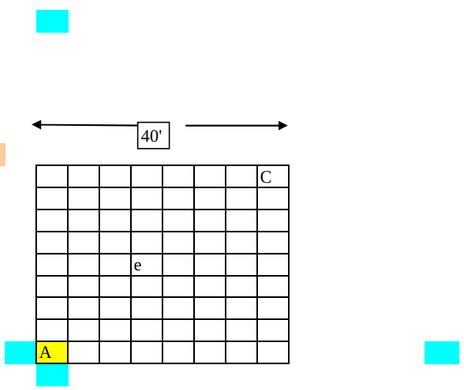
s = drawdown, feet	see below	feet			
Q = pumping rate, gpm	see below	gpm	see below	gal/yr	
T = transmissivity, gpd/ft (k * 7.48)	881	gpd/ft	118	ft^2/day	Avg from 7 day constant rate test
K = T/B, hydraulic conductivity, ft/day	79	ft/d	2.8E-02	cm/s	
B = aquifer thickness, feet)	1.5	ft	does not affect calculation because use T		
u =	see below				
r = distance from center of well, feet	see below	ft			
S - coefficient of storage (dimesionless)	0.002	based on EW-01 7 day constant rate test 2003			
t = time since pumping began, days	see below	days			
porosity	0.3	unitless			

total dd

Time 2 days

wells total flow

		3.1	gpm		v=Ki/phi	1	3.1	
Distance East from center of well (ft)			Drawdown (ft)	Gradient (ft/ft)	Velocity (ft/day)	Drawdown Point E (center)	Drawdown Point A (corner)	Drawdown Point C (far corner)
r	u	w(u)	s			10.50	16.34	8.89
0.25	1.33E-07	1.53E+01	6.15				6.15	
2	8.49E-06	1.11E+01	4.48	-0.9583	-2.51E+02			
3	1.91E-05	1.03E+01	4.15	-0.3270	-8.56E+01			
4	3.40E-05	9.71E+00	3.92	-0.2320	-6.07E+01			
6	7.64E-05	8.90E+00	3.59	-0.1635	-4.28E+01		7.18	
10	2.12E-04	7.88E+00	3.18	-0.1030	-2.70E+01			
15	4.78E-04	7.07E+00	2.85	-0.0654	-1.71E+01			
20	8.49E-04	6.50E+00	2.62	-0.0464	-1.21E+01			
25	1.33E-03	6.05E+00	2.44	-0.0360	-9.41E+00	2.44		
30	1.91E-03	5.69E+00	2.29	-0.0294	-7.68E+00	4.59		
40	3.40E-03	5.11E+00	2.06	-0.0231	-6.06E+00			
50	5.31E-03	4.67E+00	1.88	-0.0179	-4.69E+00			
55	6.42E-03	4.48E+00	1.81	-0.0153	-4.00E+00			5.42
60	7.64E-03	4.30E+00	1.74	-0.0139	-3.65E+00	3.47		3.47
63	8.42E-03	4.21E+00	1.70	-0.0130	-3.41E+00			
70	1.04E-02	4.00E+00	1.61	-0.0120	-3.15E+00			
75	1.19E-02	3.86E+00	1.56	-0.0110	-2.88E+00			
80	1.36E-02	3.74E+00	1.51	-0.0103	-2.69E+00		3.01	
85	1.53E-02	3.62E+00	1.46	-0.0096	-2.52E+00			
90	1.72E-02	3.50E+00	1.41	-0.0091	-2.37E+00			
100	2.12E-02	3.30E+00	1.33	-0.0083	-2.18E+00			
110	2.57E-02	3.11E+00	1.25	-0.0075	-1.97E+00			
120	3.06E-02	2.94E+00	1.19	-0.0068	-1.79E+00			
130	3.59E-02	2.79E+00	1.12	-0.0062	-1.63E+00			
140	4.16E-02	2.64E+00	1.07	-0.0058	-1.51E+00			
150	4.78E-02	2.51E+00	1.01	-0.0053	-1.39E+00			
200	8.49E-02	1.97E+00	0.80	-0.0044	-1.14E+00			
250	1.33E-01	1.57E+00	0.63	-0.0032	-8.47E-01			
300	1.91E-01	1.26E+00	0.51	-0.0025	-6.56E-01			
350	2.60E-01	1.01E+00	0.41	-0.0020	-5.22E-01			
400	3.40E-01	8.14E-01	0.33	-0.0016	-4.21E-01			
500	5.31E-01	5.17E-01	0.21	-0.0012	-3.13E-01			
550	6.42E-01	4.05E-01	0.16	-0.0009	-2.36E-01			
600	7.64E-01	3.10E-01	0.12	-0.0008	-2.00E-01			
700	1.04E+00	1.53E-01	0.06	-0.0006	-1.66E-01			



Assume well 3 foot from corner
Dewatering well
Image well

Ports 701B dewatering Calculations

Theis non equilibrium equation

Input
calculated

s=114.6Q W(u)/T (1)
u= 1.87 r2S/(Tt) (2)

W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….) (3)
exponentional intergral approxmiated by an infinite series (Driscol, pg 261)
Using only first 3 terms in calculations below

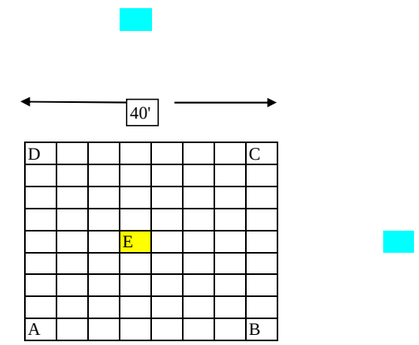
s = drawdown, feet	see below	feet			
Q = pumping rate, gpm	see below	gpm	see below	gal/yr	
T = transmissivity, gpd/ft (k * 7.48)	881	gpd/ft	118	ft^2/day	Avg from 7 day constant rate test
K = T/B, hydraulic conductivity, ft/day	79	ft/d	2.8E-02	cm/s	
B = aquifer thickness, feet)	1.5	ft	does not affect calculation because use T		
u =	see below				
r = distance from center of well, feet	see below	ft			
S - coefficient of storage (dimesionless)	0.002	based on EW-01 7 day constant rate test 2003			
t = time since pumping began, days	see below	days			
porosity	0.3	unitless			

total dd

Time 3 days

wells total flow
3.3 gpm v=Ki/phi 1 3.3

Distance East from center of well (ft)			Drawdown (ft)	Gradient (ft/ft)	Velocity (ft/day)	Drawdown Point E (center)	Drawdown Point A (corner)
r	u	w(u)	s			16.19	11.98
0.25	8.84E-08	1.57E+01	6.72			6.72	
2	5.66E-06	1.15E+01	4.94	-1.0202	-2.67E+02		
3	1.27E-05	1.07E+01	4.59	-0.3481	-9.11E+01		
4	2.26E-05	1.01E+01	4.34	-0.2470	-6.46E+01		
5	3.54E-05	9.67E+00	4.15	-0.1916	-5.01E+01		
10	1.42E-04	8.29E+00	3.56	-0.1190	-3.11E+01		
15	3.18E-04	7.48E+00	3.21	-0.0696	-1.82E+01		
20	5.66E-04	6.90E+00	2.96	-0.0494	-1.29E+01		
22	6.85E-04	6.71E+00	2.88	-0.0409	-1.07E+01		
28	1.11E-03	6.23E+00	2.67	-0.0345	-9.02E+00		8.02
40	2.26E-03	5.52E+00	2.37	-0.0255	-6.67E+00	9.47	
50	3.54E-03	5.07E+00	2.18	-0.0191	-5.00E+00		
55	4.28E-03	4.88E+00	2.10	-0.0163	-4.27E+00		
60	5.09E-03	4.71E+00	2.02	-0.0149	-3.89E+00		
63	5.62E-03	4.61E+00	1.98	-0.0139	-3.63E+00		3.96
70	6.93E-03	4.40E+00	1.89	-0.0128	-3.36E+00		
75	7.96E-03	4.26E+00	1.83	-0.0118	-3.08E+00		
80	9.06E-03	4.14E+00	1.78	-0.0110	-2.88E+00		
85	1.02E-02	4.02E+00	1.72	-0.0103	-2.70E+00		
90	1.15E-02	3.90E+00	1.68	-0.0097	-2.54E+00		
100	1.42E-02	3.69E+00	1.59	-0.0089	-2.34E+00		
110	1.71E-02	3.51E+00	1.51	-0.0081	-2.11E+00		
120	2.04E-02	3.34E+00	1.43	-0.0073	-1.92E+00		
130	2.39E-02	3.18E+00	1.36	-0.0067	-1.76E+00		
140	2.77E-02	3.04E+00	1.30	-0.0062	-1.62E+00		
150	3.18E-02	2.90E+00	1.25	-0.0057	-1.50E+00		
200	5.66E-02	2.35E+00	1.01	-0.0047	-1.24E+00		
250	8.84E-02	1.93E+00	0.83	-0.0036	-9.34E-01		
300	1.27E-01	1.61E+00	0.69	-0.0028	-7.37E-01		
350	1.73E-01	1.34E+00	0.58	-0.0023	-5.97E-01		
400	2.26E-01	1.12E+00	0.48	-0.0019	-4.93E-01		
500	3.54E-01	7.84E-01	0.34	-0.0014	-3.79E-01		
550	4.28E-01	6.54E-01	0.28	-0.0011	-2.94E-01		
600	5.09E-01	5.42E-01	0.23	-0.0010	-2.51E-01		
700	6.93E-01	3.62E-01	0.16	-0.0008	-2.02E-01		



