April 22, 2020

Ms. Jamie Schwartz
Remedial Project Manager
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, KS 66219

VIA Electronic Mail

RE: Submittal of Draft Final OU-3 Remedial Investigation/Feasibility Study Work Plan (Revision 1)
West Lake Landfill Superfund Site Operable Unit 3, Bridgeton, Missouri

Dear Ms. Schwartz:

On November 22, 2019, Trihydro Corporation (Trihydro) submitted a Draft Final OU-3 Remedial Investigation/ Feasibility Study (RI/FS) Work Plan on behalf of Bridgeton Landfill, LLC, Cotter Corporation (N.S.L.), and the United States Department of Energy (Respondents) for Operable Unit 3 (OU-3) of the West Lake Landfill Superfund Site located in Bridgeton, Missouri. The Respondents received USEPA comments on the Work Plan on February 7, 2020. Respondents submitted a response to the USEPA comments on April 8, 2020. In the April 8, 2020 submittal, the Respondents presented the merits of a phased and iterative investigative approach to optimize the OU-3 RI/FS scope of work that prioritizes collection of key data and allows real-time data evaluation. This approach is intended to fast-track several important initial tasks; prioritize off-site monitoring wells and data collection to assess the regional direction of hydraulic gradient; identify constituents of potential concern (COPCs) present above screening levels; and rapidly evaluate any potential COPCs offsite. Results from the initial phases of work will be used to refine the scope of subsequent work activities as needed, to achieve the overall RI objectives. Based on this strategy, the scope for certain aspects of the OU-3 RI/FS Work Plan have been revised to reduce the initial data collection in the first phase of work, and allow for flexibility in additional data collection during later phases to respond to the data collected and meet the data quality objectives.

The revised OU-3 RI/FS Work Plan proposes a comprehensive yet flexible investigation, and takes into account a broad understanding of available data, as well as known data gaps. As initial work scope activities commence, preliminary data will be evaluated for alignment with the analysis and assumptions made during preparation of the Work Plan. In the event newly obtained data suggest additional or alternate investigative locations or tools may be appropriate, proposed Work Plan modifications will be prepared and presented to USEPA for review, comment, and approval. No changes to the final approved Work Plan will be made without prior approval from USEPA.

The Respondents will work collaboratively with USEPA throughout the RI/FS implementation to present interim data evaluation and resulting possible scope optimizations. This approach is consistent with the July 2017 USEPA Superfund Task Force Recommendations and the November 2018 guidance on Smart Scoping at CERCLA Sites Technical Guides to Streamline Site Cleanup: Smart Scoping, Strategic Sampling and Data Management Best Practices (Office of Land and Emergency Management Directive 9200.1-164), which encourages the use of adaptive management, focused scoping, and the use of communication tools (USEPA 2017a; USEPA 2018a). This promotes focusing resources to make informed decisions throughout the RI/FS process and allows for adaptation as uncertainties in initial scoping are addressed. The phased approach will prioritize the installation of high-priority off-site monitoring wells and collection of groundwater data to assess hydraulic gradients and identify COPCs. These data will be evaluated as soon as practicable and used to propose additional work, as necessary, for USEPA review and approval.

Enclosed please find the Draft Final OU-3 RI/FS Work Plan, Sampling and Analysis Plan (including the Quality Assurance Project Plan and Field Sampling Plan), and Health and Safety Plan (Revision 1), which have been revised to address the USEPA comments. As noted in the April 8, 2020 response to comments, due to the comprehensive revisions made to the data quality objectives in the Quality Assurance Project Plan, a large number of the February 7, 2020 USEPA comments will be difficult to trace back to the original content or are no longer applicable.

These documents are being submitted in accordance with the requirements of Section VIII, Paragraph 44 of the West Lake Landfill OU-3 Administrative Settlement Agreement and Order on Consent (ASAOC) for RI/FS, Docket No. CERCLA-07-2018-0259, and the Statement of Work (SOW) thereto. Trihydro will be transmitting the Draft Final Work Plan (Revision 1) documents to the USEPA electronically. If you have any questions or encounter issues downloading the documents, please contact Ms. Allison Riffel at Trihydro at (303) 494-1172.

Sincerely,
Trihydro Corporation

Allison Riffel, P.E.
Project Manager

Gary Risse
Project Principal

63N-001-002

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DRAFT FINAL REVISION 1

VOLUME 1

REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

SITE WIDE GROUNDWATER (OPERABLE UNIT 03)

WEST LAKE LANDFILL SITE

BRIDGETON, MISSOURI

April 22, 2020

Project #: 63N-001-002

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

ENGINEERING SOLUTIONS. ADVANCING BUSINESS.

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List of Acronyms

3-D	Three dimensional
AOA	Air Operations Area
ARAR	Applicable or Relevant and Appropriate Requirement
ASAOC	Administrative Settlement Agreement and Order on Consent
B&M	Burns & McDonnell
bgs	below ground surface
BRA	Baseline Risk Assessment
BRAWP	Baseline Risk Assessment Work Plan
BTV	Background Threshold Value
$CaCO_3$	Calcium Carbonate
C&D	Construction & Demolition
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Regulations
cm/s	centimeters per second
cfs	cubic feet per second
COPC	Constituents of Potential Concern
CPT	Cone Penetrometer Test
CSM	Conceptual Site Model
CSR	Code of State Regulations
DDT	4,4'-dichlorodiphenyltrichloroethane
°C	degrees Celsius
DL	Data Logger

List of Acronyms (cont.)

DQO	Data Quality Objective
DO	Dissolved Oxygen
DOE	Department of Energy
EDD	Electronic Data Deliverable
EMSI	Engineering Management Support, Inc.
EME	USEPA Metadata Editor
EVOH	Ethylene Vinyl Alcohol
USEPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
FAA	Federal Aviation Administration
F&VD	Foth & Van Dyke
FFS	Final Feasibility Study
FGDC	Federal Geographic Data Committee
FS	Feasibility Study
FSP	Field Sampling Plan
ft	feet
ft/day	feet per day
ft^2/day	square feet per day
ft/year	feet per year
gpd	gallons per day
gpm	gallons per minute
GPS	Global Positioning System
GWPS	Groundwater Protection Standards

List of Acronyms (cont.)

HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HHT	Acronym Unknown
HPT	Hydraulic Profiling Tool
IC	Institutional Control
IDW	Investigation Derived Waste
JTU	Jackson Turbidity Units
kPa	kilopascal
LBSR	Leached Barium Sulfate Residue
LCS	Leachate Collection Sump
MCL	Maximum Contaminant Level
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering District
µg/cm^3	micrograms per cubic centimeter
µg/L	micrograms per liter
mg/L	milligrams per liter
mgd	million gallons per day
MNA	Monitored Natural Attenuation
MSD	Metropolitan St. Louis Sewer District
msl	mean sea level
MSW	Municipal Solid Waste
MSWLF	Municipal Solid Waste Landfill
NAD83	North American Datum 1983

List of Acronyms (cont.)

NAVD88	North American Vertical Datum 1988
NCC	Non-combustible Cover
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NRC	United States Nuclear Regulatory Commission
NTU	Nephelometric Turbidity Units
ONMSS	Office of Nuclear Material Safety and Safeguards
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
%	percent
PCB	Polychlorinated Biphenyl
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PID	Photoionization detector
PPE	Personal Protective Equipment
PMP	Project Management Plan
PSQs	Principal Study Questions
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act

List of Acronyms (cont.)

redox	oxidation-reduction
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIA	Remedial Investigation Addendum
RIM	Radiologically Impacted Materials
RMC	Radiation Management Corporation
ROD	Record of Decision
RQD	Rock quality designation
RSL	Regional Screening Levels
RSP	Radiation Safety Plan
SAP	Sampling and Analysis Plan
Sch	Schedule
SEM-EDS	Scanning Electron Microscope with Energy Dispersive X-Ray Spectrometry
SLAPS	St. Louis Airport Site
SLERA	Screening Level Ecological Risk Assessment
SOP	Standard Operating Procedure
SOW	Statement of Work
SP	Spontaneous Potential
SSR	Subsurface Reaction
SU	Standard Units
SVOC	Semi-Volatile Organic Compound
TBC	To Be Considered
TDS	Total Dissolved Solids

List of Acronyms (cont.)

T&E	Threatened and Endangered
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UAO	Unilateral Administrative Order
µg/L	microgram per liter
USACE	United States Army Corp of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UST	Underground Storage Tank
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
WMC	Water Management Consultants
XRD	X-Ray Diffraction

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Work Plan) has been prepared by Trihydro Corporation (Trihydro) on behalf of Bridgeton Landfill, LLC, Cotter Corporation (N.S.L.), and the United States Department of Energy (DOE) (collectively Respondents), for site-wide groundwater (Operable Unit 3 or OU-3), at the West Lake Landfill (site). The site is located at 13570 St. Charles Rock Road, Bridgeton, Missouri (Figure 1-1). The Work Plan was prepared at the request of the United States Environmental Protection Agency (USEPA) in accordance with requirements outlined in the Final RI/FS OU-3 Statement of Work (SOW), dated September 21, 2018, included as Appendix B in the Administrative Settlement Agreement and Order on Consent (ASAOC), dated February 6, 2019 (USEPA 2019a).

The site was added to the Superfund National Priorities List (NPL) in 1990 and consists of three Operable Units (OUs) including former industrial and municipal waste cells and groundwater. The site layout is shown on Figure 1-2. Operable Unit 1 (OU-1) includes former waste disposal areas Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2) where radiologically impacted materials (RIM) have been identified (USEPA ID#MOD079900932). Operable Unit 2 (OU-2) has no known areas identified as having been impacted with RIM and includes the Closed Demolition Landfill, Inactive Sanitary Landfill, and the North and South Quarry portions of the Bridgeton Landfill (also referred to as the Former Active Sanitary Landfill). The Missouri Department of Natural Resources (MDNR) is responsible for overseeing activities at the Bridgeton Landfill and the Closed Demolition Landfill portions of OU-2, in contrast to the remedial actions for the Inactive Sanitary Landfill, which are being addressed under USEPA's Superfund authority. OU-3 includes the groundwater beneath, and associated with the entire approximately 200-acre site, and is the focus of this RI/FS.

1.1 PURPOSE AND SCOPE

The purpose of this Work Plan is to outline the proposed methods to sufficiently characterize the nature and extent of hazardous substance impacts to groundwater resulting from site activities and the associated potential risk posed to human health and the environment. This Work Plan has been prepared in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Regulations (CFR) Part 300 (USEPA 2011a), as well as the USEPA guidance including, but not limited to: *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.3-01 (USEPA 1988); *Guidance for Data Usability in Risk Assessment*, OSWER Directive No. 9285.7-09A (USEPA 1992a); *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER Directive No. 9200.4-18 (USEPA 1997a); *Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing*

Preliminary Remediation Goals under CERCLA, OSWER Directive No. 9200.4-23 (USEPA 1997b); *Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6)*, OSWER Directive No. 9200.4-35P (USEPA 2000); *Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA sites*, OSWER Directive No. 9283.1-14 (USEPA 2001a); *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 3, Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium*," USEPA/600/R-10/093 (USEPA 2010); *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*, (USEPA 2014a); and *Groundwater Statistics Tool*, (USEPA 2014b), OSWER 9283.1-46.

Groundwater investigations have previously been conducted at the site for OU-1 and OU-2 under both the USEPA's and MDNR's oversight. Routine ongoing groundwater monitoring for the North and South Quarries of the Bridgeton Landfill is under MDNR oversight. The United States Geological Survey (USGS) and USEPA evaluated the possible origin of radium in groundwater at the site via groundwater monitoring completed between 2012 through 2014 (USGS 2015). The study concluded the existing data set was not adequate to conclusively determine the source(s) of radium in groundwater, and additional investigation was needed to characterize the nature and extent of constituents of potential concern (COPCs) present in groundwater. The objectives of this RI/FS, as outlined in the SOW are:

- Refine the current understanding of the site hydrogeologic system.
- Evaluate background groundwater quality near the site.
- Determine the extent of groundwater impacts occurring at, and near the site.
- Develop predictive tools to evaluate potential future impacts.
- Identify potential groundwater remedies that may be implemented based on the information collected at the site, as applicable or deemed necessary.

The OU-3 RI/FS is designed to expeditiously determine the horizontal and vertical distribution of COPCs in the subsurface at, and near the site. To the extent possible, the Work Plan has been prepared to achieve the listed objectives; however, several known data gaps preclude the ability to define a detailed scope of work for select elements of the RI/FS. Therefore, the OU-3 RI/FS will proceed in a phased, focused, and streamlined manner driven by real-time data analysis, which allows flexibility in project scope.

The Respondents will work collaboratively with USEPA throughout the RI/FS implementation to present interim data evaluation and resulting possible scope optimizations. This approach is consistent with the July 2017 USEPA *Superfund Task Force Recommendations* and the November 2018 guidance on Smart Scoping at CERCLA Sites

Technical Guides to Streamline Site Cleanup: Smart Scoping, Strategic Sampling and Data Management Best Practices (Office of Land and Emergency Management Directive 9200.1-164), which encourages the use of adaptive management, focused scoping, and the use of communication tools (USEPA 2017a; USEPA 2018a). This promotes focusing resources to make informed decisions throughout the RI/FS process and allows for adaptation as uncertainties in scoping are addressed. The phased approach will prioritize the installation of high-priority off-site monitoring wells and collection of groundwater data to assess hydraulic gradients and identify COPCs. These data will be evaluated as soon as practicable and used to propose additional work, as necessary, for USEPA review and approval.

1.2 REQUIRED CONTENTS OF THE REPORT

As outlined in the SOW, this Work Plan provides a project description, a summary of site historical information, a site setting overview, and outlines the general technical approach to achieve objectives of the RI/FS. The approach uses, and builds upon the findings of previous groundwater data, studies, sampling plans, quality plans, and associated reports to support a groundwater investigation for both radiological and non-radiological parameters at the site. This groundwater-specific OU-3 Work Plan contains a Sampling and Analysis Plan (SAP) composed of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP), included as Volume 2. A document directory with references to major elements of the applicable RI/FS scope within each of the documents is included in Table 1-1. A Health and Safety Plan (HASP), which includes a Radiation Safety Plan (RSP), has also been included as Volume 3.

The following items are required as part of this effort:

- Propose a scope of investigative and analytical activities to meet the stated objectives.
- Perform sampling, analysis, and review of data sets to adequately scope the project and to develop project plans.
- Develop preliminary remedial action objectives (RAOs).
- Identify current and future risk posed by COPCs to human health and the environment.
- Develop methods and a scope for the groundwater modeling.
- Identify potential Applicable or Relevant and Appropriate Requirements (ARARs) associated with the location and contaminants at the site and potential response actions.

1.3 REPORT ORGANIZATION

This Work Plan is being submitted in general accordance with OSWER Directive No. 9355.3-01 and contains the following sections (USEPA 1988):

- Section 2 – Site Background and Setting
- Section 3 – Initial Evaluation and Conceptual Site Model
- Section 4 – RI/FS Rationale
- Section 5 –Site Characterization
- Section 6 – Data Management and Evaluation
- Section 7 – Baseline Risk Assessment
- Section 8 – Feasibility Study
- Section 9 – RI/FS Reporting
- Section 10 – Project Management Plan
- Section 11 – References

2.0 SITE BACKGROUND AND SETTING

This section presents a brief description of the site, including the location, an overview of past and current operations, and a discussion of other near the site. Detailed descriptions of the site were included in documents submitted to USEPA under the OU-1 and OU-2 RI/FS process. Numerous investigations were previously conducted by Radiation Management Corporation (RMC), Burns & McDonnell (B&M), the U.S. Nuclear Regulatory Commission (NRC), Golder Associates (Golder), McLaren/Hart Environmental Engineering Corporation (McLaren/Hart), Water Management Consultants, Inc. (WMC), Engineering Management Support, Inc (EMSI), Herst & Associates, Inc. (H&A), and Feezor Engineering, Inc. (Feezor). The relevant data from each effort pertinent to OU-3 is summarized in this Section.

2.1 PHYSICAL SETTING

The site is 212 acres and is on the east side of the Missouri River within the western portion of the St. Louis metropolitan area in northwestern St. Louis County (Figure 1-1 and Figure 1-2). The site address is 13570 St. Charles Rock Road, which is approximately one mile north of the intersection of Interstate 70 and Interstate 270, within the City of Bridgeton, Missouri. The site includes six historical waste disposal areas (units), including Area 1, Area 2, the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the North Quarry and South Quarry Portions of the Bridgeton Landfill. A solid waste transfer station and an asphalt batch plant currently operate on the site (Figure 2-1). There is a six-foot-high chain-link fence with a three-strand barbed wire canopy enclosing most of the property. The main access gate is on the northeastern boundary and a secondary access gate is on the southwestern boundary of the landfill property.

Current ownership of the properties included in the definition of the site is depicted on Figure 2-2. The landfill property is bordered by Crossroads Industrial Park to the northwest and St. Charles Rock Road (State Highway 180) to the north and east; Taussig Road, commercial facilities (including the Bridgeton Transfer Station, LLC hauling company facility), and agricultural land are to the southeast; and Old St. Charles Rock Road and the Earth City Industrial Park (Earth City) stormwater/flood control pond are to the south, west, and north. The Earth City commercial/industrial complex continues to the west and north of the flood control pond and extends to the Missouri River.

Earth City is separated from the river by an engineered levee system that is owned and maintained by the Earth City Flood Control District. Terrisan Reste mobile home park, located to the southeast approximately 0.7 miles from Area 1 and 1.1 miles from Area 2, is the nearest residential area to the site. The Spanish Village residential subdivision is located to the south of the site near the intersection of St. Charles Rock Road and I-270, approximately 1 mile from Area 1 and 1.25 miles from Area 2.

The property on the west side of Area 2 was previously referred to as the Ford Property in the OU-1 RI (EMSI 2000) because it was previously owned by Ford Motor Credit, Inc (Ford). Most of the Ford Property was sold to Crossroad Properties, LLC in 1998 and has since been developed into the Crossroads Industrial Park. Ford initially retained ownership of a 1.78-acre parcel located immediately adjacent to the west of Area 2 (Figure 2-1). Ownership of this 1.78-acre parcel was subsequently transferred to Rock Road Industries, Inc., now Bridgeton Landfill, LLC, to provide a buffer between the landfill and adjacent property, and therefore, this parcel has been identified as the "Buffer Zone." Crossroad Properties, LLC initially developed all of the former Ford property with the exception of Lot 2A2, a 3.58-acre parcel immediately north of the Buffer Zone. Lot 2A2 was subsequently developed by AAA Trailer, the owner of much of the property immediately to the north of the Buffer Zone and Area 2, although Lot 2A2 is still owned by Crossroad Properties, LLC. Property to the north and northeast of the landfill, across St. Charles Rock Road, is moderately developed with commercial, retail and manufacturing operations. Zoning for the parcels that make up the landfill property and surrounding parcels is depicted on Figure 2-3.

The West Lake Landfill Superfund NPL Site consists of the various parcels that comprise the landfill property (on-property) and adjacent properties (off-property). OU-1 includes on-property Areas 1 and 2, the adjacent Buffer Zone, and the adjacent off-property Parcels B and C of Lot 2A2 of the Crossroads Industrial Park (Figure 2-1). The Buffer Zone and the Lot 2A2 were not used for waste disposal, but have been identified as containing radionuclides in soil as a result of transport by surficial runoff from OU-1 (EMSI 2018a). OU-2 consists of the remaining portions of the landfill property. These areas are shown on Figure 2-1 and discussed in more detail in Section 2.2.

2.2 SITE HISTORY

Historically, the on-property portions of the site have been divided into five areas:

- Area 1
- Area 2
- Closed Demolition Landfill
- Inactive Sanitary Landfill
- Former Active Sanitary Landfills (North and South Quarry) or the Bridgeton Landfill

These areas are discussed below in further detail. OU-1 includes Area 1, Area 2, the Buffer Zone, and Crossroads Properties LLC Lot 2A2. The Bridgeton Landfill, the Closed Demolition Landfill, and the Inactive Sanitary Landfill are all part of OU-2 (Figure 2-1).

The West Lake Landfill was originally used for agriculture until a limestone quarrying and crushing operation began in 1939. The quarrying operation continued until 1988 and resulted in two excavation areas and two quarry pits: the North Quarry Pit and the South Quarry Pit. Both quarries were excavated to a maximum depth of approximately 240 feet below ground surface (ft bgs) and had a bottom elevation of approximately 240 feet (ft) above mean sea level (msl) (H&A 2005; Golder 1996).

The site contains six areas where solid wastes have been disposed. The date that landfilling activities started at the West Lake Landfill is not known with certainty and has been variously cited as beginning, in or around the early 1950s (EMSI 2000), or as starting in 1952 or possibly 1962 (H&A 2005). The landfill was authorized by the county to accept sanitary waste in 1952. USEPA reported that "from 1941 through 1953 it appeared that limestone extraction was the prime activity at the facility; however, as time passed, the focus of the activity appeared to shift from mining to waste disposal" (USEPA 1989a). USEPA also reported that historical aerial photography from 1953 indicates use as a landfill had commenced.

Mine spoils from quarrying operations were deposited on adjacent land immediately to the west of the quarry (H&A 2005). Portions of the quarried areas and adjacent areas were subsequently used to landfill municipal refuse, industrial solid wastes, and construction and demolition (C&D) debris. USEPA has reported that liquid wastes and sludges were also disposed of at the landfill (USEPA 1989a). These operations, which predated state and federal laws and regulations that govern such operations, occurred in areas that subsequently have been identified as Area 1, Area 2, the Closed Demolition Landfill, and the Inactive Sanitary Landfill (Figure 2-1).

Due in part to the fact that the disposal of solid and liquid waste at the site predated state and federal regulations for landfills, there is uncertainty regarding the specific site activities and disposal practices. Specifically, based upon a review of historical aerial photographs as documented in the report entitled *Aerial Photographic Analysis of the West Lake Landfill Site* (USEPA 1989a), "deep" pits, lagoons, and other features related to past on-site disposal practices have been identified in several historical aerial photographs for the years pre-dating the arrival of radionuclides from the Latty Avenue Site (EMSI 2018a).

2.2.1 LANDFILL PERMIT HISTORY

The following sections describe the landfill history and are taken from the *Remedial Investigation Addendum, West Lake Landfill, Operable Unit 1* (EMSI 2018a). MDNR permitted areas are shown on Figure 2-4. Prior to 1974, the landfills were not subject to state permitting (although they were still subject to an authorization issued by the county), and the portion of the landfill property where these activities occurred has been referred to as the "unregulated landfill." Waste disposal in St. Louis County was regulated solely by St. Louis County authorities until 1974, when the MDNR was formed (H&A 2005). The landfill activities that were conducted in 1974 and afterwards were subject to a permit from MDNR.

In 1974, MDNR identified six waste disposal areas shown on Figure 2-4. MDNR Areas 1, 3, 5, and 6, were subsequently permitted for waste disposal. MDNR Areas 2 and 4, which included the majority of OU-1 Area 1 and the majority of OU-1 Area 2, were not permitted, and were therefore closed in 1974 (H&A 2005). The areas subsequently permitted by MDNR for waste disposal are referred to as the "regulated landfill." These areas are further discussed below.

On August 27, 1974, MDNR granted authorization for a sanitary landfill on 25 acres in the area now identified as the Inactive Sanitary Landfill. MDNR subsequently issued a permit (No. 118903) for this area on January 27, 1976 (H&A 2005). MDNR also issued a permit (No. 218903) for operation of a solid waste disposal area for a demolition landfill on 27 acres of land that included a large portion of the area subsequently identified as the Closed Demolition Landfill. The Closed Demolition Landfill was constructed over an area that had previously been used for the disposal of sanitary waste. This permit also included the eastern portion of Area 2, the eastern portion of the Inactive Sanitary Landfill, and the western portion of Area 1. On May 23, 1978, permit No. 118903 was modified to include an additional 3.5 acres within the area of the Inactive Sanitary Landfill. On August 27, 1980, MDNR issued a permit (No. 118908) for operation of a sanitary landfill on 6 acres located in the area now identified as the Inactive Sanitary Landfill. On September 18, 1984, MDNR issued a permit (No. 218912) for the operation of a demolition landfill on 22 acres in the area now identified as the Closed Demolition Landfill.

On January 22, 1979, MDNR issued a permit (No. 118906) for the operation of a sanitary landfill on 13 acres in the portion of the property described as the North Quarry of the Bridgeton Landfill (H&A 2005). A subsequent permit (No. 118909) was issued August 20, 1981 to allow for an expansion of the North Quarry landfill. On November 11, 1985, MDNR issued permit No. 118912, which allowed for a 33-acre expansion of sanitary landfill operations into the South Quarry area and continued waste placement in the North Quarry, thereby superseding prior permits No. 118909 and 118906. Permit No. 118912 covers a 52-acre area that encompasses the North Quarry and South Quarry, which together comprise what is currently identified as the Bridgeton Landfill. Placement of waste material in both the North and South Quarry areas ceased in 2004. No active landfilling has occurred since 2004, although ongoing activities pursuant to Orders from the state Attorney General's Office, USEPA Region 7, and MDNR, related to maintenance and monitoring of the Bridgeton Landfill continue. Routine groundwater monitoring for the North and South Quarries of the Bridgeton Landfill is currently conducted under this permit.

2.2.2 WEST LAKE LANDFILL RADIOLOGICAL AREA 1

Area 1, which encompasses approximately 17.6 acres, is immediately to the southwest of the landfill entrance (Figure 2-1). This area was part of the unregulated landfill operations conducted up through 1974, although the southwestern portion of what is currently identified as Area 1 was historically included under permit No. 218903. Between 2006 and 2008, during implementation of a *Materials Management Plan* (EMSI 2006) approved by MDNR, inert fill material (e.g., clean materials as defined in 10 Code of State Regulations (CSR) 80-2.010(11), such as uncontaminated soil, concrete, asphaltic concrete, brick, or inert solids) was placed over portions of Area 1.

Remnants of an asphalt entrance road and parking area are on the northwestern border of Area 1 to the south of the office building. There is a stormwater collection and conveyance pipe along St. Charles Rock Road that is composed of concrete manhole inlets and pipe. This system was evaluated as part of the OU-1 RI/FS. Additional information regarding the below-ground stormwater drain is not currently available, and this drain system will be further evaluated under the OU-1 remedial design. There is an abandoned underground diesel tank beneath the asphalt-paved area, as evidenced by the presence of a fuel dispenser in Area 1. The tank is no longer in use. However, the tank has not been removed because it is within the boundaries of Area 1 (current presence confirmed by site personnel). No information has been located regarding the date of installation of the underground tank, when it ceased to be used, or its abandonment; however, based on review of aerial photography in Appendix A, a pump likely associated with the underground tank was visible in aerial photography as early as October 8, 1980. A truck is visible in May 9, 1985 imagery adjacent to the pump as if it is in the process of refueling. This pump remains visible at least through the aerial photography taken on September 20, 2004. A septic tank is also present in Area 1.

Based on a review of aerial photography, the road and parking area appear to have been constructed sometime between August 20, 1978 and May 25, 1979. Parked vehicles can be seen on aerial photographs through May 9, 1985 but they are no longer visible on the April 1990 aerial photograph. As can be seen in aerial photographs included in Appendix A, a drainage swale is visible on the northwest side of Area 1 between June 17, 1981 and May 14, 1984 as shown on Figure 2-5. Between May 9, 1985 and June 18, 1990 an additional drainage swale is visible in aerial photographs on the northeast side of Area 1. A guard house, or similar structure, was constructed on the northwest corner of Area 1 between May 25, 1979 and December 2, 1979. It remains visible in aerial photographs through April 16, 1996.

The results of the site investigations indicate RIM is present in the area of the former entrance road, parking area, and underground tank; however, no information is available as to whether the construction of the road and parking area or the installation of the underground tank resulted in either the disturbance or relocation of RIM. Prior to 2013, the remaining portions of Area 1 were mainly covered with grass, shrubs, and trees. In 2013, 2014, and 2015, vegetation was cleared along the alignments of numerous access roads and road base material was placed along these roads to support additional drilling activities. In 2016, approximately 2.6 acres in the northern portion of Area 1 were cleared of vegetation and covered with road base material as part of construction of a non-combustible cover (NCC) over areas where RIM was present at the ground surface (EMSI 2016) pursuant to a unilateral administrative order (UAO) for removal action issued by USEPA (USEPA 2015a). NCC consisted of a minimum of 8-inches of road base material placed over a geotextile placed on the existing ground surface following the removal of existing vegetation using a brush hog. The lateral extent of the NCC was based on the extent of surface RIM defined in the 2000 RI report, additional overland gamma surveying, and the collection and analysis of surface soil samples. Small and medium-sized trees and shrubs still cover the northern, eastern and southwestern portions of Area 1. The southwestern portion of Area 1 was covered beneath the above-grade portion of the North Quarry portion of the Bridgeton Landfill in approximately 2002-2003.

2.2.3 WEST LAKE LANDFILL RADIOLOGICAL AREA 2

Radiological Area 2, which encompasses approximately 41.8 acres, is located in the northwestern part of the landfill property. Landfilling activities are first visible in the footprint of Area 2 between June 14, 1962 and April 10, 1964, based on a review of historical aerial photographs. Area 2 was also part of the unregulated landfill operations conducted up through 1974, although a small part of the eastern portion of Area 2 was also included within permit No. 218903 (Figure 2-4). Between 2006 and 2008, during implementation of a *Materials Management Plan* (EMSI 2006) approved by MDNR, inert fill material (e.g., clean materials, as that term is defined in 10 CSR 80-2.010(11), such as uncontaminated soil, concrete, asphaltic concrete, brick, or inert solids) was placed over portions of Area 2.

Review of the RMC 1982 report, NRC 1988 and 1989 reports, and review of aerial photographs indicates that a small building (referred to in the RMC and NRC reports as the Shuman building) was present in the northern portion of Area 2. According to correspondence between Reitz & Jens, Inc. and the MDNR, this building was part of a paving contractor's operation and first appears in the April 6, 1975 aerial photograph (Reitz & Jens, Inc. 1982). The building is no longer present in the April 1990 aerial photograph. With the cessation of the use of the surface of Area 2, vegetation including grasses, shrubs, and trees began to grow in this area. During the 1994-1995 field investigations, only grasses, shrubs, and small trees were present in this area, but by 2015, this vegetation had grown into large trees and extensive brush cover.

Prior to 2015, large portions of this area were covered with grasses, native bushes, and trees, while other portions were unvegetated and covered with inert fill material consisting of soil, gravel, concrete rubble, and bricks. Miscellaneous debris consisting of concrete pipe, metal and automobile parts, discarded building materials, and other non-perishable materials were also on the surface. During the 1994-1996 OU-1 RI field investigations, a number of small depressions, some of which seasonally contained ponded water and phreatophytes such as cattails, were scattered throughout Area 2, in large part due to the presence of small berms located along the top of the major landfill berm/slope along the northern, northeastern and western portions of Area 2, which are intended to contain runoff from Area 2. With the exception of the landfill slope adjacent to the Buffer Zone, the slopes of landfill berm were covered with a dense growth of trees, vines, and bushes.

In 2015, vegetation was cleared along the alignments of numerous access roads and road base material was placed along these roads to support additional drilling activities. In 2016, approximately 17.2 acres in the central portion of Area 2 were cleared of vegetation and covered with road base material as part of construction of an NCC over areas where RIM was present at the ground surface, pursuant to a UAO for removal action that was issued by USEPA (USEPA 2015a). NCC cover consisted of a minimum of 8 inches of road-base material placed over a geotextile that was positioned on the existing ground surface after removal of the vegetation using a brush hog. The lateral extent of the NCC was based on the extent of surface RIM defined in the 2000 RI report, additional overland gamma surveying, and collection and analysis of surface soil samples (EMSI 2000). Vegetation, including large trees, was cleared from the southwestern portion of the landfill berm/slope adjacent to the Buffer Zone, and approximately 1.78 acres of the Buffer Zone was covered with rock, including construction of a large rock buttress in this area as part of the NCC construction for Area 2 (EMSI 2016). Large and medium-sized trees and shrubs still cover the northern, western, and southern portions of Area 2.

2.2.4 INACTIVE SANITARY LANDFILL AND CLOSED DEMOLITION LANDFILL OPERATIONS IN OU-2

The Inactive Sanitary Landfill is located to the southwest of the Closed Demolition Landfill. The operations performed in this area were also part of the unregulated landfill operations conducted up through 1974 that were subsequently regulated by MDNR and included within the scope of permit Nos. 118903, 218903, 118908, and 218912 (Figure 2-4). Based on the results of visual inspection and geologic logging of drill cuttings and core samples, municipal solid waste

(MSW) is the primary waste disposed in the Inactive Sanitary Landfill (H&A 2005). Descriptions of waste included refuse, waste, and fill, but the descriptions did not distinguish between the type of waste placed in the Inactive Sanitary Landfill. According to the OU-1 RI Addendum (RIA), no industrial waste was identified in the samples collected from the Inactive Sanitary Landfill (EMSI 2018a).

The Closed Demolition Landfill is located in the north central part of the landfill property. The Closed Demolition Landfill is on the southeast side of Area 2, between Area 2 and the landfill entrance road. Review of the permit history indicates that sanitary wastes were placed in MDNR Area 1 and Area 5 of Permit No. 218903 prior to placement of overlying C&D debris and wastes authorized under Permit 218903 on January 27, 1976, as shown on Figure 2-4.

Based on a review of aerial photography included in Appendix A, the first disturbance of the demolition landfill footprint is visible in the August 11, 1966 aerial photographs. By September 19, 1969, the entire demolition landfill footprint has been disturbed by landfilling. Filling within the demolition landfill footprint appears to cease between April 6, 1975 and April 12, 1976, based on aerial photographs. The time period prior to January 27, 1976 appears to correspond to pre-demolition landfilling activities. The active spreading of cover is visible through the May 9, 1976 photographs. The surface is revegetating by August 20, 1978. Surface activities such as pathways, surface settling and impoundments, and grading are visible, but no major landfill activities are observed within the demolition landfill footprint until a new episode of light-toned filling is seen on the June 18, 1990 photograph. Activities on the demolition landfill appear to have ceased by the April 16, 1996 photograph.

2.2.5 BRIDGETON LANDFILL

The Bridgeton Landfill includes the former North Quarry and South Quarry portions of the landfill property (Figure 2-1). Collectively, the North and South Quarry landfill areas make up the Former Sanitary Landfill, also known as the Bridgeton Landfill. The Bridgeton Landfill was referred to as the Former Active Landfill in the OU-2 Record of Decision (ROD). Waste disposal in the Bridgeton Landfill consisted primarily of MSW and commercial waste. Disposal of waste materials in the Bridgeton Landfill ceased in 2004 pursuant to an agreement with the City of St. Louis to reduce the potential for birds to interfere with operations at a new runway at the nearby Lambert-St. Louis International Airport (Lambert Field), the western end of which is approximately 9,166 ft from the landfill. The Bridgeton Landfill is included within the scope of OU-2, and regulatory authority has been deferred to the MDNR, per the selected remedy under the OU-2 ROD.

The review of historical aerial photographs indicates that quarrying activities (removal of limestone) continued to be conducted in the North Quarry up through 1979. Based on the decrease in elevation of the quarry floor between 1969 and 1971, rock quarrying was being conducted in the southern portion of the North Quarry during this time. Some limestone continued to be removed from this area between 1971 and 1973; however, based on the change in the elevation of the quarry floor, most of the rock quarrying activity in the North Quarry shifted to the north. Between 1973 and 1974, rock quarrying occurred in the neck area located between the North and South Quarries. Between 1974 and 1975, quarrying occurred in the northern portion of the North Quarry. Between 1975 and 1977, the majority of rock quarrying occurred in the central and southern portions of the North Quarry. Between 1969 and 1977, the elevation of the base of the North Quarry was lowered approximately 25 to 75 ft. Because rock quarrying was occurring in the North Quarry area during this period and likely through 1979, placement of waste could not have occurred in North Quarry prior to 1979.

The first permit for placement of waste materials in the North Quarry (Permit No. 118906) was issued on January 22, 1979. Review of a May 1977 aerial photograph does not show any waste in the North Quarry area at that time, while review of a July 26, 1979 aerial photograph shows waste placement. Based on the permit date and review of the historical aerial photographs, it seems likely that placement of waste in the North Quarry began in or around 1979. Landfilling continued in the North Quarry area until 1985 when the landfill underwent expansion to the southwest into the area described as the South Quarry Pit pursuant to an additional permit (No. 118912) issued by MDNR on November 18, 1985 (H&A 2005).

The North Quarry portion of the Bridgeton Landfill is south of and adjacent to Area 1. The landfilling of the North Quarry portion of the Bridgeton Landfill included filling of the former North Quarry pit and above-grade landfilling over the top of the North Quarry pit that also extended outward beyond the edges of the former quarry pit. The above-grade portion of the North Quarry extends over, and overlaps, the southern portion of Area 1. Based on the date of Permit No. 118906 and review of historical aerial photographs, the placement of waste in the North Quarry began in 1979 with initial waste placement occurring in the northeastern portion of the North Quarry area (nearest to St. Charles Rock Road) and subsequently progressing to the southwest (toward the South Quarry). By 1985, most of the northeastern part (e.g., the part adjacent to Area 1) of the below-grade (quarry) portion of the North Quarry had been filled with waste; however, waste disposal in the southwestern portion of the North Quarry (a.k.a., the “neck” area) continued through approximately 2002. Placement of waste in the above-ground portion of the North Quarry portion of the Bridgeton Landfill that extended over the southern portion of Area 1 occurred in approximately 2002 through 2004. Landfilling in the North Quarry ceased in 2004.

The South Quarry portion of the Bridgeton Landfill is adjacent to and southwest of the North Quarry. Quarrying operations gradually moved from the North Quarry to the South Quarry, resulting in two quarry pits being connected via a narrow area referred to as the "neck". The South Quarry area is adjacent to the southernmost portion of the Inactive Sanitary Landfill. Landfilling in the South Quarry began in 1985 and ceased in 2004.

A subsurface reaction (SSR) was discovered in 2010 and is currently occurring in the South Quarry portion of the Bridgeton Landfill. The SSR has been in the southwestern portion of the South Quarry since 2013 and no migration is currently detected. A heat extraction system was installed in the neck area between North and South Quarries to prevent the migration of the SSR towards Area 1. Additional discussion of the SSR is provided in Section 3.1.5.7.3.

2.2.6 BUFFER ZONE AND LOT 2A2

The property located to the west of Area 2 was formerly owned by Ford and was referred to as the Ford property during performance of the 2000 OU-1 RI (EMSI 2000). Ford sold most of this property in 1997, and it was subsequently developed as the Crossroads Industrial Park between approximately 1998 through 2000. Most of the parcels associated with the Crossroads Industrial Park were subsequently sold at various times to individual owners; however, Crossroad Properties LLC retained ownership of Lot 2A2 Parcels B and C. Lot 2A2 is currently used for outdoor storage of trailer trucks by AAA Trailer, which operates on a facility located on Lot 2A1 immediately to the west of Lot 2A2.

The Buffer Zone – a portion of the former Ford property that was sold to Rock Road Industries on February 2, 2001 – is between the Area 2 slope to the east and the Crossroads Industrial Park to the west (Figure 2-1). The Buffer Zone includes the area of radiologically impacted surface soils identified in the *Phase III Radiological Assessment* performed by Dames & Moore (D&M) for Ford Financial Services Group in 1991 (D&M 1991). Investigations conducted as part of the OU-1 RI identified the presence of radionuclides in surface soil on both the Buffer Zone and Lot 2A2. The OU-1 RIA concluded that the presence of radionuclides on these properties was likely a result of historical erosion of impacted soil from Area 2 (EMSI 2018a).

2.2.7 OTHER SIGNIFICANT FEATURES NEAR THE SITE

The West Lake Landfill is approximately 1.75 miles to the east-southeast of the Missouri River with portions of the site ranging from 1.4 to 2.0 miles from the river. The Earth City Industrial Park is located on the Missouri River floodplain to the west of the site. The Earth City Industrial Park is protected from flooding by a levee (Figure 1-2) and stormwater management system operated and maintained by the Earth City Flood Control and Levee District. The stormwater management system includes a series of stormwater detention ponds, one of which is along the west side of the landfill property (Figure 1-2). There is another stormwater detention pond across St. Charles Rock Road to the north of Area 2.

There is an area that occasionally accumulates stormwater near the northern portion of Area 2, on the south side of St. Charles Rock Road (Figure 1-2). Although this low area consisted of a pond during the time frame when the original OU-1 field investigations were conducted (1995-1997), and therefore was identified as the North Surface Water Body, over the years this area has become overgrown and silted in, and only contains water after storm events. In addition to overland flow from the north slope of Area 2, stormwater runoff from much of the West Lake Landfill area is conveyed to this area by the internal stormwater conveyance ditches and the perimeter stormwater conveyance structures and ditch along the southwest side of St. Charles Rock Road. Inspection of the North Surface Water Body has not identified any outlet, or pathway for discharge of the water, and therefore, the surface water that accumulates in this area appears to dissipate over time by evaporation and infiltration.

The site, at its closest point, is within approximately 8,450 ft of the end of runway 11 of Lambert St. Louis International Airport. The site is situated within the takeoff and approach routes for the airport. As discussed in Section 2.3, the landfill is subject to a Negative Easement and Declaration of Restrictive Covenants Agreement between the City of St. Louis and Bridgeton Landfill, LLC (among other entities) that prohibits depositing or dumping of new or additional putrescible waste on the entirety of the Bridgeton Landfill after August 1, 2005 (City of St. Louis 2005).

2.3 LAND USE RESTRICTIONS

The landfill property is subject to several controls on land use (Figure 2-6). An institutional control (IC) in the form of a *Declaration of Covenants and Restrictions* was recorded on June 30, 1997, and a supplemental *Declaration of Covenants and Restrictions* was recorded on January 20, 1998, The IC prohibits future residential use of the property, and groundwater use on any of the landfill property. Additionally, the IC restricts construction of buildings and underground utilities and pipes within Areas 1 and 2. On October 31, 2016, the prior ICs were modified by a further supplemental *Declaration of Covenants and Restrictions* recorded against all of the OU-1 Areas (Areas 1 and 2 and the Buffer Zone) and the OU-2 landfill areas to include the OU-1 areas not included under the prior institutional controls, and to prohibit use of the premises for commercial and industrial purposes including, but not limited to, use as a storage yard, and to prohibit placement of water wells for agricultural purposes. These institutional controls cannot be terminated without the written approval of the current property owners, MDNR, and USEPA.

Additionally, in 2005, the City of St. Louis entered into a Negative Easement and Declaration of Restrictive Covenants Agreement with Bridgeton Landfill, LLC (among other entities) to prohibit depositing or dumping of new or additional putrescible waste on the entirety of the Bridgeton Landfill after August 1, 2005 (City of St. Louis 2005). This negative easement stemmed, in part, from an earlier determination by the Federal Aviation Administration (FAA) and the United

States Department of Agriculture, Animal and Plant Health Inspection Service that the landfill was a hazardous wildlife attractant for the Lambert-St. Louis International Airport (City of St. Louis Airport Authority 2010).

The northwest end of the Lambert-St. Louis International Airport runway 11 is approximately 8,450 ft from the nearest point of the landfill mass (east corner of the South Quarry portion of the Bridgeton Landfill). The northwest end of runway 11 is approximately 9,350 ft from the nearest point of Area 1, and approximately 11,000 ft from the nearest point of Area 2. Therefore, portions of both the Bridgeton Landfill and Area 1 are located at distances that are less than the FAA siting guidance of a 10,000-foot separation radius between an airport's Air Operations Area (AOA) and a municipal solid waste landfill (MSWLF) (FAA 2007). In addition, the FAA recommends a distance of 5 miles between the farthest edge of an airport's AOA and any hazardous waste wildlife attractant (e.g., an active MSWLF), if the attractant could cause hazardous wildlife movement into, or across, the approach or departure airspace. All portions of the site are within this 5-mile distance (EMSI 2018a).

2.4 HISTORY OF INVESTIGATIVE, REGULATORY, AND RESPONSE ACTIONS

Previous investigations, regulatory actions, and response actions conducted by local, state, federal or private parties that are related to this OU-3 RI are summarized on Table 2-1 and discussed in detail in the RIA (EMSI 2018a). A summary of the pertinent groundwater-specific OU-1, OU-2, and regional groundwater investigations is presented below. The data from these reports have been used to develop the conceptual site model (CSM).

2.4.1 1986 HYDROGEOLOGIC INVESTIGATION

The 1986 hydrogeologic investigation was conducted to evaluate groundwater flow and to delineate the nature and extent of groundwater impacts (B&M 1986). The investigation did not take into consideration leachate collection, treatment, or monitoring at the North Quarry portion of the Bridgeton Landfill, which at the time was 180 ft below the water table near the neck. The goal of the investigation was to establish a long-term monitoring network and to establish background groundwater quality. The scope of work included soil sampling at 15 soil borings, soil engineering properties testing, piezometer installation for water levels and groundwater sampling, evaluation and gauging of 20 existing piezometers for a total of 35 periodic measurements, evaluation of groundwater head and flow at different alluvial horizons, and sampling for two rounds at 18 select piezometers/wells based on their horizontal and vertical spacing. Three casing volumes were bailed, and samples collected from 18 wells in December 1985 and May 1986 to evaluate seasonal variability. Samples were submitted to various laboratories for analysis of priority pollutants under 40 CFR Part 122, gross alpha and beta, and individual isotopes. Figures displaying the historical monitoring well networks are included in Appendix B.

The investigation concluded that the alluvium was the major aquifer in the vicinity, that it is generally unconfined, and in hydraulic communication with the Missouri River, with predominant regional flow within the alluvium towards the Missouri River. A regional groundwater flow evaluation is included as part of this OU-3 RI and is expected to show a component of flow down the Missouri River Valley during normal conditions. The alluvium was mounded with downward vertical gradients in areas of localized recharge. The alluvial sediments could generally be separated into two aquifers – an upper alluvial aquifer and a lower alluvial aquifer. Shallow and intermediate alluvial wells were combined as the upper alluvial aquifer, which was present from ground surface to approximately 65 ft bgs, or above 385 ft msl. Deep alluvial wells were considered to monitor the lower alluvial aquifer, which is present from approximately 65 ft bgs to 120 ft bgs, or below 385 ft msl. Surface water monitoring point SMP-63 was located in the North Surface Water Body and was in apparent communication with groundwater. However, SMP-63 was accidentally destroyed prior to surveying.

Horizonal gradients in the upper and lower alluvial aquifers were determined to be small, and variable. The lower aquifer exhibited flatter hydraulic gradients than the upper aquifer. Hydraulic conductivity of the alluvium was found to range between 2.4 x 10^{-4} to 2.5 x 10^{-1} centimeters per second (cm/s). To better understand hydraulic conductivity, the OU-3 RI will document both the horizontal and vertical distribution of aquifer properties. Groundwater flow rates are a function of both hydraulic gradient and conductivity.

Methylene chloride was the only priority pollutant volatile organic compound (VOC) detected in background, upgradient, and downgradient wells, but was less than the drinking water quality standard in all of the groundwater samples. Bis (2-ethyhexyl) phthalate and phenol were detected below the drinking water quality standard in well D-92 at 477 micrograms per liter (µg/L) and 19 µg/L, respectively. Organics exhibited an irregular distribution in monitoring wells, so the landfill was identified as a possible source. Metals also were distributed irregularly with none in exceedance of state and federal standards and no significant differences were observed between background, upgradient, and downgradient wells. There were no significant differences in the constituent concentrations between the deep and shallow wells. Seasonality was observed between events with more constituents detected at higher concentrations during December 1985 than May 1986. Pesticides were detected at wells S-82, D-83, and S-84, but their source was not determined since pesticides were detected in what was then considered background, upgradient, and downgradient wells. Chlordane and 4,4'-dichlorodiphenyltrichloroethane (DDT) exceeded Health Risk Criteria at these locations. The presence of pesticides will be further evaluated after the regional groundwater flow direction has been established. Gross alpha radiation exceeded drinking water quality standard at downgradient well S-82, and radium concentrations exceeded the drinking water standard at wells S-82 and D-83.