Dewatering well
Image well

Ports 701B dewatering Calculations

Theis non equilibrium equation

Input
calculated

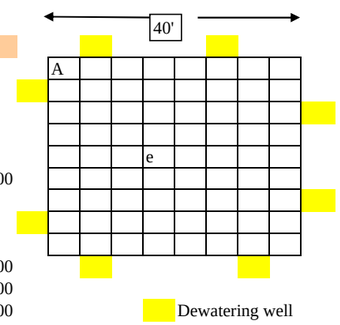
s=114.6Q W(u)/T (1)
u= 1.87 r2S/(Tt) (2)

W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….) (3)
exponentional intergral approxmiated by an infinite series (Driscol, pg 261)
Using only first 3 terms in calculations below

s = drawdown, feet	see below	feet			
Q = pumping rate, gpm	see below	gpm	see below	gal/yr	
T = transmissivity, gpd/ft (k * 7.48)	881	gpd/ft	118	ft^2/day	Avg from 7 day constant rate test
K = T/B, hydraulic conductivity, ft/day	79	ft/d	2.8E-02	cm/s	
B = aquifer thickness, feet)	1.5	ft	does not affect calculation because use T		
u =	see below				
r - distance from center of well, feet	see below	ft			
S - coefficient of storage (dimesionless)	0.002	based on EW-01 7 day constant rate test 2003			
t = time since pumping began, days	see below	days			
porosity	0.3	unitless			

Time 3 days

		2.2	gpm		v=Ki/phi	total dd wells 8	total flow 17.6
Distance East from center of well (ft)			Drawdown (ft)	Gradient (ft/ft)	Velocity (ft/day)	Drawdown Point E (center)	Drawdown Point A (corner)
r	u	w(u)	s			15.36	14.26
0.25	8.84E-08	1.57E+01	4.48				
2	5.66E-06	1.15E+01	3.29	-0.6801	-1.78E+02		
3	1.27E-05	1.07E+01	3.06	-0.2321	-6.07E+01		
4	2.26E-05	1.01E+01	2.90	-0.1647	-4.31E+01		
5	3.54E-05	9.67E+00	2.77	-0.1277	-3.34E+01		
10	1.42E-04	8.29E+00	2.37	-0.0793	-2.08E+01		4.74E+00
15	3.18E-04	7.48E+00	2.14	-0.0464	-1.21E+01		
20	5.66E-04	6.90E+00	1.97	-0.0329	-8.62E+00		
22	6.85E-04	6.71E+00	1.92	-0.0273	-7.13E+00	15.36	
30	1.27E-03	6.09E+00	1.74	-0.0222	-5.80E+00		3.49E+00
41	2.38E-03	5.47E+00	1.56	-0.0162	-4.25E+00		3.13E+00
50	3.54E-03	5.07E+00	1.45	-0.0126	-3.29E+00		2.90E+00
55	4.28E-03	4.88E+00	1.40	-0.0109	-2.84E+00		
60	5.09E-03	4.71E+00	1.35	-0.0099	-2.59E+00		
65	5.98E-03	4.55E+00	1.30	-0.0091	-2.38E+00		
70	6.93E-03	4.40E+00	1.26	-0.0084	-2.21E+00		
75	7.96E-03	4.26E+00	1.22	-0.0078	-2.05E+00		
80	9.06E-03	4.14E+00	1.18	-0.0073	-1.92E+00		
85	1.02E-02	4.02E+00	1.15	-0.0069	-1.80E+00		
90	1.15E-02	3.90E+00	1.12	-0.0065	-1.69E+00		
100	1.42E-02	3.69E+00	1.06	-0.0060	-1.56E+00		
110	1.71E-02	3.51E+00	1.00	-0.0054	-1.41E+00		
120	2.04E-02	3.34E+00	0.95	-0.0049	-1.28E+00		
130	2.39E-02	3.18E+00	0.91	-0.0045	-1.17E+00		
140	2.77E-02	3.04E+00	0.87	-0.0041	-1.08E+00		
150	3.18E-02	2.90E+00	0.83	-0.0038	-1.00E+00		
200	5.66E-02	2.35E+00	0.67	-0.0032	-8.26E-01		
250	8.84E-02	1.93E+00	0.55	-0.0024	-6.23E-01		
300	1.27E-01	1.61E+00	0.46	-0.0019	-4.91E-01		
350	1.73E-01	1.34E+00	0.38	-0.0015	-3.98E-01		
400	2.26E-01	1.12E+00	0.32	-0.0013	-3.29E-01		
500	3.54E-01	7.84E-01	0.22	-0.0010	-2.53E-01		
550	4.28E-01	6.54E-01	0.19	-0.0007	-1.96E-01		
600	5.09E-01	5.42E-01	0.16	-0.0006	-1.67E-01		
700	6.93E-01	3.62E-01	0.10	-0.0005	-1.35E-01		



Ports 701B dewatering Calculations

Theis non equilibrium equation

Input
calculated

s=114.6Q W(u)/T (1)
u= 1.87 r2S/(Tt) (2)

W(u) = (-.5772-ln(u)+u-u^2/2*2!+u^3/3*3!….) (3)

exponentional intergral approxmiated by an infinite series (Driscol, pg 261)
Using only first 3 terms in calculations below

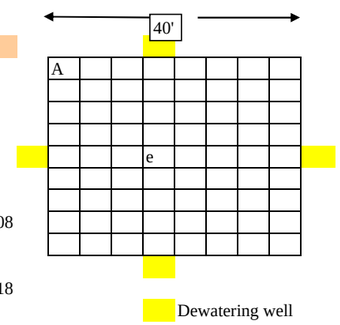
s = drawdown, feet	see below	feet			
Q = pumping rate, gpm	see below	gpm	see below	gal/yr	
T = transmissivity, gpd/ft (k * 7.48)	881	gpd/ft	118	ft^2/day	Avg from 7 day constant rate test
K = T/B, hydraulic conductivity, ft/day	79	ft/d	2.8E-02	cm/s	
B = aquifer thickness, feet)	1.5	ft	does not affect calculation because use T		
u =	see below				
r = distance from center of well, feet	see below	ft			
S - coefficient of storage (dimesionless)	0.002	based on EW-01 7 day constant rate test 2003			
t = time since pumping began, days	see below	days			
porosity	0.3	unitless			