The investigation recommended short-term supplemental data investigation to evaluate the seasonal variability in concentrations, potential impacts to fish in nearby surface water bodies to the north, the source of constituents in upgradient wells, and the installation of an additional piezometer near D-89. Routine long-term monitoring was also recommended for a select list of constituents. These recommendations do not appear to have been implemented until 1996.

2.4.2 1989 SITE CHARACTERIZATION AND REMEDIAL ACTION CONCEPTS

The report by the Office of Nuclear Material Safety and Safeguards (ONMSS) evaluated previous site characterization of remedial actions and updated groundwater monitoring data (NRC 1989). Their report presented the results, environmental characteristics of the site, the extent and characteristics of the radioactive material, some considerations with regard to potential disposal of the materials, and some concepts of remedial measures.

The Butler-type building, which has since been removed, and perimeter monitoring wells were identified in the 1989 NRC report as areas of concern due to the potential for accumulation of radon within the steel building and presence of radionuclides in monitoring wells. Their investigation concluded that the contamination of water in the bedrock aquifer did not appear likely, due to the fairly impervious limestone and observed groundwater flow in most areas from the bedrock into the alluvium. Their investigation also concluded radioactive material, as it then existed, did not pose an immediate health hazard. However, it also identified that there was a long-term potential for the RIM to pose a health problem.

2.4.3 1996 GROUNDWATER CONDITIONS REPORT WEST LAKE LANDFILL AREAS 1 & 2

A groundwater conditions investigation for Areas 1 and 2 was completed in 1996 and included grab groundwater sampling for gross alpha analysis from existing wells, installation of 14 alluvial monitoring wells, development of existing and new wells, groundwater elevation monitoring, radiological and non-radiological groundwater sampling and analysis, and aquifer testing of 18 monitoring wells (McLaren/Hart 1996). Gross alpha samples were first collected from existing monitoring wells to evaluate whether groundwater was radiologically impacted and required specific investigation derived waste (IDW) handling during monitoring well re-development. A total of 31 wells that were sampled for the IDW investigation, after filtering 3 that failed initially, met the gross alpha concentrations of less than 15 picocuries per liter (pCi/L), which was acceptable for discharge to the Metropolitan St. Louis Sewer District (MSD).

Four wells were installed in Area 1, four wells were installed in Area 2, and six wells were installed on the Ford property. Large diameter holes were first drilled through landfill debris, logged using downhole gamma geophysical tools, then re-drilled using a smaller diameter auger rig, and completed as monitoring wells beneath the refuse. Newly completed wells were logged for downhole gamma and developed, and 30 non-damaged existing wells were re-developed. A total of 44 wells were gauged and sampled for radiological and non-radiological COPCs (Appendix B). Constituents in the Uranium-228, Uranium-225, and Thorium-232 decay series, eight priority pollutant metals, eleven VOCs, four semi-volatile organic compounds (SVOCs), and three pesticides were detected in the groundwater.

2.4.4 1996 PHYSICAL CHARACTERIZATION TECHNICAL MEMORANDUM

In 1996, Golder reviewed past investigations, described the surface and subsurface features, and recommended a groundwater monitoring network for OU-2 (Golder 1996). Their characterization included a desk study and literature review; detailed geologic mapping of the exposed quarry walls; advancement of soil, bedrock, and solid waste borings; soil and rock geotechnical testing; chemical analysis of soil; borehole geophysical logging; packer testing; piezometer/monitoring well construction; conversion of MW-1201 from open-borehole monitoring well to 2-inch cased well; installation of leachate risers in solid waste; developing and slug testing piezometers; gauging monitoring wells; and measuring surface water levels in site surface water bodies. Golder developed a conceptual site hydrogeologic model and groundwater monitoring network. The conceptual site hydrogeologic model evaluated the importance of the Bridgeton Landfill leachate collection system, which removed approximately 216,500 gallons of leachate per day during 1994. The extracted water included leachate, surface water and the groundwater that flowed into the Bridgeton Landfill. The groundwater monitoring network was designed, in part, to understand the influence of the leachate collection system.

A total of 49 single, paired, and clustered piezometers/monitoring wells were installed at 33 locations approximately 350 ft apart to characterize unconsolidated and bedrock materials. Screened intervals were selected based on contacts between strata. Leachate risers were also installed in and around the Inactive Sanitary Landfill where USEPA inferred the presence of industrial and/or hazardous waste. Deep boreholes were continuously logged with some selected for geophysical logging and packer testing after drilling. Piezometers were then installed, surveyed, developed, and slug tested. Solid waste boreholes were completed as leachate risers.

Boreholes were reamed for geophysical testing, packer testing, and piezometer installation. Packer tests were conducted by selecting and isolating fractured/unfractured and porous/non-porous zones to provide a range of conductivities for each unit. Geotechnical sampling was also conducted on undisturbed Shelby tube unconsolidated samples, two disturbed unconsolidated samples, and two bedrock samples collected from the shale near the top of the Warsaw Formation. Open hole monitoring well MW-1201 was converted from a completion depth of 250 ft bgs to a piezometer PZ-1201-SS to a depth of 148.5 ft bgs. Staff gauges were installed in the Earth City Industrial Park stormwater retention pond southwest of the leachate retention pond (leachate lagoon) and monitored monthly coincident with water level gauging. Wells were developed by surging, bailing, and air lifting. Wells were then slug tested. Monthly groundwater levels and surface water levels were collected. Precipitation data was collected daily during well installation, averaged monthly, and compared to Lambert Field totals with good correlation, so Lambert Field precipitation data were used thereafter. Geologic mapping of the exposed St. Louis Formation in the limestone quarry walls was conducted to correlate large scale features to those identified in rock cores and evaluate seepage from the quarry walls into the pit. The St. Louis Formation was divided into five sub-units, as discussed below in Section 3.1.3.1.4.

A monitoring network of 24 monitoring wells/piezometers, 2 surface water points, 2 sediment sampling points, and 8 leachate sampling points in OU-2, and 28 monitoring wells/piezometers in OU-1, resulting in a total of 64 separate sampling locations across the site, was proposed based on the conceptual site model. These were considered sufficient for site characterization, risk assessment, and remedy evaluation. The results of the investigation are discussed in Section 3.

2.4.5 1997 SITE CHARACTERIZATION SUMMARY REPORT OU-1

This report was submitted as an interim evaluation to assist in the development of the baseline risk assessment for OU-1 (EMSI 1997). The report included a review of previous investigations; description of surface and subsurface features; and a summary of the nature, extent, and migration potential of contamination. An updated CSM was provided for radionuclides.

2.4.6 1997 WEST LAKE LANDFILL OU-2 RI/FS SITE CHARACTERIZATION SUMMARY REPORT

Additional site characterization activities were conducted as part of the OU-2 RI/FS (WMC 1997). They reviewed previous investigations, described the nature and extent of surface and subsurface impacts, and evaluated transport mechanisms through various media. The primary objectives were to collect additional data to better characterize the environment, chemical occurrence, migration pathways, and transport mechanisms. Two rounds of sampling were conducted in February-March 1997 and May-June 1997 in piezometers/wells at the 24 locations selected by Golder for the OU-2 monitoring network. A non-routine background groundwater sampling event was also conducted in December 1995 at three piezometers (PZ-300-AS, PZ-300-AD, and PZ-300-SS), and two wells (I-50 and S-80), prior to those five locations being decommissioned for development of nearby properties.

Samples collected during monitoring events were submitted for analyses of metals, general parameters, radionuclides, VOCS, SVOCs, pesticides, and polychlorinated biphenyls (PCBs). The analytical results of routine events were compared to results of the non-routine background event and separated into alluvial and bedrock samples. The Salem Formation groundwater monitoring results suggested there were no impacts related to site activities. Surface water and sediment quality was deemed free of impacts from OU-2.

A total of five leachate riser (prefix LR) sampling points were installed in the Inactive Sanitary Landfill to evaluate whether standing water visible in aerial photographs represented liquid waste disposal areas. Four of these leachate risers contained sufficient liquid for sampling. Four leachate collection sumps (LCS) were also sampled from within the Bridgeton Landfill for comparison. Samples were submitted for the same analytical suite as the groundwater monitoring wells. The concentrations of organic compounds and radionuclides were similar for the Inactive Sanitary Landfill and the Bridgeton Landfill. Solvents were not detected in the Inactive Sanitary Landfill. WMC's report concluded that the standing water, which was seen in the aerial photographs, was most likely ponded precipitation.

Soil samples from the screened intervals of 300 series piezometers, leachate risers LR-103 and LR-104, and soil gas boreholes were submitted for laboratory analysis of total organic carbon (TOC). Select samples were also submitted for analysis of VOCs, purgeable-range total petroleum hydrocarbons (TPH), and extractable-range TPH. VOC and TPH results suggested impacts were limited to an area west/southwest of the asphalt plant underground storage tank (UST) site near monitoring well MW-F2.

The OU-2 site characterization did not identify any hazardous substance source areas. WMC's report suggested that the groundwater quality in the Deep Salem Formation, St. Louis/Upper Salem Formation, and alluvial hydrogeologic units within and near OU-2 was similar to upgradient, background groundwater quality with the exception of a limited area in the alluvial aquifer. VOCs were detected infrequently at low concentrations.

2.4.7 2000 OU-1 REMEDIAL INVESTIGATION

The *OU-1 RI Report* was submitted in April 2000 and presented the results of site characterization field activities (EMSI 2000). The *OU-1 RIA* was submitted as an addendum in 2018 and included the contents of the 2000 *OU-1 RI* report (EMSI 2018a). Further discussion of this report follows below, in connection with the 2018 *OU-1 RIA* discussion in Section 2.4.17.

2.4.8 2005 REVISED OU-2 REMEDIAL INVESTIGATION

The revised *OU-2 RI* presented the results of previous site characterization activities (H&A 2005). In particular, it focused on work done as part of the groundwater investigation and documented in the 1996 *Physical Characterization Memorandum* (see Section 2.4.4) that included aquifer testing, laboratory permeability testing, groundwater level monitoring, horizontal and vertical gradient evaluation, seasonal variability, influence of precipitation, surface water groundwater interaction, and leachate evaluation. Monthly groundwater level measurements were collected between June 1995 and July 1996 from piezometers near the Bridgeton Landfill.

In the 2005 *OU-2 RI*, H&A concluded that it was likely the relatively high permeability of the alluvium generally allowed rapid dissipation of recharge and prevented mounding, resulting in little apparent response to precipitation. In the Upper Salem Formation/St. Louis Formation, the precipitation response was noted and occurred within one to five days of a precipitation event. In the Deep Salem Formation, there was a relatively rapid response to precipitation (one day). In the Keokuk, the response to a rainfall event was slight, as expected, given the presence of an overlying aquitard.

The 2005 *OU-2 RI Report* also included the results of groundwater sampling documented in the 1997 *Site Characterization Summary Report* (WMC 1997) and supplemental sampling completed at a list of selected alluvial wells in December 2003 and May 2004 to verify previous results. A detailed comparison of the analytical results against background concentrations was completed. The detailed groundwater quality assessment and source characterization did not identify any hazardous substance source areas and concluded that the leachate collection sumps in the Bridgeton Landfill maintained an inward hydraulic gradient. The OU-2 RI also concluded that groundwater quality in the alluvium and Deep Salem and St. Louis/Upper Salem Formation hydrogeological units near, and within OU-2, was similar to upgradient, background groundwater quality. Groundwater impacts were limited to iron, manganese, total dissolved solids (TDS), arsenic, chloride, TPH, benzene, vinyl chloride, and fluoride. Inorganic and conventional parameters were explained by variability in background concentrations. The OU-2 RI did not identify any surface water or sediment impacts.

2.4.9 2006 OU-2 FEASIBILITY STUDY

The *OU-2 FS* presented remedy considerations under the presumptive remedy approach based on the findings of the OU-2 RI (H&A 2006). The presumptive remedy of containment for CERCLA municipal landfill sites was outlined and approved in the OU-2 AOC and discussed in the USEPA approved "Remedial Action Objectives Report". An MDNR-prescribed landfill cover with long-term monitoring and institutional controls was proposed as the final remedy for OU-2, but design was postponed until a decision was made for OU-1 so the final remedies could be coordinated.

2.4.10 2006 OU-1 FEASIBILITY STUDY

The *OU-1 FS* presented remedial action alternatives for Area 1 and Area 2 in OU-1 and the Buffer Zone/Crossroad Property (Ford Property) (EMSI 2006). Impacted soil in Area 1 and Area 2 is interspersed with and contained within an overall matrix of solid waste materials. Both Areas 1 and 2 are part of larger areas of previously placed solid wastes within the 230-acre landfill complex. Consequently, the *OU-1 FS* concluded possible remedial actions for the RIM in Areas 1 and 2 could not be implemented without consideration of ongoing activities at the landfill and possible future landfill operations, closure activities, or remedial actions that may be implemented for other portions of the landfill. Selection and implementation of a remedy for OU-1 would involve coordination with the remedial action, if any, to be selected for OU-2. Of particular interest was the coordination of any grading, landfill cover, or drainage improvements that may be implemented for either of the Operable Units. The remedy for OU-1 was proposed as an upgraded landfill cover over OU-1 and the removal of impacted soil from the Buffer Zone/Crossroad Property. No technical compatibility issues were anticipated with the implementation of any cover designs for OU-2. Protection of public health would have been achieved through the installation of a Subtitle D-equivalent landfill cover, removal of impacted soils from the Buffer Zone/Crossroad Property, and the maintenance of the existing and additional land use covenants.

2.4.11 2008 OU-1 RECORD OF DECISION

The *OU-1 ROD* proposed a landfill cover, soil consolidation from the Buffer Zone/Crossroad Property to the containment area, groundwater monitoring, surface water runoff control, gas monitoring and control, institutional control, and long-term surveillance and maintenance as the major components of the selected remedy (USEPA 2008a). The *OU-1 ROD* was intended to provide the final remedies for source control and groundwater to complete CERCLA decision-making for the site. The *OU-1 ROD* concluded that isolated detections of a small number of constituents were not indicative of on-site contaminant plumes, radial migration, or other forms of contiguous impacts related to landfilling.

The *OU-1 ROD* also concluded that there was no evidence of significant leaching and migration of radionuclides from Areas 1 and 2 into perched water or groundwater, but that the pathway should be further evaluated and addressed as part of the future remedy. The *OU-1 ROD* identified the primary transport mechanism, in alluvial water, from Area 2 to the northeast, since hydrologic divide(s) created by the leachate collection system operation, and influence from Earth City flood control impact migration in other directions.

2.4.12 2008 OU-2 RECORD OF DECISION

The *OU-2 ROD* proposed containment using a landfill cover with appropriate closure and post-closure care requirements as the Selected Remedy (USEPA 2008b). This included groundwater monitoring and protection, surface water runoff control, gas monitoring and control, institutional controls, and long-term surveillance and monitoring. The Bridgeton Landfill has been pumping leachate/groundwater from the North and South Quarries at variable pumping rates since approximately 1993 and will continue pumping through at least 2036.

Groundwater and surface water analytical results from the *OU-1 RI/FS* and *OU-2 RI/FS* indicated that the constituents detected at the site in excess of USEPA maximum contaminant levels (MCLs) were chlorobenzene, benzene, dissolved and total lead, dissolved and total arsenic, and dissolved and total radium. The results generally showed sporadic and isolated detections of a small number of contaminants at relatively low concentrations. These results were not necessarily indicative of on-site contaminant plumes, radial migration, or other forms of contiguous groundwater contamination attributable to the landfill units. The Selected Remedy for the Inactive Sanitary Landfill was to install a cover system consistent with relevant and appropriate State of Missouri requirements for sanitary landfill caps, including two feet of engineered materials that meet permeability and vegetation maintenance requirements, institutional controls, long-term monitoring, and periodic reviews.

2.4.13 2011 OU-1 SUPPLEMENTAL FEASIBILITY STUDY

The *OU-1 Supplemental FS* was prepared to provide additional evaluation of a select group of potential remedial alternatives for OU-1 (EMSI 2011). The USEPA required that the *OU-1 Supplemental FS* be performed to provide an engineering and cost analysis of the ROD-selected remedy, and to evaluate two new, additional, remedial alternatives for removal of all material containing radionuclide at concentrations greater than those that would allow for unrestricted use of the radiologically-contaminated areas; one for on-site disposal and the other was for off-site disposal.

2.4.14 2012 TO 2014 GROUNDWATER MONITORING REPORTS

Between July 2012 and October 2013, there were four additional groundwater sampling events at OU-1 (EMSI 2012; EMSI 2013a; EMSI 2013b; and EMSI 2014). The USEPA requested that all available groundwater monitoring wells at the West Lake Landfill be included, and directed that samples obtained from the wells be analyzed for uranium, thorium, and radium radioisotopes (including Radium-226 and Radium-228). The radioisotopes were analyzed for both total (unfiltered samples) and dissolved (filtered samples) phases, plus total and dissolved phase trace metals, VOCs, and SVOCs.

The results of the July 2012 sampling event supported the conclusion in the USEPA May 2008 ROD: namely, there are isolated and sporadic detections of a small number of radiological and conventional contaminants in groundwater, but no contiguous plumes of radiological or conventional groundwater contaminants were present beneath the site or migrating from the site. With respect to radionuclides, uranium is not present in site groundwater above the USEPA MCL, and thorium is only present at low levels. There are two forms of radium present in groundwater: Radium-226 and Radium-228. The report concluded that the absence of any spatial relationship between the RIM locations and the radium exceedances indicates the Radium-226 and Radium-228 found in site groundwater are of natural origin. Seventy-six wells were sampled as part of this event.

A total of 75 wells were sampled during the April 2013 sampling event. Only one well (S-53) contained a calculated total uranium mass concentration that exceeded the USEPA MCL. Due to limited water in the well, it was sampled without purging and had a turbidity of approximately 524 Nephelometric Turbidity Units (NTU), indicating the sample contained a large fraction of suspended sediment. This well was dry during the July 2012 sampling event and was therefore not sampled. Additionally, this well was not included in either the OU-1 or the OU-2 RI/FS groundwater sampling programs. All other wells were less that the USEPA MCL for uranium.

Overall for thorium isotopes, only low levels (less than 1 pCi/L) were detected in most of the wells. The highest was found in well S-53. A total of 19 of the 75 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels exceeding the USEPA MCL. Trace metals were also detected in many of the wells. The most frequent metals found were iron and manganese, which were detected in nearly all of the monitoring wells. VOCs were also detected in some groundwater samples. The most common was benzene, which was reported to be present in 26 of the 75 wells. Benzene was detected in 11 wells at concentrations greater than the applicable water quality standard of 5 µg/L. The highest concentrations of benzene were found in monitoring wells adjacent to the South Quarry.

During the subsequent July 2013 sampling event, 75 wells were sampled. None of the samples contained calculated total uranium mass concentration that exceed the MCL of 30 µg/L. For thorium isotopes, only low levels (less than 1 pCi/L) were detected in most of the wells. The highest was found in well S-53. A total of 25 of the 75 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels that exceeded the USEPA MCL. Trace metals were detected in wells. The most frequently detected were iron and manganese, which were detected in nearly all the monitoring wells. VOCs were detected in groundwater samples. The most common was benzene, which was reported to be present in 27 of the 75 wells. Benzene was detected in 13 wells at concentrations greater than the water quality standard of 5 µg/L. The highest concentrations of benzene were found in wells located adjacent to the South Quarry portion of the Bridgeton Landfill.

A total of 84 wells were sampled in the October 2013 sampling event. One well (PZ-211-SD) contained a calculated total uranium mass concentration (70.25 µg/L) that exceeded the USEPA MCL of 30 µg/L. For thorium isotopes, only low levels (less than 1 pCi/L) were detected in the majority of the wells. The highest total thorium values were in bedrock monitoring wells PZ-211-SD and PZ-102-SS and in alluvial wells D-85, S-61, and MW-104. A total of 30 of the 84 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels that exceeded the MCL. The combined Radium-226 plus Radium-228 results from 14 of the 84 monitoring wells exceeded the MCL for both the total fraction and the dissolved fraction. Trace metals were detected in wells. The most frequently detected were iron and manganese, which were detected in nearly all the monitoring wells. VOCs were detected in groundwater samples. The most common was benzene, which was reported to be present in 36 of the 84 wells. Benzene was detected in 18 wells at concentrations greater than the water quality standard of 5 µg/L. The highest concentrations of benzene were found in wells located adjacent to the South Quarry.

2.4.15 2015 USGS BACKGROUND STUDY

At the direction of USEPA Region 7, the USGS reviewed data from the comprehensive groundwater sampling completed at the site between 2012 and 2014 and evaluated the source of combined radium in the groundwater. The USGS study included a review of regional historical data, occurrence and geochemistry of radionuclides in various aquifers, the geochemistry of MSWLFs, and historical data for the site. The USGS evaluated four general hypotheses for the origin of the radium in the groundwater:

- Leaching of radium from RIM
- Natural variability
- Leaching of radium from non-RIM wastes
- Mobilization of naturally-occurring radium from due to leachate

Radionuclide data from nine alluvial wells and two bedrock wells open to Mississippian-age rock within five miles of the site were combined with data from PZ-212-SS and PZ-212-SD (installed in 2013) and data from off-site wells south of the site to calculate background concentrations of dissolved and total combined radium in groundwater. The upper limits of background (95th percentile) for dissolved and total radium were 1.98 and 2.81 pCi/L for the alluvium, and 3.56 and 3.34 pCi/L for Mississippian-age bedrock. Ratios of total and dissolved Radium-228/Radium-226 ranged from 1.0 to 4.98 for the alluvium and 0.09 to 2.11 for the bedrock. The background dataset was limited with only 17 alluvial groundwater samples and 11 bedrock groundwater samples from Mississippian-age bedrock.

Background data were compared to data from 83 monitoring wells that were sampled at least once during 2012 to 2014 site-wide groundwater monitoring. Chloride, bromide, and iodide were considered the primary indicators of landfill leachate due to naturally-occurring sodium, sulfate, and boron present in samples collected from the nearby Champ Landfill expansion. Wells were scored and weighted based on concentrations of primary leachate indicators. Results suggested that 47 wells (37 alluvial and 10 bedrock) scattered across the site were affected by landfill leachate and given an L score greater than zero suggesting landfill materials are widespread. A total of 10 of these 47 wells had an L score of 0.5 and exhibited slight possible effects of landfill leachate. The eight alluvial wells with no leachate effects were each less than 45 ft deep (shallow or intermediate) and located on the western part of the site. Several constituents in groundwater had moderate to strong correlations with leachate effects related to a change in the geochemical conditions.

Average combined dissolved radium exceeded the USEPA MCL in 13 wells. Further, 11 wells positively correlate with landfill impacts (having a leachate score greater than zero). On-site dissolved or total combined radium in the groundwater was variable with concentrations generally lower in wells open to the Keokuk Limestone and higher in wells open to the deep alluvium. Each of the five alluvial wells with average dissolved combined radium above the USEPA MCL were deep wells with naturally anoxic or leachate-affected conditions (or both).

The USGS concluded that although there was a strong positive correlation between leachate effects and the dissolved radium above the USEPA MCL, it did not indicate that RIM was the source. The USGS evaluation suggested that the likely origin of the radium in groundwater was a combination of the four potential sources. Contributing to the uncertainty in determining the origin of combined radium in the groundwater was the small background dataset of concentrations; the absence of data at discrete depths from onsite leachate risers and the leachate collection sumps; and the insufficient data on concentrations, ratios and phase associations of radium in the aquifer materials, RIM, and in the leachate from other MSWLFs.

2.4.16 2016 GROUNDWATER TECHNICAL REPORT

A technical evaluation of the OU-2 groundwater monitoring network was completed at the request of MDNR (Feezor 2016). The scope of the report was to evaluate groundwater quality at monitoring wells near North and South Quarries that were not being sampled as a part of Bridgeton’s monitoring programs. It included a detailed review of data collected from wells within approximately 350 ft of the landfill’s waste boundary during quarterly monitoring events between fourth quarter 2015 and third quarter 2016, and the field and laboratory analytical results presented in the Physical Characterization Technical Memorandum (Golder 1996). The evaluation included a detailed hydrogeological review of the different stratigraphic zones and non-routine monitoring wells. Feezor subsequently recommended modifications to the OU-2 routine monitoring network.

Several wells were identified as candidates for addition to the OU-2 monitoring well network. These included St. Louis/Upper Salem Formation wells PZ-102R-SS, PZ-113-SS, PZ-203-SS, and PZ-204-SS, and alluvial well I-68. Confirmatory sampling was proposed at wells with unconfirmed organic constituent detections, and or unconfirmed inorganic constituent exceedances of the USEPA MCL during third quarter 2016. Confirmatory sampling was proposed for St. Louis/Upper Salem Formation well PZ-116-SS, and alluvial wells D-3, D-85, I-4, I-73, PZ-112-AS, PZ-113-AS, PZ-113-AD, PZ-207-AS, S-5, and S-84. Additional sampling was proposed for wells with confirmed organic constituent detections and confirmed inorganic constituent exceedances of the USEPA MCL. Additional sampling was proposed at Salem Formation well MW-1204; St. Louis/Upper Salem Formation wells PZ-101-SS, PZ-103-SS, PZ-200-SS, PZ-202-SS, and PZ-204A-SS; and shallow alluvial well PZ-205-AS. These recommendations were implemented by the Bridgeton Landfill and have been considered during preparation of this Work Plan.

2.4.17 2018 OU-1 RI ADDENDUM

USEPA requested an *OU-1 RIA*, an updated Baseline Risk Assessment (BRA), and a final FS in the *OU-1 ASAOC* as amended and associated SOW dated December 9, 2015 (USEPA 2015a). The *OU-1 RIA* updated the CSM based on additional data completed after the submittal of the *OU-1 RI* in 2000 (EMSI 2000). The CSM presented in the *OU-1 RIA* serves as the basis for the CSM presented in this Work Plan. It identified the following thirteen data gaps (EMSI 2018a):

- Background groundwater quality
- Groundwater geochemistry
- Regional, site, and local hydraulic gradients
- Recharge and discharge points
- Leachate chemistry and occurrence
- Effect of leachate extraction on groundwater levels and hydraulic gradients
- Nature and extent of off-site contamination
- Adequacy of the groundwater monitoring network along the perimeters of Areas 1 and 2
- Hydraulic properties of the aquifer
- Effect of suspended sediment on groundwater quality
- Potential for vapor intrusion into on-site buildings
- Potential correlations between radium and geochemical indicators
- Evaluation of potential leaching of wastes

The OU-1 RIA included a discussion of the potential subsurface transport mechanisms and potential tasks that should be considered as part of the groundwater investigations under the OU-3 RI/FS to address the data gaps (EMSI 2018a).

2.4.18 2018 OU-1 UPDATED BASELINE RISK ASSESSMENT

An updated BRA was prepared in conjunction with the *OU-1 RIA* by Auxier & Associates (Auxier 2018). The BRA consisted of a human health evaluation and screening level ecological risk assessment (SLERA). Current and potential future exposure pathways related to groundwater and vapor intrusion were not considered due to their inclusion in the anticipated OU-3 RI/FS.

The overall objectives of the BRA were to evaluate whether radiological and chemical constituents detected in the environmental media at OU-1 pose lifetime cancer risks (LCRs) or non-cancer effects that exceed USEPA's regulatory threshold levels under current and anticipated future conditions if no remedial actions are taken and support decisions concerning risk management. Future conditions assumed that current institutional land use and access controls limited exposure for the various scenarios. The BRA identified radionuclides associated with uranium, actinium, and thorium decay series as well as 13 inorganic COPCs at OU-1. The *OU-1 BRA* concluded there were no current unacceptable risks to on-property or off-property human or ecological receptors.

2.4.19 2018 OU-1 FINAL FEASIBILITY STUDY

The *OU-1 Final Feasibility Study* (FFS) was prepared to further evaluate of potential remedial alternatives to address the presence of RIM contained within portions of some of the landfill (EMSI 2018b). The *OU-1 FFS* provided further evaluation of the containment remedy, with some modifications, and additional evaluations of a containment remedy alternative with an engineered cover designed to meet the Uranium Mill Tailings Radiation Control Act (UMTRCA) performance standards, including;

- A full excavation with off-site disposal alternative
- A partial excavation alternative that would remove RIM containing either combined radium or combined thorium activities above 52.9 picocuries per gram (pCi/g) and located within 16 feet of the 2005 topographic surface
- A partial excavation alternative that would remove RIM containing either combined radium or combined thorium above 1,000 pCi/g regardless of depth; a risk based partial excavation alternative to remove RIM such that the remaining materials would be protective of industrial land uses (the reasonably anticipated future land use) without consideration of the presence of an engineered cover system
- A full excavation alternative with the option to re-dispose the excavated material in an on-site engineered cell

Of the seven remedial alternatives (excluding the No Action alternative), all meet the USEPA's criteria for protection of Human Health and the Environment, compliance with ARARs, long-term effectiveness and performance, reduction in toxicity, mobility or volume through treatment, short-term effectiveness, implementability, and cost.

2.4.20 2018 OU-1 RECORD OF DECISION AMENDMENT

The USEPA determined that further evaluation of remedial alternatives was warranted as a result of stakeholder and community concerns following the 2008 ROD (USEPA 2018b). Based on the results of those investigations and evaluations, the USEPA determined that a fundamental change to the 2008 ROD was appropriate. In summary, the Amended Remedy was based on:

- A better understanding of the volume, concentration and location of RIM at the site
- New information regarding the potential for RIM to leach
- Concern that should a subsurface heating event occur in OU-1, the heat could dry and desiccate a cap, and provide a pathway radon to migrate from the subsurface
- A determination that implementation of the 2008 ROD could not be accomplished without disturbance of both putrescible waste and RIM

The USEPA Amended Remedy included:

- Excavation and stockpiling of overburden in OU-1 Radiological Areas 1 and 2 to access the RIM
- Excavation of RIM from the Areas 1 and 2 of OU-1 that contains combined radium, or combined thorium activities greater than 52.9 pCi/g that is located generally within 12 feet of the 2005 topographic surface. Optimization of RIM removal above and below the 12-foot target depth (excavation as deep as 20 feet or as shallow as 8 feet) will be completed during the remedial design
- Excavation of RIM soil from the Buffer Zone and Lot 2A2 sufficient to reduce concentrations of radionuclides to background to allow for unlimited use and unrestricted exposure
- Loading and transport of the RIM, and radiologically impacted soil for disposal at an off-site permitted disposal facility
- Re-grading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5 percent (%)) and maximum (25%) slope criteria
- Installation of a landfill cover over Areas 1 and 2 designed to meet the Resource Conservation and Recovery Act (RCRA) hazardous waste design criteria, municipal waste landfill regulations, and UMTRCA performance and longevity standards

- Design, installation, and maintenance of surface water runoff controls
- Groundwater monitoring
- Landfill gas and radon monitoring and control, in accordance with ARARs
- Institutional controls to prevent land uses that are inconsistent with a closed landfill that contains radiological materials
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2 and other remedial components

2.5 HISTORICAL DATASET

Each of the investigations summarized in the previous sections were reviewed in detail, prior to and during preparation of this RI/FS Work Plan. The dataset was mined for relevant and pertinent information to begin addressing these OU-3 data gaps, which were also identified in the SOW:

1. Adequacy, usability, and status of existing and abandoned on-site and near-site monitoring wells
2. Aquifer properties, including recharge/discharge rates and hydraulic conductivities
3. Regional and localized hydraulic gradients and flow directions between alluvial and shallow bedrock aquifers
4. Background groundwater quality of alluvial and shallow bedrock aquifers near the site
5. Temporal variability in groundwater levels and flow direction
6. Temporal and spatial water elevation effects from relevant surface water features (Missouri River, streams, and surface water bodies) and storm events
7. Occurrence and extent of groundwater contamination and landfill gas migration in groundwater
8. Groundwater geochemistry parameters, oxidation-reduction (redox) couples, and organic content
9. Effects of the Bridgeton Landfill, related infrastructure, and hydraulic characteristics of landfill material on the groundwater system
10. Vapor intrusion

A summary of the existing data and the approximate date ranges during which they were collected is included as Table 2-2. This dataset was compiled and considered in preparation of a preliminary CSM. Further evaluation of this dataset will be completed to refine the CSM as part of the OU-3 RI/FS data evaluation. The historical dataset will be evaluated using relevant USEPA guidance as listed on the USEPA *Resources for Project Planning that Use Existing Data* website to determine that the data are appropriate and of sufficient quality for the intended use pursuant to the

OU-3 QAPP, which was prepared in accordance with USEPA guidance pertaining to quality assurance project planning (USEPA 2001c; USEPA 2018c). The usability of historical data will be evaluated based on the procedure outline in Section 4.1 of the QAPP on a case-by-case basis in accordance with the data quality objectives (DQOs) as outlined in Section 3.0 of the QAPP.

3.0 INITIAL EVALUATION AND CONCEPTUAL SITE MODEL

Trihydro completed an evaluation of the existing dataset and a review of the documents described in Section 2.0 to prepare this Work Plan. This included a compilation and a review of available borehole logs, well construction details, field logs, analytical data, field measurements, aquifer testing data, and geochemical data to refine the groundwater CSM and to develop a comprehensive OU-3 database. The preliminary CSM provides an understanding of:

- The potential, and known, areas of groundwater impacts
- Potential sources
- Potential routes of migration, including known or suspected pathways
- Groundwater flow (vertical and horizontal)
- Missouri River and groundwater interaction
- Factors that could influence contaminant distribution
- Potential receptors

The CSM will be updated with additional data as the investigation progresses and will be presented in the Annual Hydrogeologic Investigation and Groundwater Characterization Reports and the Final OU-3 RI Report. Groundwater data and other related data collected under the MDNR or USEPA oversight will also be considered and included in the data set for this RI. Real-time data collected during field activities will be incorporated to reflect newly collected information in accordance with *Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model* (USEPA 2011b). The remainder of this section presents Trihydro's preliminary CSM.

3.1 PRELIMINARY CONCEPTUAL SITE MODEL

The preliminary CSM synthesizes the regional setting with site-specific geology, hydrology, hydrogeology, and geochemistry data. Existing demography, land, groundwater, and surface water data are discussed along with flora and fauna of the site and surrounding areas, threatened and endangered species, rare species, sensitive environmental areas, and critical habitats to identify potential human and ecological receptors. Potential surface, subsurface, atmospheric, and biotic migration pathways are also identified.

3.1.1 REGIONAL SETTING

The site is located near the confluence of the Missouri River and the Mississippi River, in the gently undulating Dissected Till Plains Physiographic Province ranging in elevation from approximately 440 to 700 ft msl. The site is close to the southernmost extent of Pleistocene glaciation, but morainal topography is absent and till is thin and dissected (Miller et al. 1974). Loess was deposited in upland areas during Pleistocene glaciation and alluvium was deposited in river valleys. Surface water runoff reaches the Missouri or Mississippi Rivers. Quaternary deposits are generally underlain by Pennsylvanian shale, limestone, clay, sandstone, siltstone, and coal, and Mississippian limestone (Harrison 1997). Regional and local geology and hydrogeology are described in the following subsections.

3.1.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

The geology of the region is described in detail on the *St. Louis 30' x 60' Quadrangle of Missouri and Illinois* and accompanying cross-sections (Harrison 1997). These cross sections are included as Appendix C. A regional stratigraphic column with detailed descriptions of the bedrock present at the site is included as Table 3-1a. The stratigraphic sequence generally consists of strata deposited in shallow epicontinental seas (Harrison 1997).

3.1.2.1 REGIONAL GEOLOGY

The regional geology is Precambrian igneous crystalline basement rock overlain by the cyclic deposition of Paleozoic sandstone, shale, limestone and dolomite belonging to the Illinois Basin (Table 3-1b). The basin consists of nearly three vertical miles of largely shallow water marine deposits that thicken to the east and toward the Ozark Dome to the southwest. As documented by the United States Army Corps of Engineers (USACE), the bedrock units are nearly horizontal in the St. Louis area and dip less than 1 degree to the northeast as a result of uplift of the Ozark Dome (USACE 1998). Other regional structural features include the Cheltenham Syncline, the Dupo Anticline, and the Florissant Dome (McCracken 1965; Harrison 1997).

The shallowest units of the Illinois Basin, near the site, consist of Pennsylvanian and Mississippian age bedrock. The Pennsylvanian units consist primarily of siliciclastic deposits (i.e., shale, siltstone and sandstone), whereas the underlying Mississippian units consist primarily of fractured carbonate units (limestone and dolomite). Though bedrock units of Pennsylvanian age are present throughout the area, they were removed by erosion in the immediate vicinity of the site. Limestones, dolomites, and shales of the Mississippian System (Kinderhookian, Osagean, and Meramecian Series) are the dominant bedrock units at the site and are described in more detail in Section 3.1.3. The approximately 1,250 ft thick Mississippian System Series are all separated by non-distinct unconformities, and are therefore defined by paleontology (Howe 1961).

Unconsolidated deposits of Quaternary age (Pleistocene to Holocene) unconformably overly the Paleozoic bedrock units of the Illinois Basin and generally occur in low-lying areas associated with the floodplains of the Missouri and Mississippi Rivers. Melt water from glaciers during the Pleistocene generated tremendous volumes of runoff, carrying immense quantities of sediment that had to be transported down the Missouri River. In response, the river carved a much deeper and wider channel than the river occupies today (MDNR 1997). These younger unconsolidated units consist of alluvial and terrace deposits of the Missouri River Alluvium and upland aeolian loess deposits. Fluvial alluvium dominates the Missouri and Mississippi River valleys, ranges up to 210 ft thick regionally and consists of gravel, sand, silt, and clay. Aeolian loess deposited during Pleistocene glaciation covers much of Missouri and Illinois overlying bedrock and forming the upland bluffs near the Missouri River valley. While the upland loess can range up to 215 ft regionally, the loess at the site is usually less than 40 ft thick but has been observed up to 80 ft thick in some areas generally consisting of 20 to 30 ft of pure silt overlying 20 to 49 feet of clay silt (Lutzen & Rockaway 1971; USACE 1998).

3.1.2.2 REGIONAL HYDROGEOLOGY

The Missouri River generally flows to the east through Missouri, flows to the north near the site, and is a tributary to the Mississippi River, which flows south along the eastern state boundary. In 1974, of the 1,200 million gallons of water used daily in the St. Louis area 82% was pumped from the Mississippi River, 15% from the Missouri and Meramec Rivers, 2% from alluvial aquifers, and 1% from bedrock aquifers. Water withdrawn from the rivers requires extensive treatment prior to use as potable water.

The major aquifers of the region are both the alluvial aquifers and the bedrock aquifers. Alluvial aquifers are generally present in the Missouri and Mississippi River valleys within saturated sands and gravels. The production of wells installed in the alluvium is dependent on sediment sorting, saturated thickness, connection to surface water, and infiltration (Miller et al. 1974). The alluvial aquifers are recharged by the infiltration of surface water and precipitation, and upward movement of groundwater from underlying bedrock aquifers along the contact between bedrock and the base of the alluvium. Some wells installed in the alluvium yield over 2,600 gallons per minute (gpm) (Miller et al. 1974).

The groundwater within the bedrock is present within fractures, bedding planes, and solution cavities of limestone and dolomite, and within porous sandstones. The Warsaw Formation shale and the Maquoketa Shale are considered aquitards in the region. Economically feasible bedrock aquifers include the Ordovician St. Peters Sandstone, Roubidoux Formation, the Gunter Sandstone Member of the Gasconade Dolomite, and the Cambrian Potosi Dolomite. The uppermost of these, the St. Peters Sandstone, is encountered at approximately 1,450 ft below ground surface near the site and ranges from 60 to 165 ft thick with moderate reported yields between 10 and 140 gpm (Harrison 1997). The Roubidoux Formation is encountered at approximately 1,930 ft bgs and ranges from 110 to 170 ft thick (Harrison 1997). Directly underlying the Roubidoux Formation is the Gasconade Dolomite. The basal unit of the Gasconade Dolomite is the Gunter Sandstone member that ranges between 25 and 30 ft thick. The Roubidoux

Formation and Gunter Sandstone Member have yields between 10 and 300 gpm. The Potosi Dolomite is present at approximately 2,650 ft bgs with a thickness of approximately 200 ft and yields between 10 to 400 gpm.

Regional potentiometric surface maps for the alluvium and bedrock are shown on Figure 3-1 and included in Appendix D. Predevelopment regional groundwater flow in the bedrock was generally toward the Missouri and Mississippi Rivers with a bedrock groundwater divide approximately 3.5 miles southeast of the site (Imes 1990). Regional groundwater flow in the alluvium appears to be a combination of base flow (riverward) and underflow (down valley) toward the Missouri River with a vector of approximately 45 degrees in the downstream direction (MDNR 1997; Emmett & Jeffery 1968). This flow direction near the site is variable with depth, precipitation, and river stage and is presently less understood. However, the flow direction will be characterized and evaluated during the implementation of this Work Plan.

3.1.2.3 REGIONAL GROUNDWATER QUALITY

The bedrock aquifers in the St. Louis area were described as not favorable for development of high-yield wells because these potable water wells typically have yields of less than 50 gpm and the deeper aquifers yield saline water (Miller et al. 1974). Regional groundwater quality is variable with calcium-magnesium-bicarbonate type water at low TDS and sodium chloride, sodium sulfate, or sodium bicarbonate type water depending on the source at high TDS. TDS generally ranges between 122 and 17,500 milligrams per liter (mg/L). Regional groundwater quality is affected by lithologic interrelations, permeability, structural features, residence time, distance traveled, flushing of entrapped saline connate water, and development (Miller et al. 1974). Compressional structural features such as anticlines and synclines can affect groundwater quality, with recharge occurring via secondary permeability of fractures and jointing in anticlines, and conversely trapping of mineralized water in synclines (Miller et al. 1974).

The uppermost Post-Maquoketa bedrock aquifers are above the economically feasible aquifers. TDS in samples collected from wells in the Post-Maquoketa aquifers varied between 246 and 6,880 mg/L with low iron concentrations (<0.3 mg/L), high hardness (>180 mg/L), and relatively high fluoride concentrations (>1.4 mg/L in 50% of the samples) (Miller et al. 1974). Most potable water wells are located near the outcrops of Meramecian Series rocks and yield water of the calcium-magnesium-bicarbonate type. Water in northwestern St. Louis County has higher TDS generally of the sodium-chloride type with variable concentrations of calcium and sulfate. Chloride concentrations near the site are as high as 250 mg/L and could result from a lack of flushing of connate water or migration of mineralized water from deeper horizons or adjacent oil and gas rocks. High fluoride could result from solution of fluorite or saline water encroachment (Miller et al. 1974). Groundwater quality of the Ordovician, Cambrian, and Precambrian Systems is not evaluated in this CSM.

Missouri and Mississippi River alluvial aquifers have relatively well mixed and uniform concentrations of constituents but a wide variability of TDS. The water is of calcium-magnesium-bicarbonate type with localized high sulfate concentrations, high iron and manganese concentrations, and is very hard. High nitrate concentrations are likely due to impacts from surface waste (Miller et al. 1974).

3.1.2.4 REGIONAL SURFACE WATER RESOURCES AND QUALITY

The Mississippi and Missouri Rivers are a major reason for the growth and development of St. Louis and serve as commercial arteries for the nation. Combined flows historically averaged 112,000 million gallons per day (mgd) and provided 97% of the regional water use that includes industry, commerce, and recreation. They also provide means to dispose of waste and sewage. Missouri River flows are controlled upstream in the headwaters with a reservoir system reducing the flooding potential and maintaining navigable flows. Mississippi River flows are not controlled until they reach the locks and dams after the confluence with the Missouri River (Miller et al. 1974).

The Missouri and Mississippi Rivers provide an important supply of surface water to the area, with approximately 1 % of the daily flow used for industry and commerce. These rivers also assimilate large quantities of municipal, industrial, and agricultural waste, which limits usage. Missouri River water in the St. Louis area is hard/moderately mineralized with calcium, magnesium, sodium, bicarbonate, and sulfate concentrations that control TDS and need treatment prior to use. Turbidity has trended downwards due to upstream dams but remains high, and needs reducing prior to use. Increased flow of the Missouri River results in increased turbidity due to the sediment load but results in reduced hardness and alkalinity due to dilution.

Chemical and physical characteristics of the Missouri River were averaged over 1950 to 1970 from the Howard Bend Plant just upstream of the site (Miller et al. 1974). Temperature ranged from 0 degrees Celsius (°C) to 31°C with a mean of 14.5°C. Water was generally neutral to basic with a pH between 7.5 and 9.6 standard units (SU) and a mean of 8.1 SU. Alkalinity as calcium carbonate ($CaCO_3$) ranged from 53 to 294 mg/L with a mean of 150 mg/L. Hardness as $CaCO_3$ ranged between 83 and 366 mg/L with a mean of 206 mg/L. Turbidity ranged between 5 and 12,000 Jackson Turbidity Units (JTU) with a mean of 694 JTU. Annual average constituent summaries from 1951 through 1970 are included in Miller et al. 1974. These data are presented to provide context, but are not incorporated into the OU-3 temporal boundary.

3.1.3 LOCAL GEOLOGY

The local geology is loess, Missouri River Alluvium, and limestone bedrock. Detailed characterization of the Quaternary alluvium and Mississippian bedrock has been conducted at the site through installation of boreholes and descriptions of the South Quarry Pit. Updated geologic cross sections are shown on Figures 3-2 through 3-5. Cross sections were updated for this preliminary CSM based on a review and evaluation of the borehole logs, hydrostratigraphy of the alluvium, and mapping of the South Quarry Pit. A cross section on the southern property boundary in bedrock was not prepared for the Work Plan. Additionally, this data evaluation review process included applying the environmental sequence stratigraphic analyses to update the data and its interpretation and presentation in general accordance with *Best Practices for Environmental Site Management: A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models* (USEPA 2017b). Available borehole data were digitized and classified based on maximum grain size and presence of fines. The hydrostratigraphic units were correlated in three-dimensional (3-D) space based on the depositional environment described in Section 3.1.2.1. The available borehole logs for monitoring wells and historical geologic cross sections are included in Appendices E and F, respectively.

3.1.3.1 BEDROCK

The bedrock units of hydrogeologic importance to the OU-3 RI/FS from oldest to youngest are: the Keokuk Formation (upper portion of the Osagean Series), the Warsaw Formation (lower portion of the Meramecian Series), the Salem Formation (middle portion of the Meramecian Series), and the St. Louis Limestone (middle portion of the Meramecian Series). Bedrock surface elevations of the Bridgeton Landfill are included in Appendix G. The St. Louis Formation was described in additional detail, mapped in the quarry, and subdivided into five units as documented in Appendix H (Golder 1996). The bedrock beneath the site is described in detail below.

3.1.3.1.1 KEOKUK FORMATION

The Keokuk Formation is generally described as a bluish-gray, medium to coarsely crystalline, medium bedded limestone with abundant light gray tripolitic chert layers and nodules, some finely-crystalline zones, and/or crinoidal zones (Spreng 1961; Thompson 1986). Brachiopods, horn corals, and bryozoans are abundant in the formation (Spreng 1961). Four boreholes at the site penetrate the Keokuk Formation at depths between 365 and 375 ft bgs on the eastern edge of the Bridgeton Landfill and at a depth of 345 ft bgs on the western edge of the Bridgeton Landfill.