total dd

Time 3 days

wells total flow

		4.5	gpm		v=Ki/phi	4	18
Distance East from center of well (ft)			Drawdown (ft)	Gradient (ft/ft)	Velocity (ft/day)	Drawdown Point E (center)	Drawdown Point A (corner)
r	u	w(u)	s			16.16	14.26
1	1.42E-06	1.29E+01	7.55				
2	5.66E-06	1.15E+01	6.73	-0.8115	-2.12E+02		
3	1.27E-05	1.07E+01	6.26	-0.4747	-1.24E+02		
4	2.26E-05	1.01E+01	5.92	-0.3368	-8.81E+01		
5	3.54E-05	9.67E+00	5.66	-0.2612	-6.84E+01		
10	1.42E-04	8.29E+00	4.85	-0.1623	-4.25E+01		
15	3.18E-04	7.48E+00	4.38	-0.0949	-2.48E+01		
20	5.66E-04	6.90E+00	4.04	-0.0673	-1.76E+01	16.16	8.08
22	6.85E-04	6.71E+00	3.93	-0.0558	-1.46E+01		
30	1.27E-03	6.09E+00	3.56	-0.0453	-1.19E+01		
45	2.87E-03	5.28E+00	3.09	-0.0316	-8.27E+00		6.18
50	3.54E-03	5.07E+00	2.97	-0.0246	-6.44E+00		
55	4.28E-03	4.88E+00	2.86	-0.0222	-5.82E+00		
60	5.09E-03	4.71E+00	2.76	-0.0203	-5.31E+00		
65	5.98E-03	4.55E+00	2.66	-0.0186	-4.88E+00		
70	6.93E-03	4.40E+00	2.58	-0.0172	-4.51E+00		
75	7.96E-03	4.26E+00	2.50	-0.0160	-4.20E+00		
80	9.06E-03	4.14E+00	2.42	-0.0150	-3.92E+00		
85	1.02E-02	4.02E+00	2.35	-0.0141	-3.68E+00		
90	1.15E-02	3.90E+00	2.28	-0.0132	-3.47E+00		
100	1.42E-02	3.69E+00	2.16	-0.0122	-3.19E+00		
110	1.71E-02	3.51E+00	2.05	-0.0110	-2.88E+00		
120	2.04E-02	3.34E+00	1.95	-0.0100	-2.62E+00		
130	2.39E-02	3.18E+00	1.86	-0.0092	-2.40E+00		
140	2.77E-02	3.04E+00	1.78	-0.0085	-2.21E+00		
150	3.18E-02	2.90E+00	1.70	-0.0078	-2.05E+00		
200	5.66E-02	2.35E+00	1.38	-0.0065	-1.69E+00		
250	8.84E-02	1.93E+00	1.13	-0.0049	-1.27E+00		
300	1.27E-01	1.61E+00	0.94	-0.0038	-1.00E+00		
350	1.73E-01	1.34E+00	0.79	-0.0031	-8.14E-01		
400	2.26E-01	1.12E+00	0.66	-0.0026	-6.72E-01		
500	3.54E-01	7.84E-01	0.46	-0.0020	-5.17E-01		
550	4.28E-01	6.54E-01	0.38	-0.0015	-4.01E-01		
600	5.09E-01	5.42E-01	0.32	-0.0013	-3.42E-01		
700	6.93E-01	3.62E-01	0.21	-0.0011	-2.75E-01		



X701B Pumping Test
July, 2003

Well ID	East Cooord	North Coord	Straight Line Distance From -EW1	initial head (ft)	head before pump shutdown (Ft)	max drawdown (ft)
X701-EW01	10422.00	10598.50	0.0			
X701-07G	10388.55	10598.50	33.5	659.73	652.79	-6.94
X701-08G	10507.50	10601.00	85.5	659.65	653.4	-6.25
X701-13G	10469.32	10684.69	98.3	659.93	655.65	-4.28
X701-66G	10286.44	10620.98	137.4	659.43	654.17	-5.26
X701-BW4G	10489.95	10861.30	271.4	na		
X701-78G	10734.72	10593.93	312.8	657.98	656.38	-1.6
X701-04G	10011.50	10610.00	410.7	660.2	658.77	-1.43
X701-38G	10515.29	11047.57	458.7	660.2	658.79	-1.41
X701-09G	10948.00	10602.00	526.0	659	657.42	-1.58
X701-22G	11167.77	10525.42	749.3	657.58	656.48	-1.1

Distance drawdown evaluation

$T= 264Q/\Delta s$

Q=9 gpm	9.00	gpm
Δs	4.90	ft/log cycle from graph 100 ft to 1000 ft
T=	485	gpd/ft
	57	ft^2/day

storage coefficient

$S=.3T\ t_o/r^2$

Residual Drawdown X701-07G

$T=264Q/\Delta s'$

Q=9 gpm	9	gpm
$\Delta s'$	2.9	ft/log cycle from graph t/t' 10 to 100
T=	819	gpd/ft
	110	ft2/day

Residual Drawdown X701-08G

$T=264Q/\Delta s'$

Q=9 gpm	9	gpm
$\Delta s'$	2.5	ft/log cycle from graph t/t' 10 to 100
T=	950	gpd/ft
	127	ft^2/day

Residual Drawdown X701-13G

$T=264Q/\Delta s'$

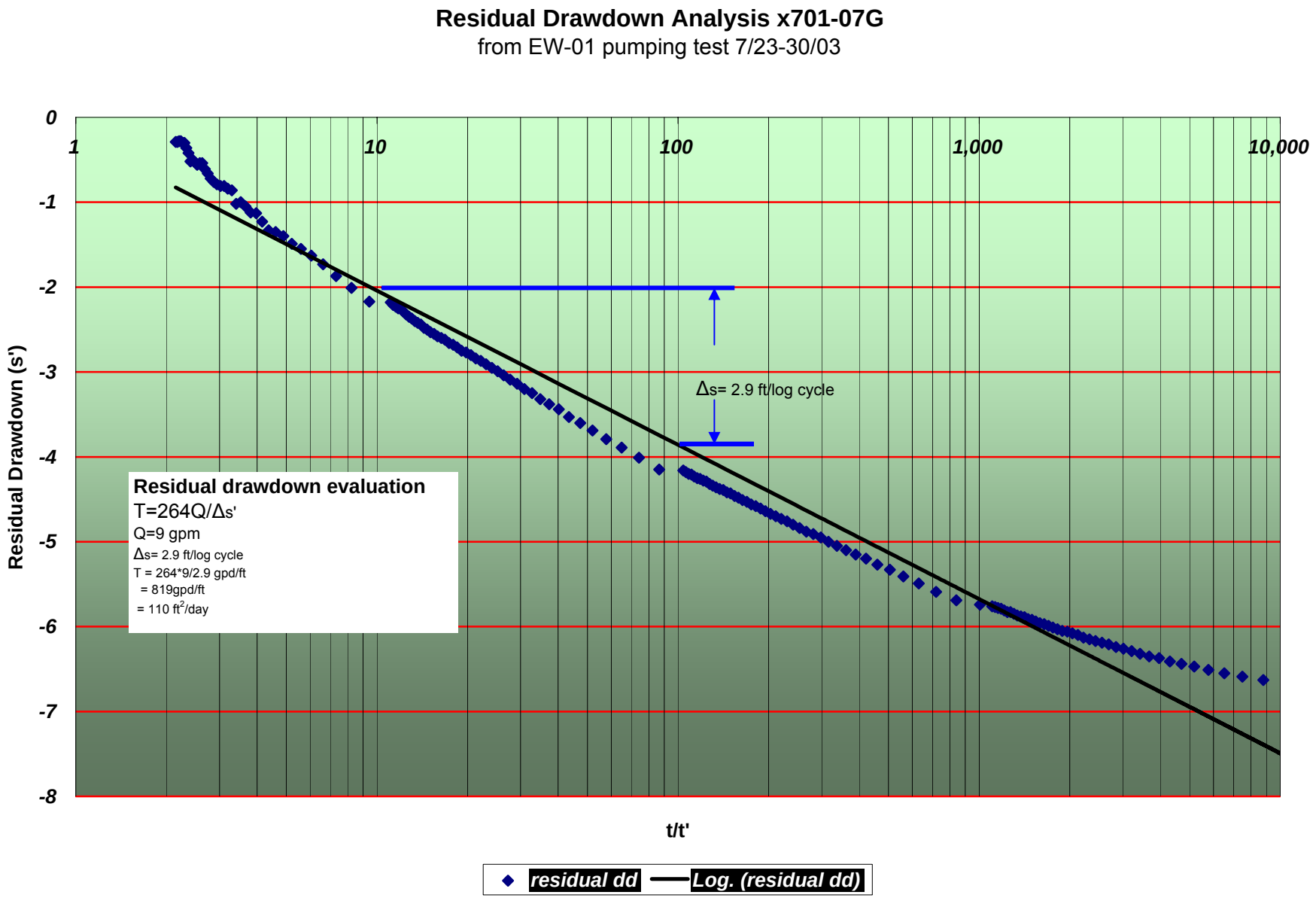
Q=9 gpm	9	gpm
$\Delta s'$	2.1	ft/log cycle from graph t/t' 10 to 100
T=	1131	gpd/ft
	151	ft^2/day