The elevation of the top of the Keokuk Formation is shown in Appendix G and ranges from approximately 126 ft msl on the southeastern corner of the North Quarry and dips toward the west to approximately 116 ft msl on the western edge of the South Quarry (Golder 1996). The description of the Keokuk Formation at the site is consistent with the general description and is a fresh to slightly weathered, medium light gray, fine to coarsely crystalline, thin to medium bedded, medium strong to strong, fossiliferous limestone with argillaceous shaley partings, numerous light bluish gray chert layers 1-2 inches thick, chert nodules between 1 to 10 mm, and disseminated pyrite. Layers of moderately weathered, medium bedded, light olive gray, medium strong arenaceous dolomite and thinly laminated, dark greenish gray, silty claystone were noted. Styolitic chert nodules, silicified zones, highly weathered joints, weak rock, and porous open vugs containing calcite crystals were noted at the bottom of the boreholes. Joints observed in rock cores were generally horizontal and infrequent with less than 2 per foot and described as irregular and rough, with some described as smooth, bedded, or planar. Open vugs and pores were commonly encountered below approximately 100 ft msl (Golder 1996).

3.1.3.1.2 WARSAW FORMATION

The Warsaw Formation at the site can be divided into two distinct lithologic zones: an upper shale-dominated zone and lower limestone-dominated zone (Spreng 1961; Harrison 1997). The conformable boundary between the Osagean Series Keokuk Formation and the Meramecian Warsaw Formation is easier to distinguish in the eastern part of Missouri where the clastic Warsaw limestone overlies pure Keokuk limestone but there is not a clearly defined faunal break (Thompson 1986). The Warsaw characteristically has geode beds underlying the Archimedes beds (Thompson 1986).

The Warsaw Formation is encountered at the site at approximately 245 ft bgs (240 ft msl elevation) to the east of the Bridgeton Landfill and at approximately 200 to 210 ft bgs (250 – 260 ft msl elevation) on the western side of the Bridgeton Landfill as shown on the bedrock surface elevation map in Appendix G. The elevation of the top of the Warsaw Formation is consistent with the basal elevation of the South Quarry Pit and suggests that quarrying terminated once encountering the formation. The total thickness of the Warsaw Formation at the site ranges from approximately 130 to 145 ft (Golder 1996).

The underlying upper Keokuk Formation grades upward into the lower portion of the Warsaw Formation at the site. The lower portion of the Warsaw Formation is generally described as an olive to dark gray, fresh, thinly to medium bedded, fine to very coarse crystalline, medium strong, vuggy, nodular, argillaceous, dolomitic, limestone with fossils, chert, and thinly bedded claystone and siltstone interbeds. The lower portion of the Warsaw Formation had a greater apparent thickness in wells PZ-106-KS and PZ-111-KS where it was encountered at approximately 295 to 300 ft bgs with a thickness of approximately 45 to 50 ft, than in wells PZ-100-KS and PZ-104-KS where it transitioned to silty claystone and clayey siltstone of the upper portion at approximately 350 ft bgs with a thickness of approximately 10 ft.

The upper portion of the Warsaw Formation is regionally described as a yellowish brown to olive black, fresh to highly weathered, thinly bedded, very fine grained, weak clayey siltstone, silty claystone, or fissile shale with fine pyrite crystals and calcite infilled veins interbedded with silty limestone and/or dolomitic limestone (EMSI 2000). The uppermost portion of the Warsaw Formation was characterized with an olive to medium dark gray, fresh, thinly to thickly bedded, fine grained, weak to medium strong siltstone or claystone reported to range from approximately 2.5 to 10 ft thick. However, based on observations at nearby off-site private wells, the thickness of upper zone at the site could be significantly thicker. The Warsaw Formation, in general, has a high rock quality designation (RQD) and very few fractures that were jointed, irregular or planar, and rough or smooth (Golder 1996). As discussed in Section 3.1.5.2, the Warsaw Formation is considered an aquitard between the Salem and Keokuk Formations.

3.1.3.1.3 SALEM FORMATION

The Salem Formation consists predominantly of fossiliferous calcarenite (a limestone with more than 50 % transported sand-size carbonate grains) that ranges regionally from 70 to 180 feet thick (Thompson 1986; Harrison 1997). A distinct "cannonball" or "bulls-eye" chert zone is present near the top of the limestone with 4 to 6-inch diameter, concentrically banded, spherical nodules and is often overlain by a thin shale (Thompson 1986). The remainder of the unit is highly variable with interbeds of fine-grained limestone, sandstone, chert and evaporites (Harrison 1997). The Salem Formation is commonly quarried in the region (Thompson 1986).

As shown on the bedrock surface elevation map in Appendix G, the Salem Formation is encountered at the site at a depth of approximately 165 ft bgs (320 ft msl) on the eastern edge of the Bridgeton Landfill and between approximately 115 to 135 ft bgs on the western edge of the Bridgeton Landfill (328 to 340 ft msl) with a thickness of approximately 67 to 83 ft. It is described as a very light to medium dark gray, fresh, medium to coarse grained, thinly to thickly bedded, medium strong, fossiliferous, arenaceous, and bioclastic calcarenite with some iron oxide staining, chert zones and nodules, and some cross bedded layers. The RQD was generally high in rock cores at the site with very few fractures in the lower portion of the formation (0 to 1 per foot) and up to 2 fractures per foot in the upper portion of the formation. The Salem Formation was exposed in the bottom parts of the North and South Quarry Pits (Golder 1996).

3.1.3.1.4 ST. LOUIS LIMESTONE

The St. Louis Limestone represents the first-encountered bedrock beneath the site and is described as a gray, lithographic to finely crystalline, medium to massively bedded limestone that ranges from 100 to over 250 feet thick that is quarried for cement manufacture and aggregate. The unit is highly variable with interbeds of dolomite, cherty limestone, fossiliferous limestone, and evaporites. Minor thin beds of shale are present throughout the formation (Harrison 1997). Limestone breccia, with a shale matrix, is common in the lower part of the formation. Chert is uncommon, but where present is fragmented and brown. Parts of the limestone are dolomitic. Lithostrontionella castelnaui and Lithostrotion proliferun are diagnostic compound corals (Spreng 1961).

The St. Louis Formation has been well characterized at the site using rock cores and geologic mapping of the exposed South Quarry Pit walls. It is encountered at depths between 14 to 52 ft bgs (425 to 450 ft msl) in the eastern portion of the site and at depths between 20 and 110 ft bgs (379 to 442 ft msl) in the western portion of the site (Appendix G). The variability in depth and elevation is due to erosion by the Missouri River. The St. Louis Formation ranges in thickness from approximately 65 to 130 ft and was previously separated into six different sub-units from oldest to youngest as Lc, Lb, Ls, Ld, Bx, and Lx as described below (Golder 1996). An additional older unit Lc was identified during development of the preliminary CSM. These sub-units are described below:

- Lc – a fresh, thinly to thickly bedded, finely crystalline, medium strong, stylolitic, argillaceous limestone.
- Lb – A thinly bedded, microcrystalline to finely crystalline thinly to thickly bedded limestone.
- Ls – A massive, microcrystalline, medium strong, very argillaceous limestone with sheet like weathering that causes 0.2 to 0.4 feet thick slabs to separate parallel to the exposed face. Localized joints, fractures, and seeps were not noted.
- Ld – A thin (1 to 3 ft thick) thinly bedded to massive, medium strong to strong, slightly argillaceous limestone that is almost continuously exposed in the quarry and overlain by a 2-inch thick fine-grained stratigraphic marker bed.
- Bx – A massive, brecciated, finely crystalline matrix, medium strong, limestone that ranges between 10 and 22 feet thick. Seeps were observed during mapping at the base of this sub-unit as described in Section 3.1.3.1.5.
- Lx – A thinly to thickly bedded fine to medium crystalline, coarsening upward, medium strong, stylolitic, fossiliferous (brachiopods, gastropods, and crinoids), limestone with iron oxide concretions, argillaceous stringers, and chert nodules.

The top of bedrock surface generally dips westward toward the Missouri River with two dominant topographic features: the quarried areas associated with the former North and South quarry pit operations and the scour surface associated with the natural eastern edge of the Missouri River floodplain. Additional detail on the structural features and hydrogeologic properties of these units is provided below.

3.1.3.1.5 STRUCTURAL FEATURES

Joints, cavities, infilled collapsed features, and groundwater seeps were mapped on five different sectors of the exposed St. Louis Formation on the South Quarry pit walls as shown in Appendix H (Golder 1996). Joints were mapped as follows:

- 12 joints were oriented 60 degrees east of north
- 4 joints were oriented at 20 degrees east of north

- 3 joints were oriented 70 degrees east of north
- 3 joints were oriented 80 degrees east of north
- 8 joints were oriented between 40 and 185 degrees east of north (40, 55, 62, 75, 98, 100, 120, 185)

Sectors 4 and 5 had the densest spacing of mapped joints with a total of 24. The face of Sector 1 was oriented at 60 degrees east of north, parallel to the most dominant set, and had only two joints mapped at an orientation of 20 degrees east of north. It is likely these joints were caused by regional structural geologic features including the Dupo Anticline and Florissant Dome. Infilled collapsed features where voids collapsed and were infilled with fine-grained sediments were also mapped on the exposed walls of the South Quarry Pit. Sector 1 had none, Sector 2 had four, Sector 3 had two, Sector 4 had five, and Sector 5 had three. The base of smaller structures generally terminated at the Bx/Ld contact, with larger structures propagating to the base of the Ls (Golder 1996).

Groundwater flow into the North and South Quarry portions of the Bridgeton Landfill during quarrying, landfilling, and leachate extraction activities is an important component of the CSM. The locations and flows of six seeps in the quarry were mapped and measured in 1989 by Laidlaw as documented in Appendix H. The total approximate flow of the six seeps into the quarry was approximately 1,110 gallons per hour. Of this total volume, groundwater appeared to contribute approximately 1,010 gallons per hour. Seep 2 was located on the north wall of the South Quarry pit (Sector 5) at an elevation of approximately 330 ft msl and contributed 500 gallons per hour of water. A total of 88 seeps were observed by Golder during mapping of the South Quarry pit walls. Most of these seeps were present within the Ld unit at the Bx/Ld contact. Seeps above the Ls contact and the absence of seeps within the Ls unit suggest that the Ls unit is a less transmissive unit (Golder 1996).

A total of 14 cavities are indicated on the quarry wall maps included as Appendix H. Four cavities were mapped near the base of the Lx sub-unit in Sector 2 and Sector 3. Only one had an associated seep. Five cavities were mapped within the Bx sub-unit. Seeps were observed in two of these cavities. Two cavities were observed in the Ls sub-unit. One was associated with a vertical joint. Three cavities were observed in the Lb sub-unit.

3.1.3.2 UNCONSOLIDATED SEDIMENTS AND MATERIALS

Unconsolidated sediments at the site are primarily Missouri River Alluvium and aeolian loess. Missouri River Alluvium is present to the north and west of the edge of the alluvial valley (Figure 3-1). Loess forms the bluffs and hills to the east and south. Alluvium isopach maps are included in Appendix I.

3.1.3.2.1 ALLUVIUM

Alluvium at the site varies in thickness ranging from absent to approximately 120 feet. The alluvium is generally present above 330 ft msl west of the edge of the alluvium. Deposits consist primarily of sand and gravel interbedded with minor silt and clay present at shallower depths less than 25 ft bgs or above 430 ft msl and are interpreted to be deposited as glacial outwash, point bars, natural levees, filled channels, swamps, lakes, overbank deposits, and small channels. The depositional environment resulted in rapid termination of the alluvium both vertically and horizontally (B&M 1986). Fining upward sequences typical of fluvial depositional environments, are present within an overall fining upward sequence. Cross sections previously prepared and presented in other reports are included in Appendix F.

Alluvial cross sections and interpretations were updated during preparation of this Work Plan based on USEPA guidance on environmental sequence stratigraphy to identify preferential flow and flux pathways. These updated cross section locations are shown with monitoring wells used to construct them on Figure 3-2 and cross sections are shown on Figure 3-3, Figure 3-4, and Figure 3-5. Alluvium is more uniform and can be correlated at elevations between 400 ft msl and bedrock due to channel scour and regrading of sediment after deposition (B&M 1986; NRC 1989). The alluvium has historically been divided into three separate units. These units are apparent on the cross sections and are described in the following subsections.

Deep alluvium is present from approximately 330 ft msl to 385 ft msl, is roughly 55 feet thick, and consists of fining upward sequences of coarse gravel to coarse sand likely deposited as bars during the rapid channel infill of the Missouri River Valley. Color ranges from gray to brownish and greenish gray, which is consistent with mineralogic descriptions of predominantly quartz with feldspar and some mafic minerals. Deep alluvium was generally documented as subrounded with little to no presence of fines.

Intermediate alluvium is present from approximately 385 ft msl to 415 ft msl and averages about 30 feet thick. It is less uniform than the deep alluvium consisting of fining upward point bar sequences of coarse gravel through fine grained sand with some overbank flood plain type deposits of silt and clay present at the edge of the alluvial valley. The color is generally described as gray, brown, dark gray, or olive gray and mineralogic descriptions are consistent with the deep alluvium.

Shallow alluvium is present above the intermediate alluvium from approximately 415 ft msl with variable thickness up to the top of the alluvium or where it has been disturbed by landfilling. The water table is generally present in the shallow alluvium. Shallow alluvium ranges predominantly from medium-grained sand to clay with lenses of gravel and coarse-grained sand. Sand in the shallow alluvium is generally described as gray and mostly quartz with some mafic minerals present. Silty clay is present above 430 ft msl (~ upper 10 ft), which was deposited during Missouri River floods as overbank deposits.

3.1.3.2.2 LOESS

The upland loess consists of windblown silt, clayey silt, and silty loam. Surficial loess generated during Pleistocene glaciation was transported from glacial melt-out drainages by westerly winds and redeposited near the site approximately 17,500 years ago (Heim 1961). The variable thickness is controlled by both surface erosion and bedrock topography and is generally thinner than floodplain alluvium. A soil profile of loess is included in Appendix J and is generally described as pure silt overlying clayey silt up to approximately 80 ft thick near the site. Loess is encountered from 13 to 22 ft thick on the eastern side of the Bridgeton Landfill at an elevation of approximately 460 ft msl. Loess is uncommon above the alluvium on the western side of the Bridgeton Landfill but is occasionally interbedded with the underlying alluvium within the alluvial valley shown on Figure 3-6.

3.1.3.2.3 SOILS

Surficial soils along the floodplain of the Missouri River generally consist of Blake-Eudora-Waldron association while the surficial soils on the bluffs east of the river are the Urban Land-Harvester-Fishpot association. The floodplain materials are described as nearly level, somewhat poorly drained to well drained, deep soils formed in alluvial sediment. The upland materials are urban land and nearly level to moderately steep, moderately well drained to somewhat poorly drained, deep soils formed in silty fill material, loess and alluvium, which are formed on uplands, terraces, and bottom lands (EMSI 2018a).

Soils near the site consist of the Freeburg-Ashton-Weller association, which are nearly level to gently sloping, somewhat poorly drained, deep soils formed in loess and alluvial sediment. The Freeburg silt loam is found on the terrace adjacent to the eastern site boundary, while the Ashton silt loam is found to the east and south of the South Quarry portion of the Bridgeton Landfill (including the landfill borrow area).

3.1.3.2.4 SOLID WASTE AND LANDFILL LINER

The solid waste, which is present above the alluvium west of the alluvial divide in OU-1, was well characterized in the *OU-1 RIA*. The depth and configuration of the landfill deposits varies between each of the six landfill areas. The variation depends upon the pre-landfill topography and the effects of pre-landfill disturbances (e.g., quarrying), the amount of above-grade disposal that took place, and the type of waste materials disposed. The landfill debris thickness varies between 5 to 56 feet, with an average thickness of 36 ft in Area 1 and 30 feet in Area 2 (McLaren/Hart 1996).

There is no liner present beneath the northwestern portion of landfill and waste may have been placed directly on the ground surface (NRC 1989). Areas 1 and 2 are both in this unlined above-ground former landfill.

The solid waste encountered in OU-2 is described as common municipal wastes such as paper, plastics, clothing, and C&D debris. Older wastes were predominantly wood, construction debris, and other charred materials (Golder 1996; WMC 1997). Old mine spoils overlain with silt were also encountered in OU-2 (Golder 1996). A layer of approximately 7 to 10 feet of compacted clay was placed beneath permitted portions of the Inactive Sanitary Landfill constructed after 1974 as a liner to prevent downward movement of leachate (NRC 1989). The lining and compaction process prior to 1974 is unknown.

3.1.4 LOCAL HYDROLOGY AND CLIMATE

The major hydrological feature near the site is the Missouri River. Currently the Missouri River channel is approximately two miles west-northwest of the site and has a surface slope of approximately 0.00018 ft per foot (Golder 1996). The USGS stream gage 06935965 at St. Charles Missouri is approximately 1.5 miles northwest of the northwest corner of Area 2, as shown on Figure 3-7. This gage has a surveyed elevation of 413.47 ft msl North American Vertical Datum 1988 (NAVD88) and a drainage area of approximately 524,000 square miles.

Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) gauge at Lambert Field are shown on Figure 3-8. Daily Missouri River stage data from October 1984 to October 2018, and discharge data from April 2000 to April 2020, were downloaded from the USGS website. A hydrograph of the Missouri River elevation (based on the conversion listed on the USGS website) and daily precipitation is shown on Figure 3-8. The average flow in the Missouri River has been approximately 97,000 cubic feet per second (cfs) since April 2000 and generally ranges between approximately 25,000 cfs in December/January and 142,000 cfs in May/June. Peak flow within the historical record occurred on August 1, 1993 with a stage of 452.91 ft msl.

The Missouri River is in direct communication with the Missouri River alluvium and the river affects groundwater levels. The immediate impact of the Missouri River on regional and local horizontal and vertical groundwater gradients at the site is not well understood and will be characterized during this RI/FS.

The Earth City Levee system ponds are to the west and northwest of the site, as shown on Figure 1-2. A relief well network along the land side of the levee allows groundwater to gravity flow, under natural pressure gradients, to the ground surface and into the network of ponds as needed to maintain the integrity of the levee during a flood. These gravity flow relief wells have a designed discharge capacity of 780 gpm. Water flows through the system of ditches, channels, and lakes to a fully automated pump station which maintains a constant water elevation. Water is pumped through a discharge structure installed in the levee to a stormwater discharge channel west of the levee. The Earth City Levee system is designed to exceed the 500-year flood level and ranges from 462.03 ft msl at the south end to 459.34 ft msl at the north end. Assuming a 500-year flood were to occur, the Missouri River would be three to seven feet below the top of the Earth City levee. Most of the landfill property boundary is outside the Missouri River 500-year floodplain, with the exception of low-lying areas, the Buffer Zone, and Lot 2A2 that are within the area protected by the Earth City Levee system. The interaction between the Earth City Levee system ponds and the site (if any) are not well understood and will be characterized during this RI/FS.

Climate at the site is typical of the midwestern United States and has four distinct seasons ranging from mild winters to hot summers with high humidity. Daily on-site precipitation data were collected and compared to Lambert Field with good correlation (Golder 1996). Precipitation data for Lambert Field are shown on Figure 3-8 and are included in Appendix K. Approximately 40 inches of precipitation falls annually at the site. Local precipitation likely has a minimal effect on the Missouri River, but is an important factor for the water levels in alluvium and surface water bodies. Surface water drainage patterns are included in Appendix L.

3.1.5 LOCAL HYDROGEOLOGY

The site-specific aquifers consist of the Missouri River Alluvial Aquifer and the Post-Maquoketa and Ozark bedrock aquifers. Given the location of the site on the margin of the Missouri River Valley, there is a significant aquifer boundary along the bedrock interface, between bedrock groundwater within St. Louis and Salem Formations (east side of the site and below the alluvium) and shallow groundwater within the Missouri River Alluvial Aquifer (west side of the site).

The Missouri River Alluvial Aquifer is unconfined and contains highly-permeable alluvial sediments. The aquifer is up to approximately 150 feet thick (MDNR 1997). The aquifer underlies the Missouri River floodplain, which is generally two to three miles wide in St. Louis County. The shallow alluvial aquifer is a very important and widely-used water source in Missouri and the hydraulic conductivity of the most permeable sand and gravel zones is likely on the order of 1,000 feet per day (ft/day). In many places, the upper 20 to 30 feet of alluvium consist of low-permeability materials.

In much of the central, eastern, and northern parts of St. Louis County, only the Mississippian-age limestones, including the St. Louis, Salem and Keokuk-Burlington limestones, produce usable quality water and are capable of yielding several gallons of water per minute (MDNR 1997). Collectively, these water-bearing units are referred to as the post-Maquoketa Aquifer, which is an independent, water-yielding unit on the northeast edge of the Ozark Plateau.

The thick shale in the upper portion of the Warsaw Formation is generally impervious to groundwater flow and represents a lower confining unit within this portion of the post-Maquoketa Aquifer.

Over 130 monitoring wells and piezometers have previously been installed at, and near, the site. Wells are screened in the Keokuk Formation, the lower portion of the Salem Formation, the upper portion of the Salem Formation/St. Louis Formation, and the Missouri River Alluvium. Selected monitoring wells and piezometers have been monitored since 1979 to evaluate the groundwater quality near the site and the local hydrogeology. The current status and construction of wells installed during prior site investigations is shown on Table 3-2 and Figure 3-9. The adequacy, usability, and status of existing and abandoned on-site and perimeter monitoring wells, and associated data, will be evaluated during this RI/FS. Details of this evaluation are discussed in Section 5.3.1.

Local hydrogeologic descriptions are consistent with the terminology of the local geology and are separated into consolidated and unconsolidated deposits. The screened intervals of monitoring wells were reviewed during the development of the preliminary CSM. The hydrostratigraphic zones of monitoring wells were reclassified based on the environmental sequence stratigraphic evaluation (Table 3-2). Important features that affect the local hydrogeology are the local geologic boundaries, the North and South Quarry Pits, and the various sources of recharge and discharge. Some current and historical sources of recharge and discharge include precipitation, the Missouri River, historical quarry dewatering, the leachate extraction system, quarry wall seeps, the levee system, and other surface water bodies.

3.1.5.1 GROUNDWATER OCCURRENCE

The bedrock aquifers of interest at the site include the St. Louis Formation and the Salem Formation. Both formations are unconfined, and the Warsaw Formation serves as a confining unit to the underlying Keokuk Formation. The Keokuk Formation is isolated from the overlying St. Louis and Salem Formations, as evidenced by water levels from wells screened in the different units and the lack of response in the Keokuk Formation to localized pumping in the overlying strata.

Mississippian limestone at the site has low intergranular permeability when undisturbed and groundwater flow, predominantly, occurs through secondary porosity (NRC 1989). The secondary porosity of the St. Louis Formation and Salem Formation was likely enhanced by quarrying activities. Connectivity of the secondary porosity is not well understood and will be characterized during this RI/FS.

In general, bedrock aquifers within the Salem Plateau (representing approximately 46% of Missouri's potable groundwater), which include the Ozark and post-Maquoketa aquifers, are recharged through precipitation. In addition, the surface and subsurface weathering of carbonates (limestones and dolostones) has created numerous karst groundwater-recharge features such as sinkholes and losing streams that allow very rapid movement of water from the surface into the subsurface. In areas where competent and unweathered bedrock (i.e., non-karst) is exposed at the surface (e.g., immediately east of the site), recharge from precipitation is minimal and almost all precipitation becomes runoff. The annual average precipitation for the area is about 40 inches per year (in/yr) and annual recharge rates vary depending on local geology, vegetation, and surface features. Recharge rates are estimated to range from a few inches to 14 in/yr (MDNR 1997).

The deep, intermediate, and shallow alluvial aquifers are of particular importance to the OU-3 RI/FS. They are separated based on the hydrostratigraphic properties of each unit. Groundwater is generally encountered near, or immediately below, the landfill base in the underlying alluvium. The absence of continuous confining units and small vertical gradients in clustered wells suggest groundwater in the alluvium is generally unconfined below fine-grained soils, but localized and temporary confining conditions occasionally exist when water levels rise above the base of fine-grained deposits in the shallow alluvium.