Residual Drawdown X701-66G

$T=264Q/\Delta s'$

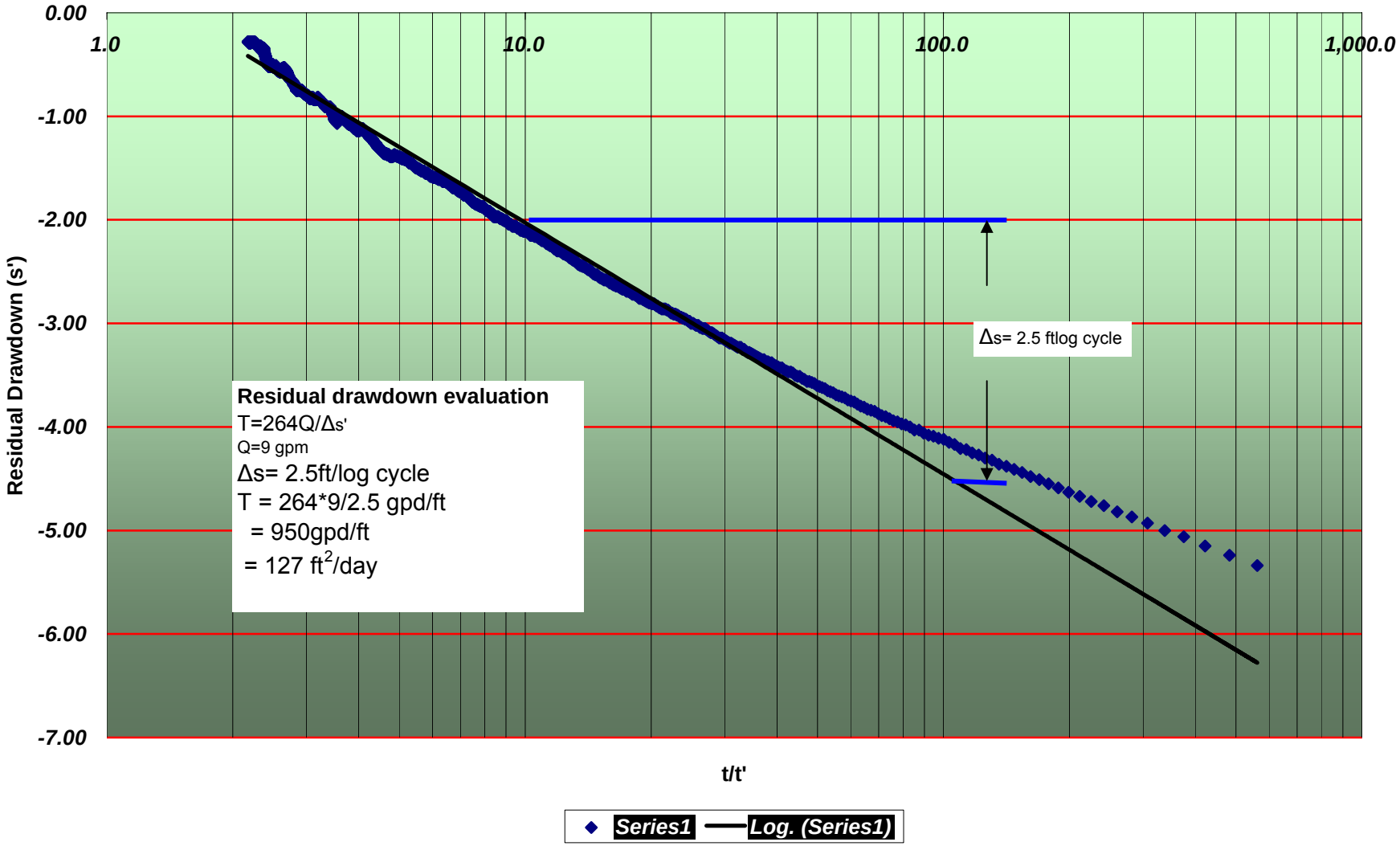
Q=9 gpm	9	gpm
$\Delta s'$	2.2	ft/log cycle from graph t/t' 10 to 100
T=	1080	gpd/ft
	144	ft^2/day

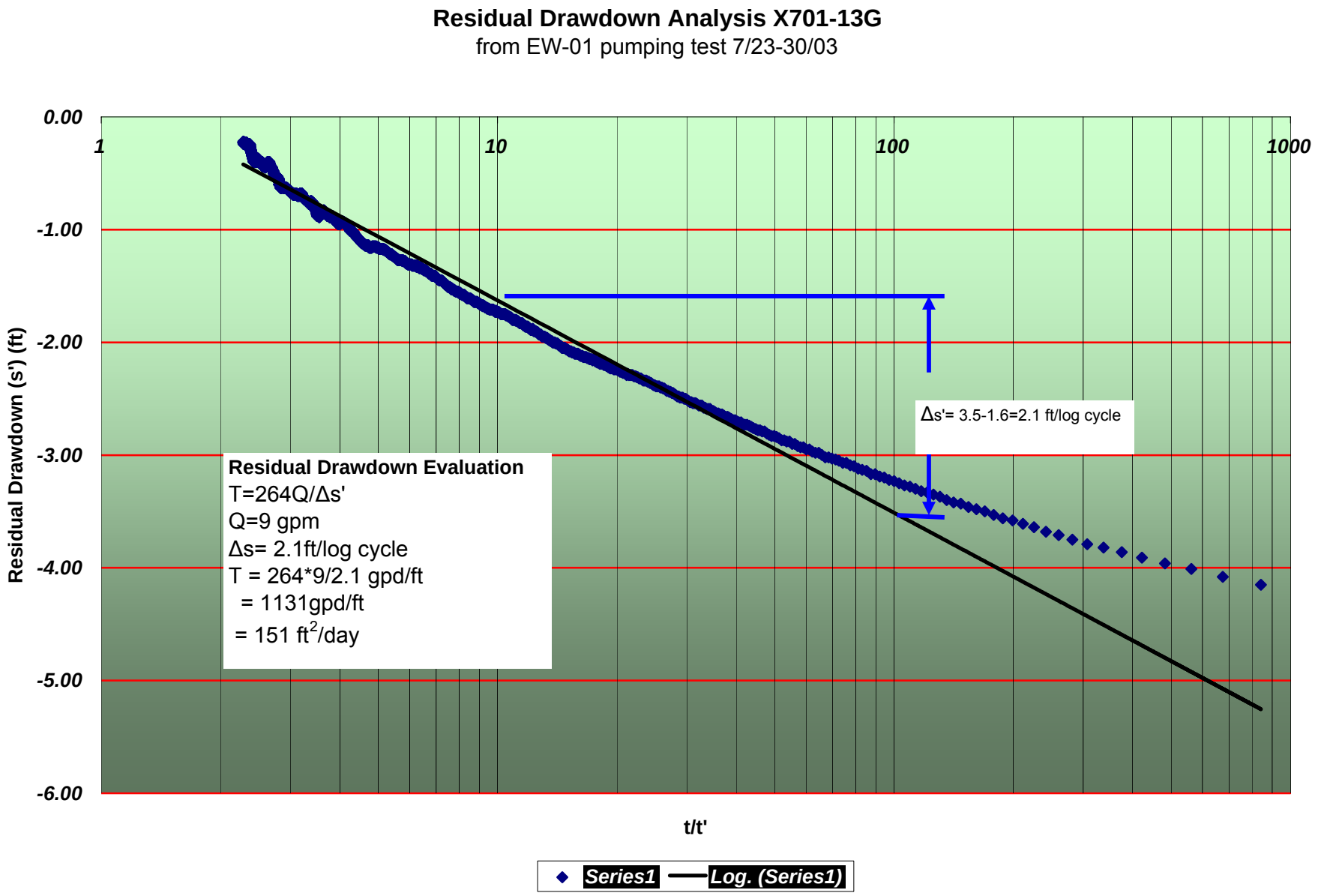
average 118 ft^2/day


Residual Drawdown Analysis x701-07G
from EW-01 pumping test 7/23-30/03
0
-1
-2
-3
-4
-5
-6
-7
-8
1
10
100
1,000
10,000
Residual Drawdown (s')
t/t'
Δs= 2.9 ft/log cycle
Residual drawdown evaluation
T=264Q/Δs'
Q=9 gpm
Δs= 2.9 ft/log cycle
T = 264*9/2.9 gpd/ft
= 819gpd/ft
= 110 ft²/day
residual dd
Log. (residual dd)

Residual Drawdown Analysis X701-08G

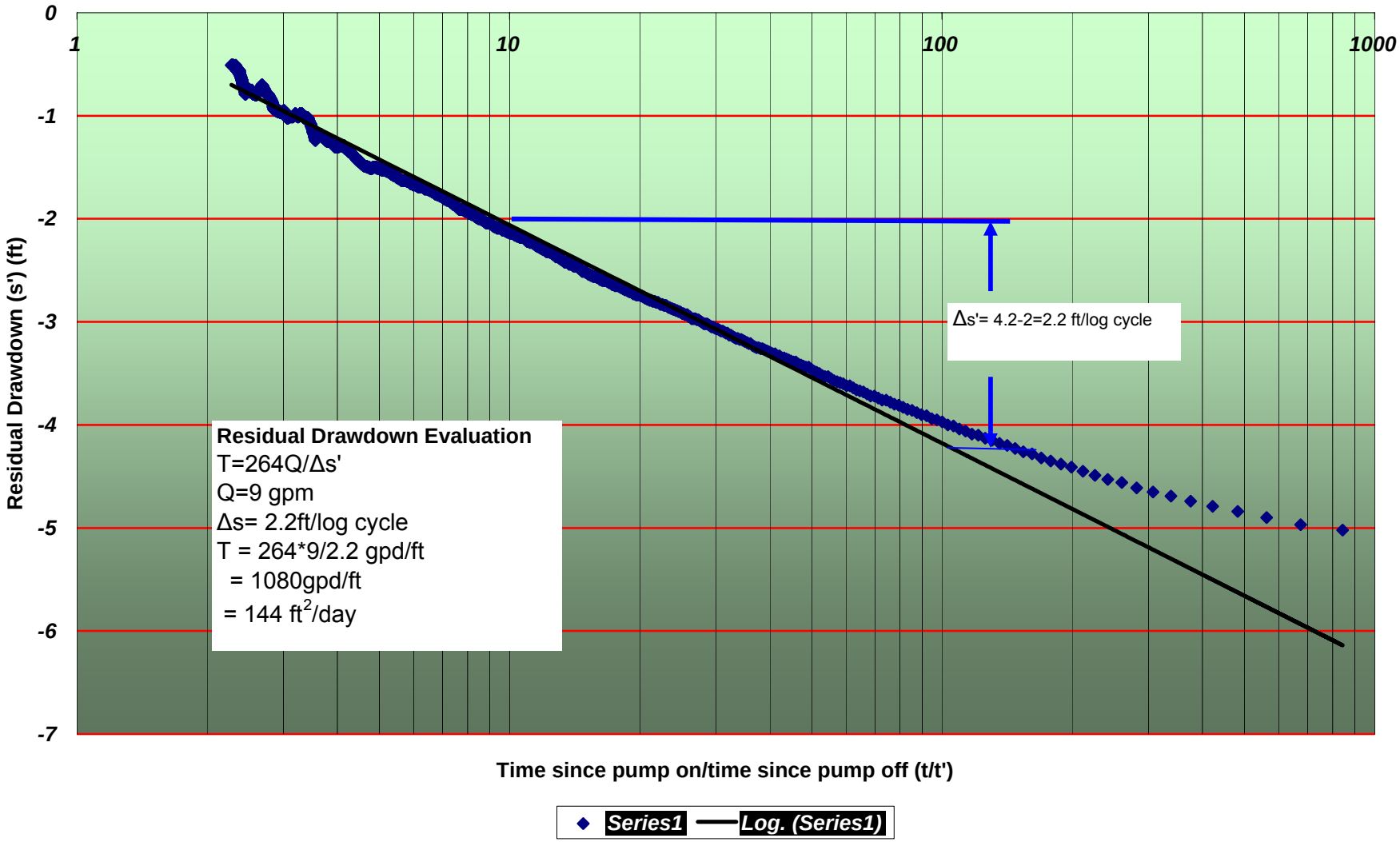
from EW-01 Pumping test 7/23-30/09



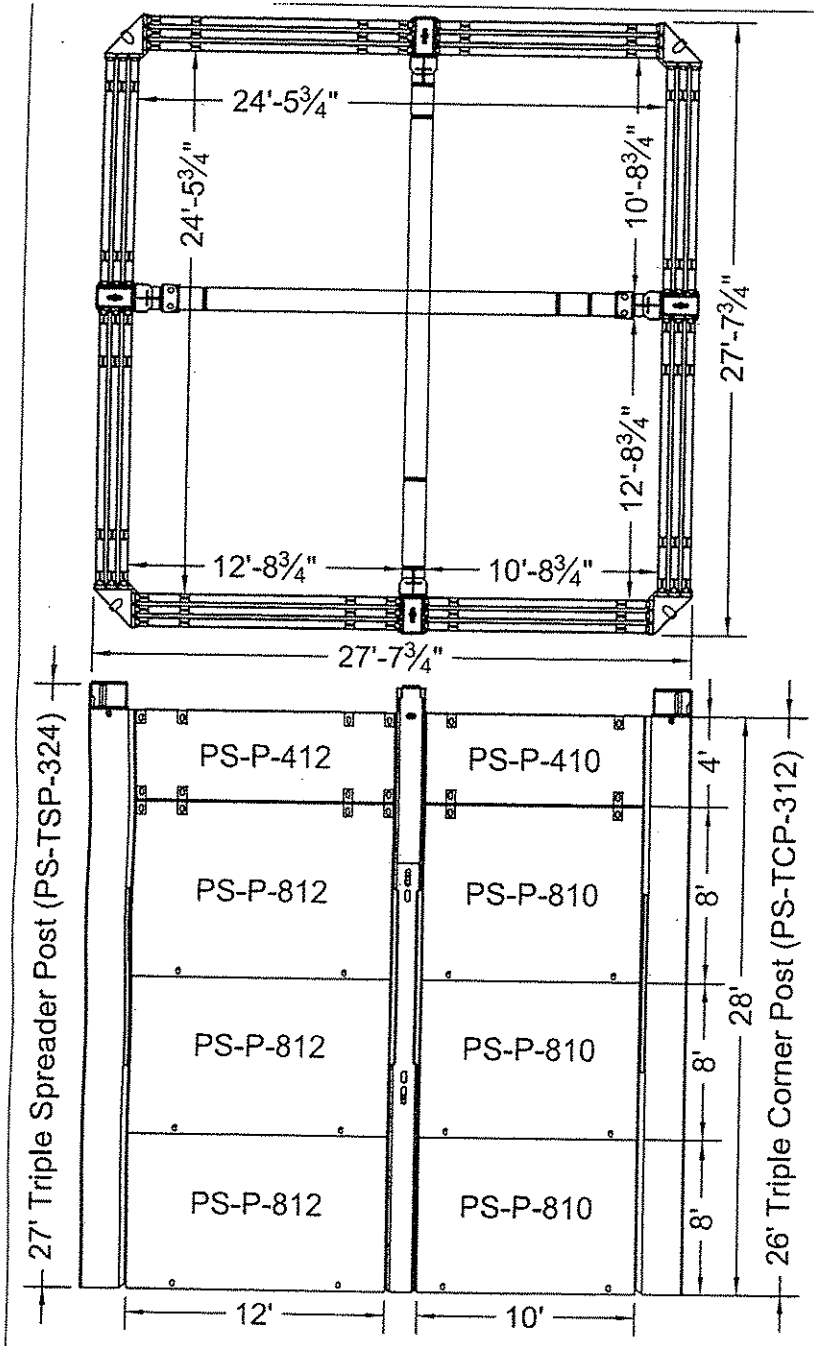

Residual Drawdown Analysis X701-13G
from EW-01 pumping test 7/23-30/03
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
1
10
100
1000
Residual Drawdown (s') (ft)
t/t'
Δs'= 3.5-1.6=2.1 ft/log cycle
Residual Drawdown Evaluation
T=264Q/Δs'
Q=9 gpm
Δs= 2.1ft/log cycle
T = 264*9/2.1 gpd/ft
= 1131gpd/ft
= 151 ft2/day
Series1
Log. (Series1)