In general, vertical gradients between clustered wells screened in the shallow, intermediate and deep zones within the alluvium are negligible, indicating these zones are in hydraulic communication and are part of a connected hydrostratigraphic zone. Based on previous characterization, the deep alluvium appears to behave as a single aquifer of relatively homogeneous high permeability that decreases near the bedrock valley walls and edge of the alluvium.

Recharge to the Missouri River Alluvial aquifer occurs by upward movement of groundwater from underlying bedrock, major river-aquifer interaction, gradual downward infiltration of water from precipitation, seepage from upland loess, and from downward infiltration of water from streams flowing across the alluvium (Miller et al. 1974; USGS 1986; MDNR 1997). Streams and underflow are a major source of recharge. Radial mounding of the potentiometric surface is observed where streams enter the floodplain. There is a filled oxbow lake present in the alluvium along the southwest landfill boundary.

The potentiometric surface of the bedrock aquifer units adjacent to the Missouri River is normally above the potentiometric surface of the alluvial aquifer. Therefore, under natural conditions, there is groundwater flow upward from the bedrock into the alluvium. Water from the Missouri River generally recharges the alluvium under two conditions:

- When the river is at flood stage and is above the elevation of the potentiometric surface, and
- Where high-yield pumping wells are constructed close enough to the river to induce direct recharge from the river to the well (Miller et al. 1974; MDNR 1997).

There is a direct hydraulic communication between the Missouri River and groundwater in the alluvium, although there is a delayed response of several days between higher river stages and higher groundwater levels. Seasonal river stages are associated with the gradual rise in groundwater levels in early spring through summer and the gradual decline of water levels during the fall and winter months (MDNR 1997). Similarly, there is a strong correlation in site water levels in alluvial wells when compared with river stage and precipitation over time, as expected for an unconfined system. Increases in alluvial water levels are matched by increases in river stage and precipitation, as a result of recharge to the alluvium by river water and precipitation.

3.1.5.2 AQUIFER TESTING

Various aquifer tests have been conducted in select monitoring wells and boreholes at the site during previous site investigations. In situ aquifer testing includes slug testing and packer testing. Available slug testing results are included as Table 3-3 and shown on Figure 3-10. Packer testing results are included as Table 3-4 and shown on Figure 3-11. Aquifer testing evaluations completed during previous site characterization are included as Appendix M and include results of ex situ triaxial permeability laboratory testing results.

The properties of the various aquifers, including recharge/discharge rates and hydraulic conductivities, were identified as a data gap in the SOW. Additional characterization will be conducted during this RI/FS. Historical slug testing data will be evaluated based on its intended use, and new slug tests will be conducted at those locations previously tested on a case-by-case basis. Results of existing data derived from the aquifer tests are discussed below.

3.1.5.2.1 SLUG TESTING

Slug testing was conducted in monitoring wells installed in the shallow alluvium, the intermediate alluvium, the deep alluvium, the St. Louis/Upper Salem Formation, the Salem Formation, and the Keokuk Formation during various stages of the OU-1 and OU-2 site characterization. A total of 77 slug tests were conducted by Golder and McLaren Hart (Golder 1996; McLaren/Hart 1996). Slug tests were generally conducted using a rising head test. A minimum, maximum, and geometric mean of slug tests by zone are presented on Table 3-3. Geometric means were calculated using one rising head slug test from each location; falling head slug tests were used if a rising head test was not conducted.

Hydraulic conductivity results for slug testing of the shallow alluvium ranges from 0.35 to 97 ft/day with a geometric mean of 8.9 ft/day; intermediate alluvium ranges from 0.39 to 189 ft/day with a geometric mean of 49 ft/day; and deep alluvium ranges from 4.6 to 251 ft/day with a geometric mean of 59 ft/day. Hydraulic conductivity results of slug testing in the alluvium are consistent with grain size trends and increase with depth. As shown on Figure 3-10, the lowest hydraulic conductivities in the alluvium are adjacent to the edge of the alluvium and are likely influenced by overbank deposits.

Hydraulic conductivity results for slug testing of the bedrock units are generally orders of magnitude lower than those of the alluvium, with the exception of PZ-202-SS and are, therefore, presented with scientific notation. Well PZ-202-SS is near one of the seeps discussed in Section 3.1.3.1.5 and, therefore, could intersect a highly transmissive fracture. Hydraulic conductivity results of slug tests are as follows:

- Hydraulic conductivity of the St. Louis Formation ranges from 6.5 x 10^{-5} ft/day to 7.8 x 10^{0} ft/day with a geometric mean of 3.7 x 10^{-3} ft/day.
- Hydraulic conductivity of the Salem Formation ranges from 2.4 x 10^{-4} ft/day to 4.2 x 10^{-2} ft/day with a geometric mean of 1.9 x 10^{-3} ft/day.
- Hydraulic conductivity of the Keokuk Formation ranges from 1.7 x 10^{-3} ft/day to 1.1 x 10^{-2} ft/day with a geometric mean of 5.8 x 10^{-3} ft/day.

Hydraulic conductivity results suggest a low intergranular permeability of the Mississippian limestone and that flow in competent rock at the site occurs primarily through secondary porosity such as fractures and solution cavities.

3.1.5.2.2 BOREHOLE PACKER TESTING

Single and straddle constant head injection packer testing was conducted as part of OU-2 site characterization activities in 1995 and 1996 prior to the installation of piezometers (Golder 1996). Single packer testing was conducted on intervals ranging from 10 to 93 ft in length. Straddle packer tests were generally conducted on 5-foot intervals. Intervals were selected for packer testing based on degree of fracturing and degree of porosity and isolated to provide a range of hydraulic conductivities. Results of borehole packer testing are presented on Table 3-4 and are plotted with fractures per foot on Figure 3-11.

Hydraulic conductivity results of packer testing are as follows:

- Hydraulic conductivity of the St. Louis Formation ranges from 1.0 x 10^{-3} ft/day to 1.2 x 10^{-2} ft/day with a geometric mean of 2.7 x 10^{-3} ft/day.
- Hydraulic conductivity of the Salem Formation ranges from 1.6 x 10^{-4} ft/day to 7.2 x 10^{-2} ft/day with a geometric mean of 4.6 x 10^{-3} ft/day.

- Hydraulic conductivity of the Warsaw Formation ranges from 7.3 x 10^{-4} ft/day to 1.6 x 10^{-1} ft/day with a geometric mean of 5.5 x 10^{-3} ft/day.
- Hydraulic conductivity of the Keokuk Formation ranges from 2.2 x 10^{-3} ft/day to 1.2 x 10^{-1} ft/day with a geometric mean of 2.8 x 10^{-2} ft/day.

The geometric means of packer tests are slightly higher than slug tests conducted in the Salem and Keokuk Formations. This is also the case for the St. Louis Formation if the highly transmissive feature encountered at well PZ-202-SS is not included in the geometric mean. These conclusions provide another line of evidence that flow in competent rock at the site occurs primarily through secondary porosity, such as fractures and solution cavities.

3.1.5.2.3 GEOTECHNICAL TESTING

Geotechnical testing at the site was historically conducted using a triaxial permeability test method. The results are shown on Table 3-5. The mean vertical hydraulic conductivity of the two rock cores collected from the shale near the top of the Warsaw Formation (PZ-106-KS GTS-1 and PZ-106-KS GTS-2) was 6.4 x 10^{-7} ft/day suggesting it acts as a confining aquitard. Undisturbed unconsolidated samples collected near surface soils and loess had much higher conductivity values ranging from 5.7 x 10^{-4} ft /day to 8.5 x 10^{-1} ft /day.

3.1.5.2.4 AQUIFER PROPERTIES OF SOLID WASTE

The depth of landfill materials in the North Quarry and South Quarry (about 180 feet and 275 feet, respectively) is much greater than landfill materials in OU-1 Area 1. Therefore, the hydraulic conductivities are expected to be much lower for landfill materials near the bottom of the former pits. The reported values of hydraulic conductivity of aged municipal waste vary with respect to overburden stress, such that an overburden stress of 500 kilopascals (kPa) is associated with a measured hydraulic conductivity in the range of 5x10^{-6} cm/s (Powrie et al. 2005; Reddy et al. 2009). The saturated landfill materials in the deepest portions of the Bridgeton Landfill may have approximately 500 to 600 kPa of overburden stress, which corresponds to an expected range of hydraulic conductivity on the order of 1x10^{-5} to 1x10^{-7} cm/s.

3.1.5.2.5 TRANSMISSIVITY

The transmissivity of the alluvium was calculated using the geometric mean of conductivity and the thickness of each hydrostratigraphic zone. The transmissivity of the shallow alluvium assumes an average ground surface elevation of 450 ft msl, resulting in a thickness of 35 feet and transmissivity of approximately 310 square feet per day (ft^2/day). The transmissivity of the intermediate alluvium is approximately 1,500 ft^2/day. The transmissivity of the deep alluvium is approximately 3,300 ft^2/day. These data confirm the deep alluvium is the most transmissive hydrostratigraphic zone at the site.

3.1.5.3 GROUNDWATER ELEVATIONS AND GRADIENTS

Groundwater elevations have been measured at the site since 1979. Historical data have been measured relative to several different datum, and thus required conversion to a single standard to make a meaningful evaluation of gradients at the site. Historical measuring point elevations and groundwater elevations were converted to NAVD88 based on the conversion in the OU-1 RIA and are included in Appendix N. The conversion from the site coordinate system to 1983 Missouri East State Plane and NAVD88 was completed by adding 40.97 feet to the northing, adding 320174.7 feet to the easting, and subtracting 0.402 feet from the elevation. Depth to water measurements, or groundwater elevation data used to populate the database are also included in Appendix N. Potentiometric surface maps from previous OU-1 and OU-2 reports are included as Appendix D.

Potentiometric surface maps were prepared during preparation of this Work Plan for October 1984 and April 1985, which were among the first comprehensive site-wide gauging events conducted post RIM placement to evaluate groundwater flow direction seasonally and are included as Figures 3-12 and 3-13, respectively. Potentiometric surface maps were also prepared for April 2013 and September 2013, which were among the most recent comprehensive site-wide gauging events and are included as Figures 3-14 and 3-15, respectively. Groundwater elevations and gradients are discussed below.

3.1.5.3.1 GROUNDWATER ELEVATIONS

The depth to groundwater ranges from approximately 10 to 60 ft bgs and is dependent on the site topography. The water table in floodplain deposits, is generally within 10 ft of ground surface. Hydrographs are included in Appendix O.

Groundwater elevations are generally highest during spring or summer and are influenced by topography, the Missouri River stage, precipitation, surface run-on, infiltration, and groundwater/leachate extraction. Groundwater elevation fluctuations in the alluvium mimic the Missouri River stage, but are subdued and delayed. A groundwater mound is often observed near monitoring wells S-75, S-76, and I-73 where there is surface recharge. Monitoring well I-50 is partially confined when the water table rises above shallow fine-grained material.

Perched water has been observed in monitoring well S-80, two soil borings advanced in Area 1, and nine soil borings advanced in Area 2. Locations of perched water encountered during the RIA are included as Appendix P. The temporal variability in groundwater levels and flow direction and effects of the Missouri River stage and precipitation were previously identified as data gaps and remain objectives of the proposed investigations.

3.1.5.3.2 HYDRAULIC GRADIENTS

During normal flow conditions for the Missouri River, the groundwater gradients in the Missouri River alluvium are towards the river with a vector of about 45 degrees in the downstream direction (MDNR 1997). Regionally observed gradients are typically gentle and on the order of 1 to 2 feet per mile. During temporary river flood stage, sustained high river stages, or near high-yield alluvial pumping wells, groundwater gradient reversals can occur under losing conditions, where groundwater flow is away from the Missouri River (Miller et al. 1974). The average Missouri river stage at the USGS St. Charles stream gauge station 06935965 is approximately 430 ft msl (2000 to present), and depending on the year and season, the river stage generally fluctuates by as much as 10 vertical feet.

Groundwater in the alluvial aquifer near the site generally flows to the northwest. The current leachate collection system discussed in Section 3.1.5.7.2 is of significant hydrogeologic importance as it directly affects groundwater levels, hydraulic gradients, groundwater flow directions, groundwater flux, and the overall water balance between precipitation recharge and groundwater inflow and outflow from the site area. Additional details regarding the hydrogeology of the site, and the effects of the leachate collection system on groundwater, will be further evaluated as part of this RI/FS.

The water table across the site has a low horizontal gradient ranging between 0.0003 and 0.0005 feet per foot (ft/ft) in July 2013. This is consistent with the previously measured (1979) off-site gradient of 0.0006 ft/ft (B&M 1986). Groundwater elevation fluctuates seasonally in direct response to the Missouri River stage and precipitation. Variable hydraulic gradients are induced by the Missouri River bedrock channel and influenced by river stage with groundwater superimposed mounds and depressions that influence shallow water table gradients as shown on potentiometric surface figures in Appendix D.

As documented in previous reports, small scale changes in the water table gradient and flow direction are observed due to recharge and infiltration with macro effects towards the Missouri River. The water levels in the deep alluvium appear to respond more rapidly to the Missouri River stage. A horizontal gradient beneath Area 1 to the south toward the Bridgeton Landfill and to west-southwest beneath Area 2 towards the Earth City flood control channel was documented in the OU-1 RI (McLaren/Hart 1996). This can be observed on Figure 3-13b.

Observations of downward vertical gradients have been made near the bedrock valley walls (B&M 1986). A downward component of flow has also been observed in southeast near wells D-81 and D-89. Contour patterns and flow patterns are generally the same seasonally. Localized shallow mounding was observed historically due to pumping during quarrying operations, when water from the North and South Quarries was routed to drainage ditches, surface water infiltration, and storage ponds nearby. Mounding is also affected by variable permeability.

The bedrock aquifers in the St. Louis area are confined and bedrock wells are often flowing artesian, where the hydrostatic pressure in these aquifers raises the water level in the well above the ground surface (Miller et. al. 1974). During periods of no, or low, groundwater extraction, groundwater in bedrock (including the St. Louis, Salem, and Keokuk Formations) has a natural upward and horizontal gradient towards the alluvium and the Missouri River, which is typical of a low valley groundwater discharge system. However, the effects of leachate pumping in the landfill are evident in the St. Louis and upper Salem Formations, where there is an observed strong correlation between bedrock water levels with pumping rates. Increased pumping results in lower water levels and greater downward gradients in the St. Louis and upper Salem Formations; decreased pumping results in the recovery of water levels to regional water levels and a natural upward gradient. Water levels for the deeper Keokuk-Burlington Formation indicate minimal influence from pumping, likely as a result of upper confinement from the overlying Warsaw Shale.

The water levels in the Keokuk-Burlington Formation are significantly higher than the St. Louis and upper Salem Formations with consistent upward vertical gradients for all historical events. However, the regional and localized hydraulic gradients and flow directions between the alluvial and shallow bedrock aquifers are a data gap and will be evaluated in more detail as part of this RI/FS. Previous summaries of vertical gradients are included in Appendix Q. The temporal and seasonal trends will be discussed in more detail in the refined CSM.

3.1.5.4 GROUNDWATER VELOCITY AND DISCHARGE

Horizontal groundwater velocities of the shallow, intermediate, and deep alluvium were calculated using the ranges of hydraulic conductivities from slug testing data, a regional hydraulic gradient of 0.0006 ft/ft, and an assumed effective porosity of 0.15 for the shallow alluvium and 0.2 for the intermediate and deep alluvium. The groundwater velocities in the shallow alluvium range from 0.5 to 142 feet per year (ft/year) with a geometric mean of 13 ft/year; intermediate alluvium range from 0.43 to 208 ft/year with a geometric mean of 53 ft/year; and deep alluvium range from 5.0 to 274 ft/year with a geometric mean of 65 ft/year. These results suggest that the horizontal flow in the alluvial aquifer is relatively uniform.

Horizontal groundwater velocities of the St. Louis Formation, Salem Formation, and Keokuk Formation were also calculated using the ranges of hydraulic conductivities from slug testing data, a regional hydraulic gradient of 0.003 ft/ft, and an assumed effective porosity of 0.008. Groundwater velocity results for groundwater velocities in the St Louis Formation ranges from 0.01 to 1,065 ft/year with a geometric mean of 0.51 ft/year; Salem Formation ranges from 0.034 to 5.7 ft/year with a geometric mean of 0.27 ft/year; and the Keokuk Formation ranges from 0.24 to 1.5 ft/year with a geometric mean of 0.80 ft/year. The groundwater velocities in the bedrock are lower than those in the alluvium. However, groundwater velocities in localized features such as fractures and solution cavities are likely much higher.

Groundwater discharge was estimated, as part of the 1986 evaluation, based on Darcy's Law using average permeabilities and flow rates for the upper (shallow and intermediate alluvium) and lower aquifers (deep alluvium). Results across the cross-sectional area on the northern and western perimeters were 500 gallons per day (gpd) in the shallow aquifer and 400,000 gpd in the deep aquifer. Eastward flow, which was estimated at 43,000 gpd, was pumped from the leachate collection system, treated, and discharged to the sanitary sewer (B&M 1986). Additional evaluation of groundwater velocity and discharge will be conducted during the RI/FS. This evaluation will be based on the results of additional aquifer testing and hydraulic gradient evaluations as discussed in Section 5.4.13 and Section 5.4.15.1.

3.1.5.5 SURFACE WATER/GROUNDWATER INTERACTION

Staff gauges were previously installed at the site as part of OU-1 and OU-2 site characterization. They have since been removed. Surface water elevations are shown on in Appendix L and the former locations of the gauges are shown in Appendix B. The relationship between surface water and groundwater at the site is not fully understood. Additional staff gauges will be installed, and further characterization will be conducted during the RI/FS to address this data gap and is discussed in Section 5.4.16.

3.1.5.6 GROUNDWATER GEOCHEMISTRY

Understanding groundwater geochemistry at the site remains one of the most critical components of the CSM and was, correctly, identified as a data gap by the USGS. Various factors can affect the redox conditions and groundwater pH, including the presence of landfill leachate and precipitation. The common geochemical redox conditions and species, and reactive minerals (Fe/Mn oxyhydroxides, clay minerals, and solid organic materials) typically associated with landfills, can influence radionuclide transport via exchange-adsorption/desorption and precipitation/co-precipitation or dissolution over time scales on the order of seconds to months.

High dissolved iron, low sulfate, and low uranium concentrations noted in prior site investigations suggest that there is anoxic groundwater, which is iron and possibly sulfate reducing, beneath the site. Combined dissolved radium concentrations were significantly higher in wells exhibiting leachate impacts (USGS 2015). A preliminary evaluation of historical groundwater geochemistry parameters, redox couples, and organic content was completed prior to preparation of this proposed RI/FS scope of work. Existing figures from the USGS report and RIA are included as Appendix R. Groundwater geochemistry will be discussed in detail in the refined CSM.

3.1.5.7 EFFECTS OF THE QUARRY AND BRIDGETON LANDFILL

Quarrying in the North and South Quarry Pits began in 1939. The effects of quarry dewatering, the Bridgeton Landfill related infrastructure, and hydraulic characteristics of landfill material are also an important component of the CSM and are a data gap. Additional evaluation will be conducted during this RI/FS to address this data gap. A preliminary evaluation was, however, performed as part of this RI/FS Work Plan preparation, and effects of the quarries and the Bridgeton Landfill are discussed below.

3.1.5.7.1 QUARRY DEWATERING

Prior to landfilling in the North and South Quarry Pits, the open quarry mining operations required dewatering. Water would enter the quarry via direct precipitation, runoff, and through seeps. Seeps were mapped as part of a water balance conducted by Reitz & Jens, Inc., and a volumetric flow through the seeps were documented (Appendix F). Seeps were also mapped on the open faces of the South Quarry Pit during OU-2 site characterization (Appendix F). Quarry faces had 88 seeps. In the St. Louis Formation, most of the seeps were observed above the Bx/Ld contact and within the Ld unit. Seeps were generally observed above the Ls unit of the St. Louis Formation. Seeps above the Ls contact and the absence of seeps within the Ls unit suggest that the Ls unit is a less transmissive unit (Golder 1996). Attempts were made to seal the cavities and seeps in 1990, but those efforts were unsuccessful (F&VD 1990).

Leachate was observed to be migrating vertically downward from the Inactive Sanitary Landfill through the alluvium into the South Quarry through more than 98 feet of limestone and entering the quarry at approximately 220 ft msl (NRC 1989). Blasting activities performed during quarrying may have propagated fractures in the walls up to 30 ft horizontally beyond the quarry face (NRC 1989). It is, however, unlikely the fractures would have extended beyond this point (NRC 1989). The noted leachate inflow suggests landfill-related impacts may extend into the limestone (NRC 1989).

3.1.5.7.2 LEACHATE COLLECTION SYSTEM

The Bridgeton Landfill leachate collection system is of significant hydrogeological importance, since it is designed to remove (capture) surface water and groundwater flowing into the landfill and thus creates a sink to surrounding aquifers as illustrated by the historical potentiometric data in Appendix D. Leachate collection sumps are fitted with pumps designed to maintain a maximum of 30 ft leachate head from the base of the sump in accordance with permit conditions. Groundwater was observed to flow inward towards the leachate collection sumps, which produced a groundwater divide in the alluvium, west of the quarries (Golder 1996). This can be seen on the potentiometric surface maps included as Appendix D.

During early operations, the Bridgeton Landfill pumped and discharged approximately 200,000 gpd (approximately 6 million gallons per month) of liquid to a lined, and aerated, leachate retention pond (leachate lagoon) shown on Figure 1-2 (WMC 1997). In 2006, the leachate, sludge, the plastic liner, and potential sources of water contamination were removed. The MDNR approved the closure of the former leachate pond as documented in letter correspondence (MDNR 2006).

The LCS points associated with the leachate system have been installed over the course of many years throughout the lifetime of the site. Seven LCS points currently exist as shown in Appendix S; the LCS points have flow meters which monitor the amount of leachate extracted from each individual wellhead. The leachate pretreatment plant was constructed at Bridgeton Landfill between April 2013 and August 2014. The 316 Tank was built first in April 2013. The 1 million-gallon aeration tanks were started in September 2013, and the associated building construction was started in December 2013. System start-up procedures began in June 2014, and the biological system startup/shakedown commenced in August 2014. The system includes five above ground storage tanks: one 316,000-gallon tank and four 1 million-gallon tanks. The leachate system treatment train includes solids removal, polymer addition/flocculation, pH adjustment, and biological treatment.

The flow associated with the active leachate collection system at Bridgeton Landfill is monitored via two totalizing flow meters as well as discrete flow measurements from operating extraction wells. LCS-3D, LCS-4B, LCS-5A, LCS-5B, and LCS-6B are currently operational. Pumps installed in LCS-1D and LCS-2D are not presently operable. The leachate collection system consolidates several sources of extracted leachate, including the LCS sumps, dual phase extraction gas wells, landfill gas condensate, and other auxiliary extraction points. The leachate is routed to the leachate pretreatment plant. During the leachate treatment process, potable water is added during some of the processes and is discharged through the permitted MSD discharge location. As reported to the MSD under Permit #100380300-1.4, the current monthly amount of total leachate and potable water discharged to the MSD during 2019 ranged from 4.0 to 7.3 million gallons (approximately 130,000 to 240,000 gpd). Additional measures to better quantify volumes extracted from individual points, and to understand the effects of the leachate extraction system are proposed in Section 5.4.17, which outlines measures intended to address data gaps pertaining to the LCS.

3.1.5.7.3 SUBSURFACE REACTION

In December 2010 an SSR was discovered in the South Quarry portion of the Bridgeton Landfill, resulting in elevated temperatures and accelerated decomposition of wastes. The reaction appears to be occurring approximately 80 to

150 feet below the South Quarry landfill surface. An ethylene vinyl alcohol (EVOH) cover, landfill gas extraction wells, and temperature monitoring probes have been installed to address the SSR. Recent data suggest that the temperature, gas quality, and settlement effects of the SSR have decreased significantly. The primary heat front currently appears to be most active in the southern portion of the South Quarry. The heat front of the SSR appears to have migrated from an initial location in the eastern portion of the South Quarry in a counterclockwise direction to the north, then to the west, and, most recently, to the southwestern portion of the South Quarry.