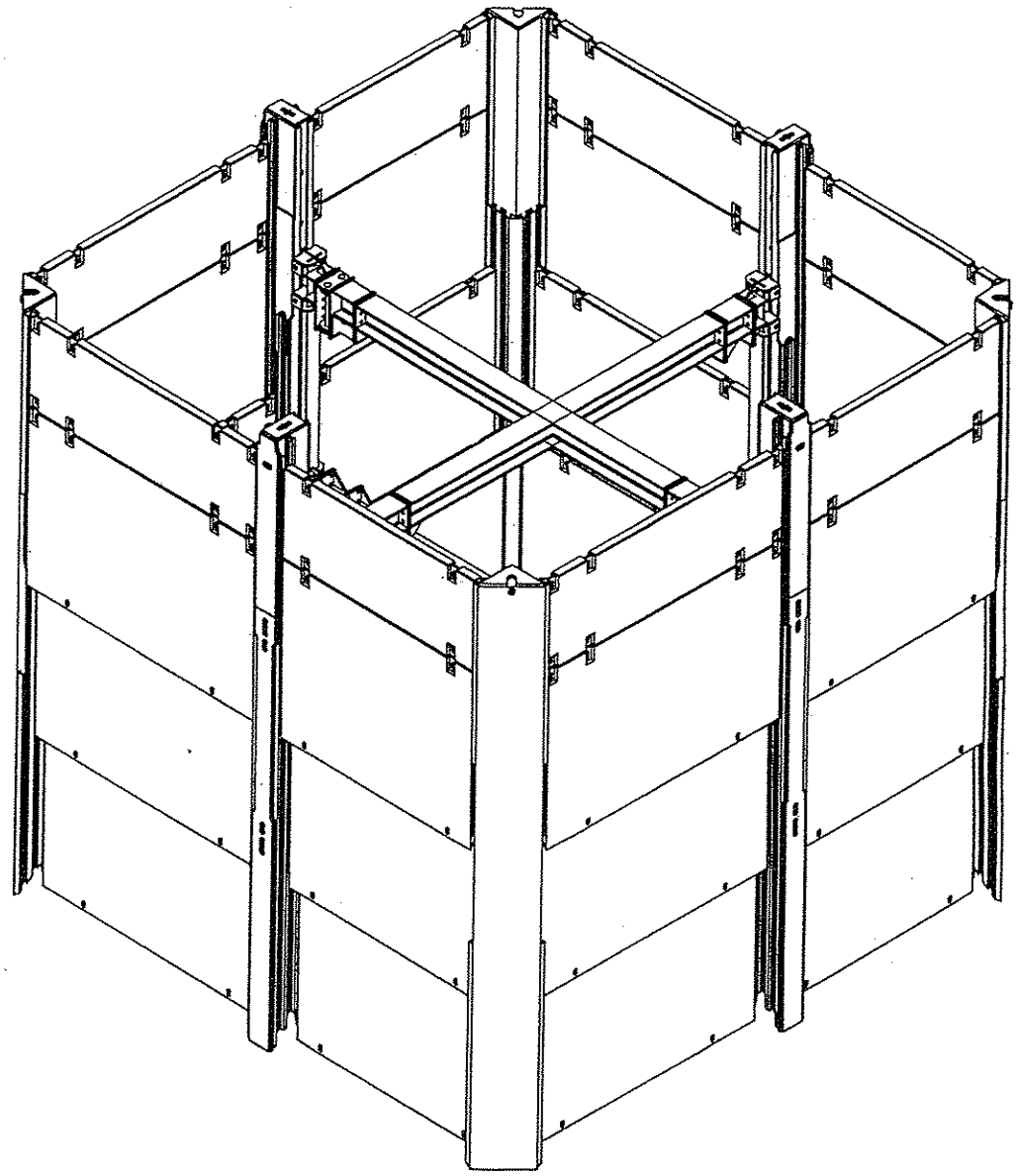
Residual Drawdown Evaluation X701-66G

from EW-01 pumping test 7/23-30/03



Appendix E
Shoring Design



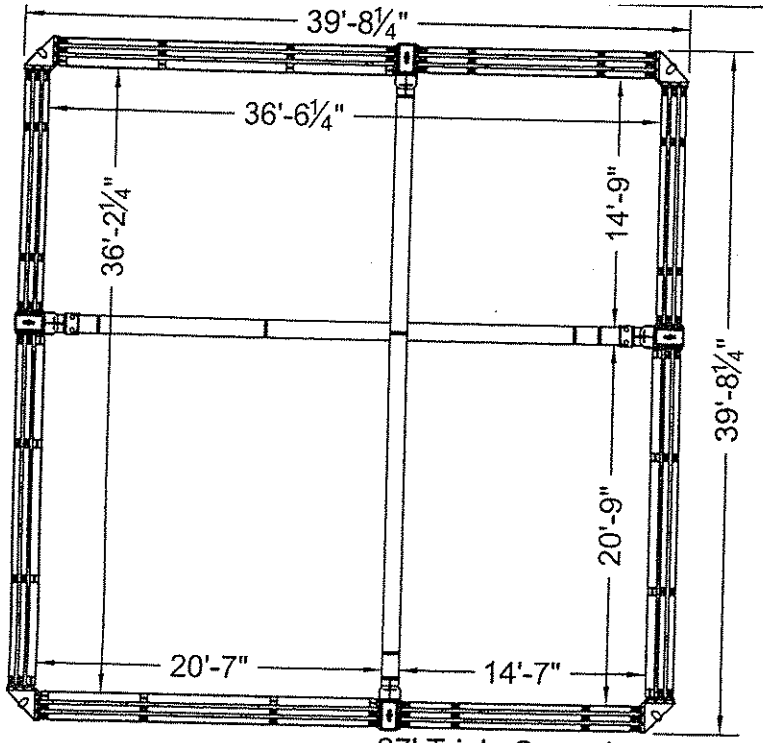


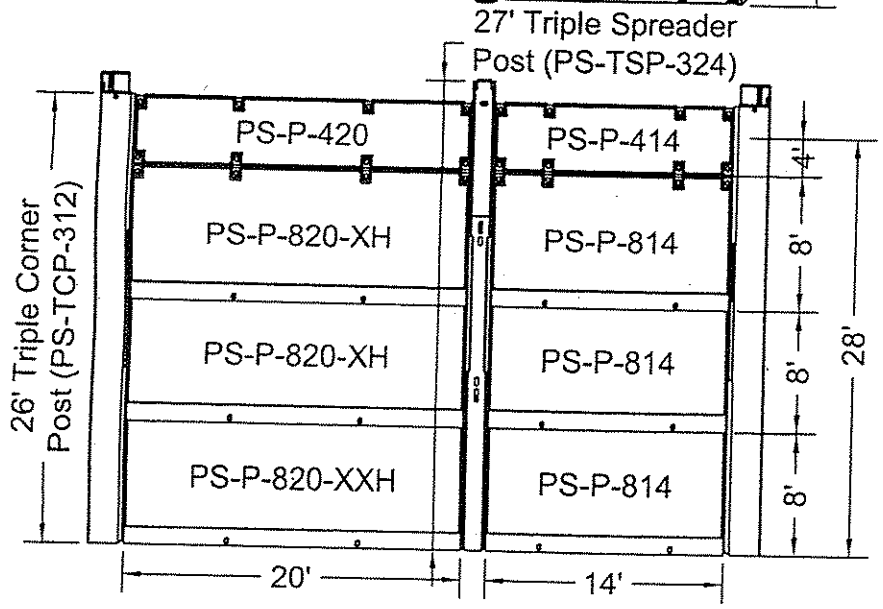
Subject To Engineering Approval.