A heat extraction system has been installed and is currently operating in the neck area between the North and South Quarry portions of the Bridgeton Landfill. Additional temperature monitoring probes have been installed in the North Quarry between the neck area and Area 1 (EMSI 2018a).

3.1.6 NATURE AND EXTENT OF IMPACTS

A clear understanding of the background water quality in the alluvial and shallow bedrock aquifer near the site remains undetermined and was identified as a significant data gap in the CSM. Analysis of available data relating to nature and extent of impacts is discussed below. These data will be substantially supplemented with the results of the proposed investigation.

Potential on-site and off-site health and environmental effects posed by groundwater impacts will be evaluated upon completion of the field data gathering outlined in Section 6.2 of this RI/FS Work Plan. Additionally, potential surface water, sediment, and biotic impacts from OU-3 will be further evaluated as the RI/FS progresses.

3.1.6.1 NATURE AND EXTENT OF RIM

Radionuclides have been identified in soil interspersed with solid waste materials in portions of the landfill deposits in Area 1 and Area 2. Radionuclides have also been detected in the shallow soil on the Buffer Zone and Crossroads Lot 2A2. The specific screening criteria, approved by USEPA, to define RIM are:

- 7.9 pCi/g or higher of combined Radium-226 plus Radium-228
- 7.9 pCi/g or higher of combined Thorium-230 plus Thorium-232
- 54.5 pCi/g or higher of combined uranium activity

Leached barium sulfate residue (LBSR) generated by Mallinckrodt Chemical Works (Mallinckrodt) during uranium processing for the Manhattan Engineering District (MED) was moved from the St. Louis Airport Site (SLAPS) to nearby 9200 Latty Avenue in Hazelwood, Missouri in 1966 (EMSI 2018a). An NRC investigation conducted in 1976 reported that approximately 8,700 tons of leached barium sulfate residues, together with approximately 39,000 tons of soil removed from the top 12 to 18 inches of the Latty Avenue site, were transported to the West Lake Landfill over a three-month period from July 16 through October 9, 1973 (USEPA 2008a; NRC 1976; NRC 1988; RMC 1982).

The data and evaluations presented in the RIA identified RIM in multiple irregular volumes, some of which are partially at, or near, the surface, while others are in the deeper portions of Area 1 and Area 2. The RIA described the RIM at the site as irregularly interspersed within the overall larger matrix of MSW. The distribution of the RIM within the landfilled areas has been impacted by both natural and anthropogenic processes, such as the initial placement and the subsequent 40-plus years of decomposition, consolidation, and differential settlement of the MSW over time. Consequently, the RIM is not present as a laterally continuous layer but is now interspersed within separate areas and intervals of MSW such that RIM cannot be easily distinguished from the surrounding MSW, landfill cover, and native soil matrix within which it is found. Additional detail on the nature and extent of RIM was provided in the RIA and is included as Appendix T.

3.1.6.2 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As summarized in the RIA, groundwater samples have been analyzed for radionuclides as part of the various OU-1 investigations. Most recently (2012-2013), groundwater samples collected from 85 wells were analyzed for radionuclides. The radionuclides in groundwater are discussed in terms of the isotopes of three elements: radium, thorium, and uranium. A detailed discussion of the nature and extent of these constituents was presented in the RIA. Figures showing their distribution are included as Appendix U. Radium has been detected in groundwater monitoring wells in most portions of the site, in both the bedrock and the alluvium. The USGS identified four general hypotheses for the origin of dissolved combined radium above the USEPA MCL in the groundwater including (USGS 2015):

- Leaching of radium from the RIM
- Radium values are within the range found in natural groundwater
- Leaching of radium from the non-RIM wastes disposed at the site
- Mobilization of naturally-occurring radium from the limestone bedrock and alluvium by landfill leachate

The USGS further stated that other than the radium in groundwater samples being from the natural variation in groundwater, no single hypothesis can be invoked to explain all the occurrences of radium above the USEPA MCL. Furthermore, the available groundwater data are not adequate to provide definitive conclusions regarding the validity of any hypotheses.

The fate and transport of radium is complicated by its natural occurrence and association with redox sensitive iron oxides (USGS 2015). Combined total Radium-226 and Radium-228 was detected above the USEPA MCL for all sampling dates between August 2012 and February 2014 in four deep alluvial wells (D-83, D-6, PZ-113-AD, and D-3) and five St. Louis/Upper Salem Formation wells (PZ-107-SS, PZ-115-SS, PZ-101-SS, PZ-102-SS and MW-1204). The ratios of Radium-228/Radium-226 are variable in these wells. Dissolved levels of thorium have not been detected at concentrations that exceed the gross alpha USEPA MCL of 15 pCi/L.

Trace metals and VOCs have also been detected in site groundwater (Appendix U). Benzene has been detected in groundwater monitoring wells near the South Quarry (most notable occurrences were associated with the SSR and have decreased), the Inactive Sanitary Landfill and Area 1 (but not Area 2) at concentrations above its USEPA MCL of 5 µg/L. Chlorobenzene was detected in one well near the Inactive Sanitary Landfill and one well near Area 1 at concentrations above its USEPA MCL of 100 µg/L. Vinyl chloride has been detected during some, but not all, sampling events in some wells near the Inactive Sanitary Landfill and Area 2. Arsenic has been detected in most of the site monitoring wells at concentrations above its USEPA MCL of 10 µg/L. Iron and manganese have been detected at concentrations above their respective secondary USEPA MCLs (300 and 50 µg/L, respectively) in most of the site monitoring wells. Chloride has also been detected in most of the monitoring wells at concentrations above its USEPA Secondary MCL of 250 mg/L.

The occurrence and extent of potential groundwater contamination and landfill gas migration in groundwater are not delineated and are identified as a data gap. Additional evaluation of radionuclide and chemical occurrences in groundwater will be conducted as part of this investigation.

3.1.6.3 SOIL GAS IMPACTS AND VAPOR INTRUSION

The presence and extent of soil gas beneath the site and the potential for gas to migrate into buildings are unknown. No buildings will be constructed in OU-1, in accordance with the land use controls described in Section 2.3. A landfill gas evaluation is being conducted currently as part of the OU-1 program and perimeter landfill gas sampling is being conducted for OU-2. A subslab depressurization system was installed at the Scale House to mitigate the potential for vapor intrusion and a fan was installed in the Engineering Office due to odor issues. An additional evaluation of the potential for soil gas to migrate into indoor air will be conducted as part of this investigation.

3.1.7 POTENTIAL PATHWAYS OF CONTAMINANT MIGRATION/PRELIMINARY PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS

A Baseline Risk Assessment was prepared during both of the OU-1 and OU-2 RIs to evaluate the potential receptors, exposure routes, and potential risks that the site could pose to current and future workers and the general public, including off-site residential areas. Potential receptors and pathways are presented below.

3.1.7.1 POTENTIAL RECEPTORS

Potential receptors associated with the site primarily include humans ingesting groundwater and ecological receptors ingesting sediment, surface water, or biota that have accumulated site-related constituents conveyed through the groundwater pathway. A preliminary CSM figure for OU-3 is included as Figure 3-16, which identifies the potential receptors associated with OU-3. Additional receptors may be considered throughout the RI/FS process if data indicate that other exposure pathways are currently complete or could reasonably be complete in the future.

A potential exposure pathway is through potable or production water wells. Previous documentation of wells was compiled and reviewed as part of the planning process (Appendix V). An inventory of existing and abandoned wells within 2 miles of the site will be conducted during this investigation. Information summarizing pertinent OU-3 area boundary features, general site physiography, hydrogeology, geology, and hydrology were summarized in Sections 2 and 3 of this Work Plan.

Potential ecological receptors are those that are expected to inhabit or use aquatic resources within the site or in areas where a complete exposure pathway exists. The land surrounding the site is largely developed and, therefore, provides limited overall habitat. The Missouri River provides habitat to both aquatic species and terrestrial species that may consume both food and water. At the conclusion of the OU-3 RI, specific ecological receptors will be identified for potential exposure areas. No threatened and endangered (T&E) species have been noted to be present on site. Signs of wildlife noted during historical and recent inspections included deer tracks, rabbits, red-winged black birds, robins, crows, great blue heron, and stool pellets containing fur suggesting a coyote or red fox (EMSI 1997). Bridgeton Landfill staff also report seeing coyotes, turkeys, racoons, skunks, and groundhogs.

3.1.7.2 EXPOSURE ROUTES AND PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS

Potential exposure routes include the inhalation of vapors associated with, and dermal contact with, and the ingestion of groundwater, sediment, or surface water containing COPCs. Vapor intrusion was identified as a data gap in the ASAOC SOW and is a potential exposure route for inhalation of vapor-forming COPCs. A preliminary CSM figure for OU-3 has been included as Figure 3-16, which identifies potential exposure pathways associated with OU-3.

Potential exposure routes and public health and environmental impacts will be further evaluated in this RI/FS when the existence, nature, and extent of off-site impacts are defined. A Baseline Risk Assessment Work Plan (BRAWP) will be developed and submitted. This BRAWP will provide details regarding the site-specific receptors and associated exposure routes that will be evaluated per CERCLA.

3.2 PRELIMINARY OU-3 STUDY AND MODEL BOUNDARIES

The preliminary extent of the OU-3 study area includes the area proposed for investigation as part of the OU-3 RI work plan as shown on Figure 3-17. This initial estimate of the study area will be refined during site characterization and as the OU-3 investigation progresses.

The preliminary groundwater modeling boundary is also shown on Figure 3-17. The proposed modeling boundary reflects the proposed modeling domain, which extends beyond the study area to incorporate natural hydrogeologic and hydrologic flow boundaries. Additional details on the proposed model boundary are included in Section 6.2.1.

3.3 PRELIMINARY IDENTIFICATION OF RESPONSE OBJECTIVES AND GROUNDWATER REMEDIAL ACTION ALTERNATIVES

Preliminary response objectives are to prevent human and ecological receptors from ingesting groundwater or surface water with COPC concentrations in exceedance of chemical-specific ARARs. The following is a preliminary list of potential remedial action alternatives that may be considered, consistent with applicable Superfund/CERCLA protocols.

3.3.1 NO ACTION

The No Action alternative provides a baseline for the comparison of other alternatives. The No Action alternative would not reduce or eliminate exposure to groundwater impacted by COPCs; therefore, the response objectives would not be met if the groundwater is determined to be impacted and if the groundwater poses a significant threat to ecological or human receptors. Regardless of the effectiveness of the No Action alternative, the NCP requires this alternative be carried through the detailed analysis of alternatives.

3.3.2 INSTITUTIONAL AND ENGINEERING CONTROLS

Institutional controls are non-engineered administrative and legal controls put in place to limit the potential for human exposure. They are a subset of Land Use Controls. Engineering controls can be used to support institutional controls and generally restrict access to the site or contact with certain portions of the site to prevent human and ecological exposure. They provide limited action as remedial action alternatives. Existing institutional and engineering controls are discussed in Section 2.3.

3.3.3 MONITORED NATURAL ATTENUATION

Monitored Natural Attenuation (MNA) generally consists of monitoring the rate at which natural processes are degrading COPCs. The monitoring typically includes a multiple lines-of-evidence type of approach that supplements COPC concentration data with geochemical and other data. Routine quarterly groundwater sampling of OU-3 will collect useful data that will allow assessment of MNA under current site conditions. Geochemical conditions will be evaluated during quarterly sampling as well. This will include dissolved oxygen (DO), nitrate, and sulfate concentration, and also oxidation-reduction potential (ORP). Each of these can be used to determine the potential for oxidative or reductive biological and abiotic attenuation of certain COPCs.

3.3.4 GROUNDWATER EXTRACTION (HYDRAULIC CONTROL)/TREATMENT/DISPOSAL

Groundwater control can be achieved by pumping and on-site treatment for off-site disposal to a publicly owned treatment works or other treatment facility. Depending upon the COPCs determined to be present, groundwater treatment alternatives may include air stripping (volatile organics), carbon adsorption (organics), chemical oxidation (organics), aerobic biodegradation (organics), chemical precipitation (metals), ion exchange (metals) or a combination of the above. Options preliminarily identified for disposal of treated groundwater include discharge to the sanitary sewer system, which serves the site.

3.3.5 GROUNDWATER CONTAINMENT

A groundwater containment scenario would involve capping of the landfilled areas and potentially pumping of groundwater and leachate to create an inward groundwater gradient to prevent off-site migration of impacted groundwater. In addition, the effects of the OU-1 remedial action will need to be considered in the short and long term if a containment strategy is implemented.

3.3.6 IN SITU TREATMENT

Groundwater can be treated in situ to facilitate the attenuation or degradation of dissolved COPCs in the groundwater. Treatment of dissolved contaminants in situ requires an assessment of groundwater flow, COPC concentrations, and site geochemistry to develop a treatment method to break down the contaminants or reduce contaminant mobility. Depending on the COPCs present, options for in situ treatment may include reactive barrier to attenuate the movement of COPCs in groundwater and injection of chemicals or other amendments to stabilize or enhance degradation of dissolved COPCs.

3.4 DATA NEEDS

The specific data needs and data gaps for the OU-3 RI activities are outlined in Section 2.5 and were based upon an evaluation of previous investigations; these specific data needs and data gaps were considered when developing the Work Plan rationale and the additional data acquisition program. The data needs identified for the OU-3 RI include:

- Identifying existing wells and proposing new borings and groundwater monitoring wells to define the physical and geochemical characteristics of the hydrogeologic system.
- Identifying, sampling, and analyzing COPCs and other relevant parameters to assess background groundwater quality and potential down-gradient landfill impacts (e.g., geochemical redox indicators, landfill leachate indicators, trace anions, tritium, wastewater organic compounds, and radionuclide isotopic analysis) upon groundwater quality.

These data will also support groundwater modeling and the completion of human health and ecological risk assessments needed to inform RI/FS decisions regarding potential remedy selection.

Information from the OU-3 activities included in Section 5.0 to have been proposed to answer the principal study questions (PSQs) identified in Section 4.0. The results from the proposed RI activities will be evaluated to identify data gaps that still exist, and which will be further evaluated as additional phases of the RI process. Data gaps may include sediment, sediment pore water, surface water, soil gas, indoor air, and additional groundwater quality data. Data needs and a plan to satisfy them will be outlined in additional addenda to this Work Plan.

3.5 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides the preliminary identification of potential OU-3 ARARs and other relevant guidance and criteria "to be considered" (TBC) for the site. The preliminary identification of potential ARARs and TBCs will continue throughout the OU-3 RI/FS process as more information is developed. In addition to the ARARs and TBCs described below, the work described in this RI/FS Work Plan will be completed in general accordance with the NCP (40 CFR Part 300).

A detailed discussion of ARARs was included in the OU-1 Final Feasibility Study (FFS) and modifications and an addendum to the approved FFS per the USEPA letter, dated February 5, 2018, and the OU-1 ROD Amendment (EMSI 2018b; USEPA 2018b). Since OU-3 consists of the groundwater at, or surrounding the West Lake Landfill site, which includes OU-1 and OU-2, the previously identified ARARs were used as a starting point for identifying OU-3 ARARs. Potential chemical-specific and location-specific ARARs and TBCs were also identified based upon a review of available data. Potential action-specific ARARs and TBCs will be based on the remedial action alternatives to be developed in the OU-3 FS.

The ARARs and TBCs are divided into three categories: chemical-specific, action-specific, and location-specific:

- Chemical-Specific ARARs are typically health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, are expressed as numerical values. The values represent cleanup standards (e.g., the acceptable concentration of a chemical at the site). A list of preliminary chemical-specific ARARs for OU-3 is presented in Table 3-6.
- Action-Specific ARARs are generally technology- or activity-based requirements or limitations on actions or conditions taken with respect to hazardous substances on the site. Action-specific ARARs do not typically determine the remedial alternative; however, the ARARs indicate how a selected alternative must be implemented or achieved. A list of preliminary action-specific ARARs for OU-3 is presented in Table 3-7.
- Location-Specific ARARs are restrictions on the concentrations of hazardous substances or the conduct of activities in certain locations. A list of preliminary location-specific ARARs is presented in Table 3-8.

4.0 RI/FS RATIONALE

The RI/FS is designed to collect sufficient data to meet the objectives outlined in the *OU-3 ASAOC SOW* (USEPA 2019a):

- Refine the current understanding of the hydrogeologic system.
- Evaluate background groundwater quality near the site.
- Determine the extent of groundwater impacts occurring at, and near the site.
- Develop predictive tools, such as models to evaluate potential future impacts.
- Identify potential groundwater remedies that could be implemented at the site.

The entire scope of the RI/FS cannot be defined at this stage due to the existing data gaps presented in Section 2.5. Therefore, a phased and iterative approach will be implemented to guide decisions as the RI/FS progresses. To begin addressing the data gaps, this RI/FS will build upon the existing dataset and CSM through expansion of the study area installation of off-site wells and staff gauges, and enhancing the on-site well network. The data collected during the RI will be used to characterize the groundwater quality, refine the conceptual site model, conduct a baseline risk assessment, and support the development of a groundwater model. Then, based on the results of these evaluations, additional tasks will be recommended to the USEPA for their approval to continue to fill data gaps as necessary.

4.1 DESCRIPTION OF THE PROBLEM

As noted in Section 3.1.1 of the QAPP, the following problem statement has been developed for the OU-3 RI/FS:

> Petroleum hydrocarbons, VOCs, trace metals, trace anions, and various radionuclides have been detected in groundwater at the site. The nature and extent of site-related impacts to groundwater, indoor air, and groundwater-related impacts to surface water and sediment are unknown. An improved understanding of the nature, extent, and source(s) of groundwater contamination at the site, and the mechanisms of contaminant migration, will be used to:
>
> 1) Assess the potential for site-related contamination to migrate beyond site boundaries into critical exposure pathways,
> 2) Determine the current and predicted future risks posed to human health and the environment, and
> 3) Develop potential groundwater remedies as necessary.

4.2 RI/FS APPROACH

To address the problem stated above and build the rationale for the RI/FS, the following PSQs were developed:

1. Are COPCs present in groundwater above screening levels?
2. What is the vertical and horizontal spatial distribution of COPCs that exceed screening levels in groundwater?
3. Are the COPCs site-related?
4. What are the sources of site-related COPCs in groundwater?
5. Where will COPCs migrate in the future?
6. Are exposure pathways complete or will they be complete in the future?
7. What are the current and predicted future exposure point concentrations?
8. Is a remedy warranted?

The seven-step DQO process was applied to PSQ-1 through PSQ-5 in the QAPP, which is consistent with USEPA's *Guidance on Systematic Planning Using the Data Quality Objective Process* and used to identify the types of information needed to answer each question (USEPA 2006). The seven-step process will also be applied to PSQ-6 through PSQ-8 after the completion of the initial field activities, which are required to fill the most important data gaps. The resulting answers to PSQ-1 through PSQ-5 will be used to complete the DQO process for PSQ-6 through PSQ-8. The DQO process is iterative and flexible; therefore, the DQOs will be refined as the RI process progresses and throughout the phases of work.

4.3 PHASES OF WORK

This RI/FS is designed to collect the data necessary to sufficiently answer both the initial and subsequent PSQs and to meet the objectives identified in the *OU-3 ASAOC SOW* (USEPA 2019a). Due the existing data gaps, sufficient information is not currently available to specify the detailed scope of work for certain activities that may ultimately be required to achieve the overall objectives of the RI/FS. Therefore, it is proposed the RI/FS will proceed in a phased and focused manner that builds upon data as they are collected and supports informed decision making. Note the discussed phasing speaks more to actual sequencing of work tasks within the overall SOW, and is not intended to represent stops or discontinuities in implementation. Data will be continuously be evaluated to streamline the approval of additional scope. This approach is consistent with the November 2018 USEPA guidance on Smart Scoping at CERCLA Sites *Technical Guides to Streamline Site Cleanup: Smart Scoping, Strategic Sampling and Data Management Best Practices* (Office of Land and Emergency Management Directive 9200.1-164), which encourages the use of adaptive management, focused scoping, and the use of communication tools.

For the West Lake Landfill OU-3 RI/FS, the phased approach is intended to:

- Fast-track the initial tasks
- Prioritize the installation of high priority off-site monitoring wells and the collection of water level data to assess the hydraulic gradient and direction of groundwater flow
- Identify COPCs present that exceed screening levels
- Allow for rapid determination of the presence of COPCs offsite

Results from the initial sequence of work will be used to refine the scope of subsequent work activities (such as locations of additional wells) to achieve the objectives of the RI. All subsequent work scope modifications will be submitted to USEPA and MDNR for their review, comment, and approval prior to implementation. The following sequencing is proposed as per the April 8, 2020 *Response to Comments* submittal to the USEPA (Trihydro 2020). Details on the scope of work for these tasks and field procedures for these tasks are included in Section 5.4 and in the FSP, respectively.

Several tasks are proposed to be performed on an expedited basis prior to final approval of the OU-3 RI/FS Work Plan based on the procedures noted in the November 12, 2019 *Draft Final RI/FS Work Plan* documents, as amended by the April 8, 2020 submittal (Trihydro 2020):

a. Complete Well Inventory Field Work

b. Prepare Well Inventory Summary Report

c. Initiate the collection of groundwater level data

f. Prepare access agreements

g. Install staff gauge and initiate surface water level data collection

Progress on these five initial tasks will be reported to the USEPA through routine monthly reports, routine teleconferences and meetings, and through the use of a project-specific GIS webpage with real-time data management capabilities.

Upon RI/FS Work Plan approval by the USEPA, these three Phase I field tasks will be completed, which are described in detail in Section 5.0:

- Complete indoor air testing

- Install 65 Phase I monitoring wells
- Sample groundwater

Progress on these Phase I tasks will be reported to the USEPA through the same tools noted above for the initial tasks. The need for additional scope or interim action will be evaluated on an ongoing basis. When appropriate, addenda for scope modification to the project planning documents will be submitted to the USEPA for approval.

Data obtained in the Phase I Field Tasks will be evaluated according to the Data Quality Objectives in Section 3.0 of the QAPP and with consideration for the overall objectives of the investigation. The initial data will be reviewed to evaluate whether the scope of work for the following proposed activities still aligns with the overall investigation objectives as specified in the Work Plan documents. If changes are warranted, recommendations for modifications to the Work Plan will be promptly presented to USEPA for their consideration and approval prior to implementation. At this point, the Phase II activities are anticipated to include the following tasks, which are described in detail in Section 5.0:

- Install 13 Phase II wells
- Install 4 Phase II piezometers

Lastly, due to existing data gaps, sufficient information is not currently available to specify the detailed scope of work for certain activities that may ultimately be required to achieve the overall Work Plan objectives. Specific Work Plan addenda will be prepared for each supplemental investigation step during the course of the ongoing field mobilization and promptly presented to USEPA for their input and final approval. Addenda documents will be prepared in general accordance with the parent Work Plan and reference the guidance documents contained therein (i.e., QAPP, FSP, etc.). DQOs will be developed for the addenda as needed. Topics that will be addressed in addenda include, but are not limited to:

- Gauging/sampling of third-party off-site wells
- Step-in and step-out wells
- Sampling to support the vapor intrusion evaluation
- Sediment pore water/sediment/surface water sampling
- Screening Level Risk Assessment (SLERA)

A more detailed description of the content of the addenda is included in Section 9.2.

In sum, the data needs for both Phase I and II are specified in the OU-3 RI/FS Work Plan, FSP, and QAPP for USEPA review and approval with the understanding that Phase II tasks may be subject to subsequent revision based on the results of Phase I, and implementation of scope of work in approved addenda may be performed concurrent with Phase I and II activities pending USEPA approval of the addenda. Note that the goal is to complete Phase I, Phase II, and addenda work scope in a continuous manner. As stated previously, this will be accomplished by continuous data evaluation with recommendations for Work Plan modification presented to USEPA for review and approval.

4.4 DATA INPUTS

Data inputs for PSQ-1 through PSQ-5 were developed to confirm the data collected would meet the objectives of the RI/FS and answer all of the PSQs. Data inputs as they relate to specific PSQs are presented in QAPP Table 3-1. Site characterization activities are designed to collect the inputs required to achieve the objectives of this investigation.