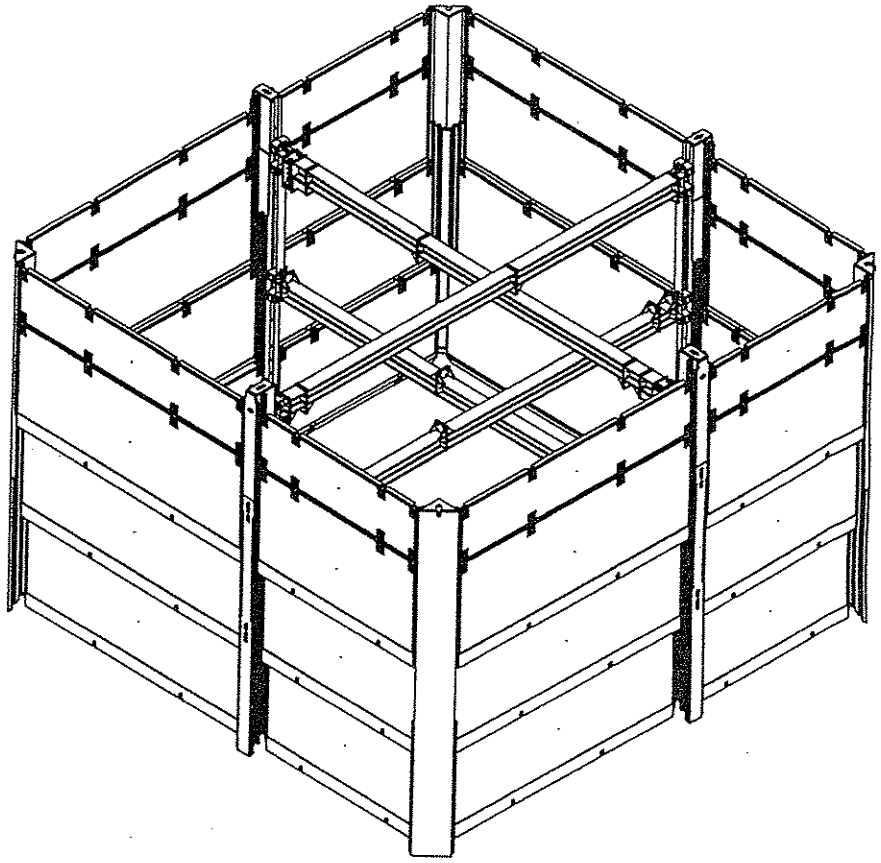
Confidential - The Drawings And Technical Information Included Or Referenced Herein Are To Be Treated As A Trade Secret And Confidential To Pro-Tec Equipment, Inc.

PRO-TEC Equipment Inc.
P.O. Box 130 1298 Lipsey Dr.-Charlotte MI 48813 (517) 541-0303 1-800-292-1225

Customer: ~	Triple Slide Rail
Dwg. # Q-SR-T-8-8-8-4Hx12-10Wx12-10L	Two Bay Bore Pit
Date: 13-May-2008 By: C. Stevens	







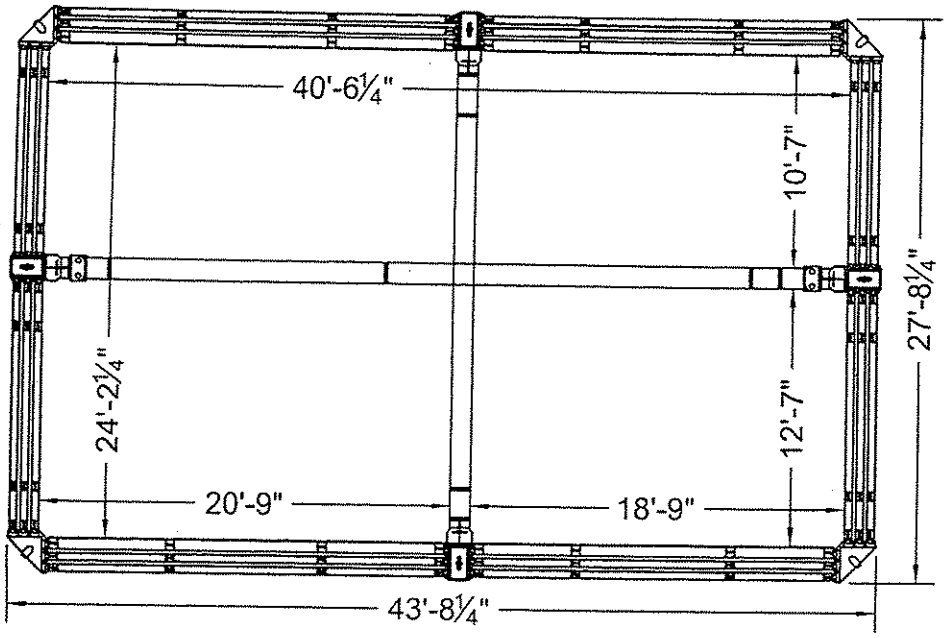
Subject To Engineering Approval.

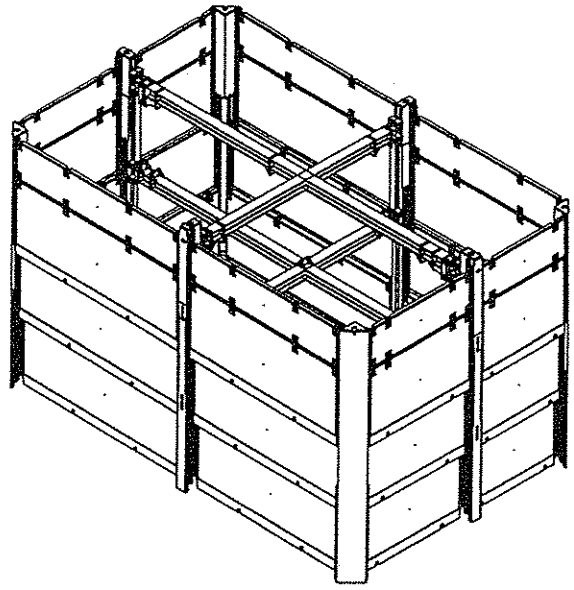
Drawings And Technical Information Included Of Referenced Herein Are To Be Treated As Confidential To Pro-Tec Equipment, Inc. - Copyright © 2008

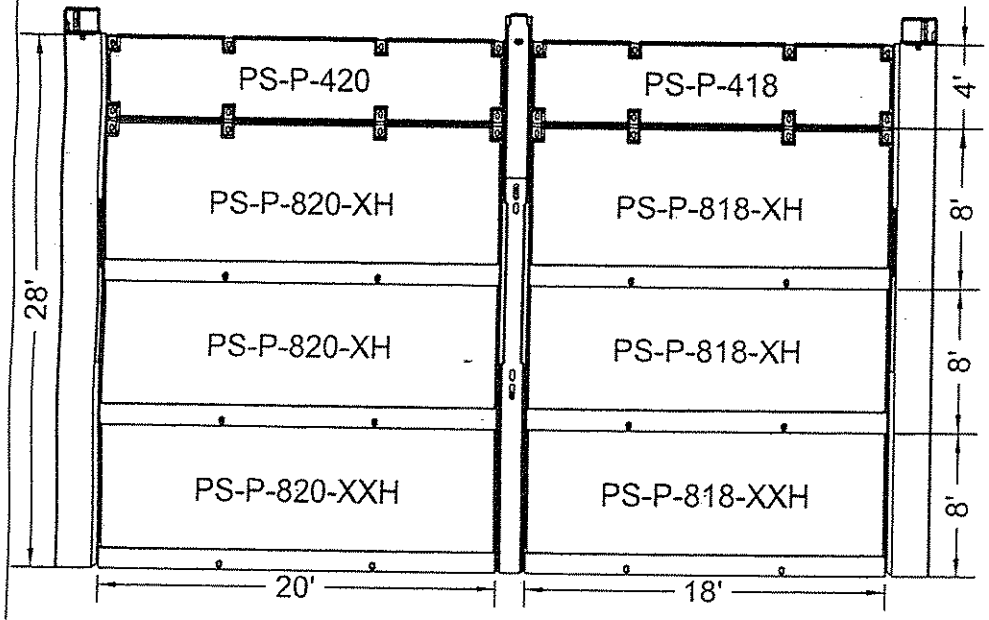
PRO-TEC Equipment Inc.
P.O. Box 130 1298 Lipsey Dr.-Charlotte MI 48813 (517) 541-0303 1-800-292-1225

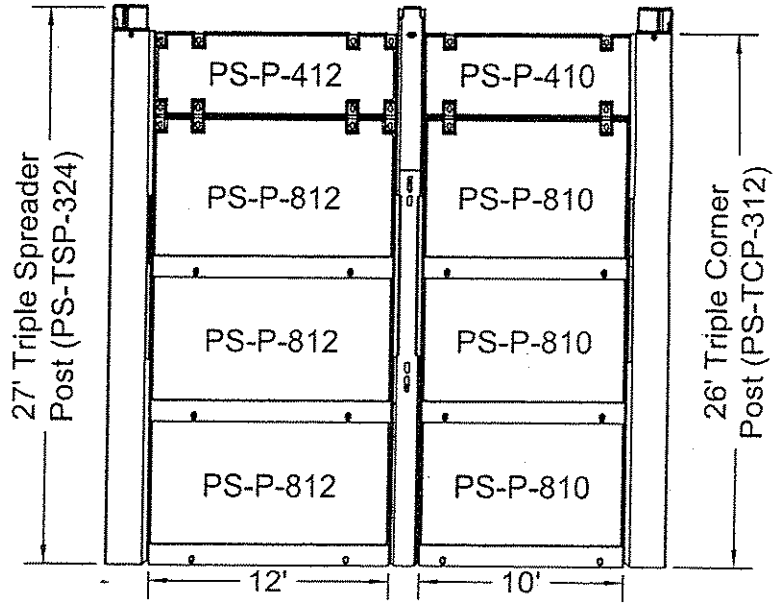
Customer: ~	Page 1 Of 1
Dwg. # Q-SR-T-8-8-8-4Hx20-14Wx20-14L	
Date: 07-Jul-2009	By: C. Stevens

Triple Slide Rail
Two Bay Bore Pit









Subject To Engineering Approval.

Drawings And Technical Information Included Of Referenced Herein Are To Be Treated As Confidential To Pro-Tec Equipment, Inc. - Copyright © 2008

PRO-TEC Equipment Inc.
P.O. Box 130 1298 Lipsey Dr.-Charlotte MI 48813 (517) 541-0303 1-800-292-1225

Customer: ~	Page 1 Of 1	Triple Slide Rail Two Bay Bore Pit
Dwg. # Q-SR-T-8-8-8-4Hx20-18Wx12-10L		
Date: 20-Jul-2009	By: C. Stevens	

Appendix F
Potential Alternative Oxidant
Hydrogen Peroxide

Because of a high level of TCE contamination within the bottom soil horizon of many excavation cells, it may prove beneficial to utilize an alternative, fast acting oxidant for ISCO. The decision to utilize an alternative oxidant will be finalized after all of the soil characterization data for the remedy is available. However, in the interim, this appendix to the Interim Action Work Plan is provided to describe what oxidant would be selected, and how it would be implemented.

Although this appendix is written to primarily to address the application of an alternative oxidant to the bottom soil horizons of the source area, the alternative oxidant may also be selectively applied to other Interim Measure soil horizons which contain a high level of TCE contamination.

1.1 Technology Overview

Catalyzed hydrogen peroxide (CHP) has been selected as the alternative oxidant for the bottom soil horizons because of its effectiveness in treating DNAPL, short half-life in the subsurface, and relatively innocuous reaction products. By removing the overlaying soils, and directly exposing the weathered shale and lower Gallia (bottom soil horizons), the short half-life of CHP which is normally a disadvantage now becomes an asset.

Contact between the CHP and contaminated soils can be assured by direct mechanical mixing to whatever level that is required. In addition, previous experience at X-701B has shown that the CHP reaction will be complete within several hours of an application. This means that soil samples taken the morning after CHP treatment can be used to verify that the desired level of contaminant destruction has been achieved. If the desired level of contaminant destruction has not been achieved, then additional treatment with CHP can be conducted as often as necessary, before the placement of subsequent soil lifts reduces the accessibility of the bottom soil horizons.

Fenton's chemistry was first documented by H.J.H. Fenton in 1894. CHP is an improvement on the original process and is characterized by the combination of soluble iron with low concentrations of hydrogen peroxide to produce hydroxyl free radicals. These hydroxyl free radicals are very powerful and short-lived oxidizers. They attack the carbon double bonds of the chlorinated hydrocarbon molecule. The summary equation for the formation of the hydroxyl free radical is shown below:

$$\mathbf{Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^- + OH\bullet}$$

Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, OH• is the hydroxyl free radical and OH^- is the hydroxide ion.

Iron will be used to catalyze the reaction, and maintaining iron in solution is important for the process to be successful in an in situ application. To eliminate the necessity of performing the reaction under low pH conditions, complex iron is used during CHP applications via a proprietary process. A food-grade chelating agent will be used to keep the iron in suspension so it can propagate into the soils and react with the peroxide and contaminates. The reaction time is very fast, with the oxidation capacity of the reagent being consumed within a few hours. After reacting, hydrogen peroxide will break down into water and oxygen and the iron catalyst will be oxidized and precipitate out of solution into the aquifer soils.

The summary equation for the oxidation of TCE by hydrogen peroxide is shown below:

$$\mathbf{C_2Cl_3H + 3H_2O_2 \rightarrow 2CO_2 + 2H_2O + 3Cl^- + 3H^+}$$

Where C_2Cl_3H is TCE, H_2O_2 is hydrogen peroxide, CO_2 is carbon dioxide, Cl^- is the chloride ion, and H^+ is the hydrogen ion.

Hydrogen peroxide that is not consumed in the above reaction will continue to oxidize other groundwater and soil contaminants, or naturally degrade to oxygen and water.

1.2 Delivery Methodology

Bulk mixing of oxidant with target soils will occur within an excavation cell for a lift that is approximately one to three feet in thickness. The delivery process will begin by initially breaking up the soil to be treated with a Terex Model WS60N (or equivalent) tilling/cutting attachment attached to large excavator such as a Komatsu PC-600. The stabilized hydrogen peroxide solution and catalyst solution will then be brought to the work area at pre-mixed concentrations and directly applied to the soils while the tilling is ongoing. This mixing and solution application process will progress across the excavation cell until all of the target soils have been treated.

After treatment of all the target soils, then the mixing and solution application process will stop, and the soils will be allowed to "rest" for a time interval that allows the CHP to react or degrade. Following completion of the "rest" period, soil samples will be taken to verify that the required level of contaminant destruction has been achieved. If the required level of contaminant destruction has not been achieved, then the mixing, solution application, and sampling process described above will be repeated as often as necessary.

The mixing time which is required to achieve the required contact between the oxidant, activator and contaminate will be established during the first six cells of the IRM, and applied throughout the cleanup. In addition, the rest time which is required to allow the CHP to react or degrade will be established during the first six cells of the IRM, and applied throughout the cleanup.

1.3 Monitoring

Soil, groundwater, and air monitoring during the application of the alternative oxidant will be the same as described in section 5 of the Work Plan, with the following exception.

In addition to the soil sampling described in section 5.1.1.1 of the Work Plan, soil samples will also be collected following each "rest" period to verify the completeness of the treatment. These samples will be analyzed for TCE and the results reported within 12 hours of sample collection. To achieve this quick turnaround for analytical results, one of two techniques will be utilized.

1) an analytical field technique will be developed during the first six cells of the IRM, and used throughout the cleanup. The field technique will be approved by the regulators prior to use. The technique will likely utilize a field portable gas chromatograph, and follow an appropriate SW-846 method to perform either a static or dynamic head space analysis for TCE. Likely methods for the analysis are: 8260B/5021, 8261A, or 5032.
2) an existing onsite analytical laboratory will be utilized on a short turnaround basis for the analysis of TCE in soil.

RECORD COPY DISTRIBUTION

File – LPP RMDC-RC