5.0 SITE CHARACTERIZATION

The OU-3 site characterization activities are designed to supplement the existing dataset through the collection of additional data to sufficiently characterize the nature and extent of hazardous substance impacts to groundwater and their potential risk posed to human health and the environment. The resulting data will be used to answer the PSQs outlined in Section 4.0. This Work Plan includes the site characterization activities currently planned, and the work will proceed in a phased manner until the PSQs are adequately answered. Certain site characterization tasks have been prioritized for expedited completion during Phase I.

Using the data from Phase I activities, the scope of work for Phase II proposed activities will be reviewed to confirm if the scope of work still aligns with the overall investigation objectives as specified in the Work Plan documents. If changes are deemed appropriate, recommendations for Work Plan modification will be promptly presented to USEPA in Work Plan addenda for consideration and approval prior to implementation.

The following site characterization tasks have been initiated and/or will be completed to address the data gaps outlined in Section 2.5 and meet the objectives of the RI/FS process:

- Compile quantitative data and information pertaining to existing surface water features, geology, hydrogeology, geochemistry, property access conditions, and the proximity of potential receptors to known or potential contaminants.
- Determine adequacy, usability and status of existing monitoring wells and their associated data, and the usability of data from on-site/near-site abandoned monitoring wells. Install additional monitoring wells/piezometers, as needed.
- Collect continuous cores at select new locations (grain size, minerology, organic carbon content).
- Apply borehole geophysical methods in areas sufficiently far from the site to provide a more complete characterization of the alluvial aquifer and bedrock formations as necessary.
- Conduct aquifer testing in areas sufficiently far from the site to better understand flow characteristics and vertical hydrogeological aspects to minimize model boundary effects of estimated aquifer information.
- Gauge/sample wells periodically and measure certain groundwater and surface water levels continuously.
- Collect and analyze field data to assist in the evaluation of potential groundwater remedies.
- Determine background radionuclide and other contaminant concentrations in aquifers located beneath, and near, the site.

- Prepare a geologic modeling database and perform groundwater modeling.
- Assess whether information related to current and potential receptors is sufficient to determine if exposure pathways identified in the *OU-1 RIA* are fully complete.
- Complete a detailed well survey and gather any additional data needed to complete the human health and ecological risk assessments for OU-3.

Samples will be collected and analyzed in accordance with this Work Plan, related documents, and appropriate USEPA methods and test procedures unless otherwise noted based on actual field conditions pending approval by USEPA. Site characterization will be conducted in accordance with the SAP.

5.1 SAMPLING AND ANALYSIS PLAN

The SAP consists of the FSP and a QAPP, which have been prepared for the OU-3 RI/FS. The SAP is included in this submittal as Volume 2. Work conducted as part of the site characterization will follow the SAP. The SAP includes standard operating procedures (SOPs) and other relevant information needed to properly document and to conduct the work in a safe and efficient manner to achieve the goals of the project.

5.1.1 FIELD SAMPLING PLAN

The FSP specifies the needed activities to collect and obtain field data. The plan explains the additional data required to adequately characterize subsurface conditions including, but not limited to, vertical or horizontal flow, extent of COPCs, background levels of contaminants and naturally-occurring materials to support evaluations conducted in the OU-3 BRA, and as warranted to support the evaluation of remedial technologies. The FSP includes:

- Sampling objectives
- Sampling methods and equipment
- Anticipated sample types, locations, and frequency
- Project field schedule
- Deliverable schedule

General requirements regarding site access and related site control measures are defined in the FSP.

5.1.2 QUALITY ASSURANCE PROJECT PLAN

The QAPP addresses the types of investigations and analysis that will be conducted and includes the following discussions:

1. A project description (duplicated from this Work Plan).
2. A project organization chart illustrating the lines of responsibility of the personnel involved in the various phases of the project.
3. DQOs in accordance with the seven-step process.
4. Quality assurance objectives for data, such as the required precision and accuracy, completeness of data, representativeness of data, comparability of data, sensitivity, and the intended types and use of the collected data.
5. The type and frequency of calibration procedures for both field and laboratory instruments, internal quality control checks, and supporting quality assurance performance audits and system audits.
6. Preventative maintenance procedures and schedule, and corrective action procedures for field and laboratory instruments.
7. Specific procedures to assess data precision, representativeness, comparability, accuracy, completeness, and sensitivity of specific measurement parameters.
8. Data documentation, reporting, validation, and tracking procedures.

5.2 COMPILE EXISTING DATA

Publicly available records on the USEPA website and databases maintained by the OU-1 and OU-2 consultants that included historical groundwater data, reports, and correspondence pertinent to OU-3 were searched and reviewed during the RI/FS planning phase as outlined in Section 2.0. Existing spatial and temporal hydrogeologic, geochemical, and analytical data were digitized as needed and the data were compiled to refine the current understanding of the hydrogeologic system, prepare the preliminary CSM (Section 3.0), and scope the OU-3 RI/FS.

Digitized data included:

- Alluvial and bedrock borehole logs for monitoring wells
- Bedrock discontinuity data
- Monitoring well construction diagrams
- Aquifer testing results

- Stabilized groundwater monitoring field parameters
- Groundwater elevations
- Surface water elevations.

This information was incorporated into a 3-D data visualization tool and a USEPA-accessible database. The investigation data will be managed in accordance with the SAP.

5.2.1 RECORDS REVIEW AND OFFSITE WELL INVENTORY

Additional records will be reviewed to refine the CSM as the RI/FS progresses. Additional records include Environmental Data Resources database reports and historical local and regional studies on OU-1, OU-2, and groundwater and vapor by local, MDNR, federal, and private parties within the preliminary groundwater modeling domain shown on Figure 3-17.

An offsite well inventory will also be completed. The MDNR will be contacted directly to obtain available information for older wells. Utility records will be reviewed for buildings without water connections. Visual assessments and drive-arounds will also be conducted to document potential receptors near the site. The USEPA-accessible database will be updated as new data become available. Data management and evaluation are discussed in more detail in Section 6.0 of this Work Plan. Findings of the evaluation and the refined CSM will be presented in the Annual Hydrogeologic Investigation and Groundwater Characterization Report.

5.3 PROPOSED MONITORING WELL NETWORK

Existing and new on-site groundwater data will be used to support this OU-3 RI/FS. A preliminary well inventory was conducted to confirm the status of existing monitoring wells. This information was incorporated into the 3-D site visualization to evaluate which alluvial zones on-site monitoring wells are screened in, where groundwater impacts exist, and to understand where additional monitoring wells are needed. The regional and local wells listed in the preliminary CSM were used to propose on-site, near-site, off-site, and background monitoring well locations.

5.3.1 EXISTING MONITORING WELL NETWORK

A preliminary monitoring well inventory was conducted on several of the inactive monitoring wells not included in the active Bridgeton Landfill groundwater monitoring well network during a site walkover on April 17, 2018. The purpose of the preliminary monitoring well inventory was to update the monitoring well status and to understand the available, existing monitoring well network. Inactive monitoring wells visited were photographed, and depth to water, well construction, and total depth were recorded as shown on Table 5-1. Photo-documentation is included in Appendix W.

Current monitoring well status is shown on Figure 5-1. A total of 80 existing wells will be included in the OU-3 monitoring well network, which includes 78 wells associated with the site and 2 wells installed by the MDNR near the site. The existing wells include 50 wells in the current Bridgeton Landfill monitoring program and 30 wells not routinely sampled. The complete monitoring well inventory (preliminary and proposed inventories) will be documented in the Well Inventory Summary Report as described in Section 9.1.

5.3.2 PROPOSED NEW MONITORING WELL NETWORK

The installation of new monitoring wells will address the PSQs presented in Section 4.0 and the data gaps outlined in the *OU-3 ASAOC SOW* (USEPA 2019a). Well designations are based on location and screened interval. In general, the proposed well network embodies a more regional evaluation of groundwater near the site. Historical investigations focused almost entirely on areas within the site boundary but have not defined the potential horizontal and vertical extent of impacts on groundwater quality. Additionally, the existing network did not provide adequate data to make a clear determination of background groundwater conditions upgradient or laterally away from the site. Locations and rationale for each location are discussed in the following sections.

5.3.2.1 MONITORING WELL DESIGNATIONS

Monitoring well nomenclature is generally consistent with that used in the past and consists of reference to a well series and a monitoring zone. New monitoring wells will be identified using the “MW” prefix. Series will be designated based on proximity to site features as described below:

- 100 Series – Adjacent to the Bridgeton Landfill
- 200 Series – Within 500 feet of the Bridgeton Landfill
- 300 Series – Adjacent to the Inactive Sanitary Landfill
- 400 Series – Within 350 feet of Area 2
- 500 Series – Offsite and potentially downgradient
- 600 Series – Background

New water level piezometers will be identified using the "PZ" prefix. The 700 Series piezometers represent supplemental groundwater level measurement points at locations distant from the site, which are not anticipated to be impacted by COPCs.

The groundwater monitoring zones are dependent on the hydrogeologic characteristics of the alluvium or bedrock and the vertical location the screened interval intersects. Alluvial monitoring zones are:

- AS – Shallow Alluvium: screened across or near the water table above 415 ft msl in the fine-grained shallow alluvium.
- AI – Intermediate Alluvium: generally screened within elevations of approximately 385 to 415 ft msl across intermediate alluvial fine to coarse sand between the shallow alluvium and deep alluvium.
- AD – Deep Alluvium: generally screened within elevations of approximately 330 to 385 ft msl across alluvial coarse sand to coarse gravel near the alluvium bedrock interface.

Bedrock monitoring zones are:

- SS – St. Louis Formation/Upper Salem Formation
- SD – Salem Formation
- KS – Keokuk Formation

No additional Keokuk Formation monitoring wells are proposed during the initial site characterization activities. Four Keokuk Formation monitoring wells that surround the South Quarry, which is part of the Bridgeton Landfill groundwater monitoring program. Historical groundwater quality data from these wells show that impacts do not appear to have migrated through the Warsaw Formation aquitard into the Keokuk Formation. Groundwater monitoring of the Warsaw Formation aquitard is not proposed.

Descriptions of the proposed monitoring wells are provided in the subsequent subsections. With respect to the phasing of monitoring well installation, Phase I will include installation of 65 high priority wells, beginning with the 500-series off-site alluvial wells (AS, AI, AD) (18 wells), then the 200-, 300-, and 400-series on-site wells along the perimeter of the site (30 wells), and then the 600-series off-site background wells (17 wells).

Phase II will include 8 off-site bedrock, 5 select on-site wells, and 4 off-site piezometers. The scope of work for Phase II will be reevaluated based on initial results obtained from the Phase I monitoring wells, but is currently anticipated to include the 500-series bedrock wells (SS and SD) (8 wells), wells MW-111 (AS, AI, AD), well

MW-113-SD, and well MW-205-SD. The location of these wells may change based on the initial Phase I well sampling. Phase II will also include the installation of four piezometers (PZ-700-series).

5.3.2.2 PROPOSED OFF-SITE MONITORING WELL LOCATIONS AND RATIONALE

There are currently no off-site monitoring wells beyond 350 feet of the property boundary. To characterize off-site groundwater quality, new off-site wells will be installed to the west and north as show in Figure 5-3. Six off-site monitoring locations will be installed that include 26 total wells: MW-500 (5 wells), MW-501 (5 wells), MW-502 (5 wells), MW-503 (3 wells), MW-504 (3 wells), and MW-505 (5 wells). The proposed off-site well locations were also selected based on the ability to physically access the areas with drilling equipment, and the likely success in securing access agreements with the current property owner(s). Off-site monitoring well locations remain subject to securing access agreements with individual property owners. In the event access issues prevent installation in a proposed location, Respondents will either propose an alternate location or seek assistance from USEPA in securing access at the subject property.

An evaluation of existing potentiometric data and groundwater velocities suggests the proposed locations are appropriate to evaluate the nature and extent of COPC impacts. Alluvial and bedrock wells at these locations will help to evaluate the extent of off-site impacts, regional groundwater flow, and response to influence of the Missouri River in addition to the data gaps outlined in Section 2.5.

In addition to defining downgradient extent of impacts, off-site monitoring wells are proposed to evaluate off-site: (a) aquifer properties; (b) localized hydraulic gradients and flow directions within and between the alluvial aquifer and bedrock aquifer system; (c) the occurrence and extent of groundwater impacts; (d) groundwater geochemistry; (e) potential effects of the Bridgeton Landfill-related infrastructure on groundwater; (f) temporal variability in groundwater levels and flow direction; (g) and effects of nearby surface water features and storm events. Specific rationale for the proposed locations and selected screen intervals is presented in Table 5-2.

The proposed Phase I monitoring well series will be comprised of three alluvial wells at each of the off-site locations, including shallow alluvial, intermediate alluvial, and deep alluvial wells. Off-site Upper Salem/St. Louis Formation (if encountered) and Salem Formation wells at the MW-500, MW-501, MW-502, and MW-505 locations are proposed to be installed during Phase II such that their need and locations can be reevaluated based on the findings of Phase I drilling, the results of initial groundwater sampling of the 500-series alluvial wells, and sampling of the existing in Phase I. Groundwater concentrations from these wells will be used to inform decisions on placement of additional (step-in/step-out) 500-series wells as summarized in Section 5.3.2.5.

5.3.2.3 PROPOSED ON-SITE / NEAR-SITE MONITORING WELL LOCATIONS AND RATIONALE

A total of 13 new on-site/near-site well locations are proposed to be installed as part of the OU-3 RI as shown on Figure 5-2, including 30 Phase I wells and 5 Phase II wells. The rationale behind the location and anticipated depth of screened intervals is presented in Table 5-2. A brief discussion of each proposed on-site and near-site monitoring well series is provided below.

Phase I Wells:

MW-213-AS and MW-213-AD – This series includes two wells: one shallow alluvial well (MW-213-AS) and one deep alluvial well (MW-213-AD). The MW-213 series wells will be installed adjacent to existing intermediate alluvial well I-67, which has had documented historical landfill leachate effects, including chloride, bromide, and boron. No shallow alluvial or deep alluvial wells currently exist at this location and these wells will complete the alluvial series. The two wells installed at this location will provide additional information on the extent of groundwater impacts.

MW-302-AD – One deep alluvial well (MW-302-AD) is proposed adjacent to intermediate alluvial well PZ-302-AI to assess contaminant migration in the deeper more permeable alluvium. These wells will complete an alluvial cluster with monitoring well S-53. This well will provide additional information on the potential effects of the Bridgeton Landfill pumping system.

MW-303-AI and MW-303-AD – This series includes two wells: one intermediate alluvial well (MW-303-AI) and one deep alluvial well (MW-303-AD). The MW-303 series wells will be installed adjacent to existing shallow alluvial well PZ-303-AS, where landfill leachate effects have been documented historically. These two wells will complete an alluvial cluster with well PZ-303-AS. Wells installed at this location will provide additional information on the potential effects caused by the Bridgeton Landfill.

MW-304-AD, MW-304-SS, MW-304-SD – This series includes three wells: one deep alluvial well (MW-304-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-304-SS), and one Salem Formation well (MW-304-SD). The MW-304 well series will be installed adjacent to existing wells PZ-304-AS and PZ-304-AI. There are no deep alluvial or bedrock wells at this location. Wells installed at this location will provide additional information to evaluate potential impacts related to the Inactive Sanitary Landfill, and to evaluate the potential effects caused by the Bridgeton Landfill. An evaluation of existing potentiometric data suggests this MW-304 series may also occasionally be downgradient of Area 1.

MW-306-AI and MW-306-AD – This series includes two wells: one intermediate alluvial well (MW-306-AI) and one deep alluvial well (MW-306-AD). The MW-306 series wells will be installed adjacent to existing shallow alluvial well MW-103. These wells will complete an alluvial cluster with well MW-103. Wells installed at this location will provide additional information on the occurrence and extent of groundwater impacts.

MW-400-AS, MW-400-AI, MW-400-AD, MW-400-SS, MW-400-SD – This series includes five wells: one shallow alluvial (MW-400-AS), one intermediate alluvial well (MW-400-AI), one deep alluvial well (MW-400-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-400-SS), and one Salem Formation well (MW-400-SD). The MW-400 series will be installed near deep alluvial well D-6, which may be abandoned during OU-1 remedy implementation and former shallow alluvial well S-1 and I-2 that were destroyed by grading work performed by AAA Trailer. The actual location of the MW-400 series will be determined based on results of the hydraulic profiling tool (HPT) pilot test as discussed in Section 5.4.5. Installation of the MW-400 series remains subject to access agreements with AAA Trailer and/or remedy design in this area (i.e. potential stormwater basin).

MW-401-AS, MW-401-AI, MW-401-AD, MW-401-SS, MW-401-SD – This series includes five wells: one shallow alluvial (MW-401-AS), one intermediate alluvial well (MW-401-AI), one deep alluvial well (MW-401-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-401-SS), and one Salem Formation well (MW-401-SD). The MW-401 series will be installed near alluvial wells S-8, I-62, and D-83, which will likely be abandoned during OU-1 remedy implementation. The MW-401 series is downgradient of Area 2. Potentiometric and water quality data for bedrock are not currently available from this area. Installation of the MW-401 series remains subject to access agreements with AAA Trailer.

MW-402-AS, MW-402-AI, MW-402-AD, MW-402-SS, MW-402-SD – This series includes five wells: one shallow alluvial well (MW-402-AS), one intermediate alluvial well (MW-402-AI), one deep alluvial well (MW-402-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-402-SS), and one Salem Formation well (MW-402-SD). The MW-402 series will be installed near alluvial wells D-13 and I-66, which likely will be abandoned during the OU-1 remedy implementation. The MW-402 series location may be downgradient of Area 1. Potentiometric and water quality data for bedrock are not available at this location.

MW-403-AS, MW-403-AI, MW-403-AD – This series includes three wells: one shallow alluvial well (MW-403-AS), one intermediate alluvial well (MW-403-AI), and one deep alluvial well (MW-403-AD). The MW-403 series will be installed near intermediate alluvial well I-65, which may be abandoned during OU-1 remedy implementation.

<u>MW-404-SS, MW-404-SD</u> – This series includes two wells: one Upper Salem/St. Louis Formation (if encountered) well (MW-404-SS), and one Salem Formation well (MW-404-SD). These wells will be installed near alluvial wells S-82, I-9, and D-93 in an area beyond the footprint of proposed OU-1 remedy implementation. Elevated chloride concentrations are present in nearby deep alluvial well D-93.

<u>Phase II Wells</u>:

<u>MW-111-AS, MW-111-AI, MW-111-AD</u> – This series includes three wells: one shallow alluvial (MW-111-AS), one intermediate alluvial well (MW-111-AI), and one deep alluvial well (MW-111-AD). The MW-111 series will be installed adjacent to the west side of Area 1, east of the asphalt plant, and adjacent to the PZ-111 bedrock series wells. Potentiometric and water quality data for both the alluvium are not currently available at this location. Alluvial wells at this location will also help to identify and potential impacts to groundwater that may result from implementation of the OU-1 remedy and provide for long-term monitoring of the effectiveness of the OU-1 remedy relative to groundwater.

<u>MW-113-SD</u> – One Salem Formation well (MW-113-SD) will be installed in close proximity to the PZ-113 series. No Salem Formation wells currently exist at this location. This well will help define the Salem Formation potentiometric surface in this area.

<u>MW-205-SD</u> – One Salem Formation well (MW-205-SD) will be installed near PZ-205-AS and PZ-205-SS. No Salem Formation wells currently exist at this location. This well will help define the Salem Formation potentiometric surface in this area.

5.3.2.4 PROPOSED BACKGROUND MONITORING WELL LOCATIONS AND RATIONALE

An understanding of natural background groundwater quality is an important and necessary component of this OU-3 groundwater study. Background monitoring wells are pertinent to PSQ-3, which addresses whether the COPCs are site related. The USGS attempted to establish natural background groundwater quality, but concluded that the existing data set was not sufficient (USGS 2015). Regional potentiometric data for both the alluvium and the bedrock at the site suggest a down-valley component of groundwater flow direction. Therefore, newly-installed background wells will be installed to the southwest, south, southeast, and east of the site.

Establishing natural background groundwater quality requires the collection of "near-site" data that are representative of the aquifer. The locations of wells used by the USGS, along with regional groundwater flow in the alluvial and bedrock aquifers, were evaluated to select locations for additional background monitoring wells. Six locations are proposed for new background monitoring wells as shown on Figure 5-4a.

The rationale behind the proposed background well locations and depth of screened intervals is shown on Table 5-2. A statistical evaluation will be completed on the current and new datasets after the first year of monitoring to evaluate whether the number of background samples and/or background well locations is sufficient to adequately characterize natural background water quality.

Two background monitoring well series, MW-600 and MW-601, will be installed to the southwest of the site, and will each include three alluvial wells: shallow alluvial, intermediate alluvial, and deep alluvial. An evaluation of existing potentiometric data suggests these locations may be upgradient of the site. Alluvial wells at these locations will help to establish background conditions and to help evaluate regional groundwater flow directions.

The proposed background monitoring well series MW-602 will be located southwest of the site and includes five wells: shallow alluvial, intermediate alluvial, deep alluvial, Upper Salem/St. Louis Formation (if encountered), and the Salem Formation. An evaluation of existing potentiometric data suggests this location may befree of landfill-related impacts. Alluvial and bedrock wells at these locations will help to establish background conditions and to help evaluate regional groundwater flow directions.

The proposed background monitoring well series MW-603, MW-604, and MW-605 will be located east, southeast, and south of the site and will include two bedrock wells at each location: Upper Salem/St. Louis Formation and Salem Formation. Alluvial deposits are not expected to be present at these locations, and therefore no alluvial monitoring wells are proposed for these locations. An evaluation of existing potentiometric data suggests these locations are upgradient of the site. Bedrock wells at these locations will help to establish background conditions and to help evaluate regional groundwater flow directions.

The 600-series wells will be used to calculate natural background groundwater conditions, as described in the QAPP Section 4.2.7. It is acknowledged that due to the regional presence of anthropogenic groundwater impacts, groundwater quality in some of the 600-series monitoring wells could be affected by off-site sources, such as those shown on Figure 5-4b, or others not yet identified. A list of the MDNR registered environmental sites in the area are listed on Table 5-3. Groundwater geochemistry, COPC concentrations, and statistics will be used on an ongoing basis to evaluate whether COPC data from 600-series monitoring wells are appropriately representative to be used to establish natural background groundwater quality in accordance with Section 4.2.7 of the QAPP. Additional 600-series monitoring wells will be proposed in an addendum if the data quality objectives for determination of natural background cannot be met with the proposed network.

5.3.2.5 STEP-IN AND STEP-OUT MONITORING WELLS

The data collected from the 500-series wells will be used to inform placement of future 500-series off-site monitoring wells. The need for additional wells will be assessed throughout the monitoring program and addenda with their proposed locations will be submitted for USEPA review and approval. Distances for stepping in and stepping out with additional 500-series wells cannot be predetermined, since the variety of potential investigation results cannot be anticipated. However, the following guidelines will be used to determining the next 500-series wells:

- An additional step-out well will be installed downgradient of a 500-series well with COPC impacts above current USEPA Regional Screening Levels (RSLs), or the calculated background for radium.
- An additional well will be installed between 500-series wells if they are downgradient of the site, have impacts that may be attributable to the site, and do not appear to have adequate spacing between them.
- Additional step-in wells will be installed between selected 500-series wells and the site if the 500-series well is downgradient and has no impacts attributable to the site, but there are impacts at the property perimeter upgradient of the well. This is subject to property access being granted by third parties and subject to the physical limitations (i.e. presence of ponds).

Step-in and step-out 500-series wells will be installed in Phase II pending approval from USEPA if results from Phase I suggest the need to install additional wells. As discussed in Section 5.3.2.2, the off-site 500-series bedrock monitoring well locations will be reevaluated after Phase I monitoring wells have been installed. No bedrock wells currently exist along the western and northern property boundaries. The site perimeter bedrock wells will be installed during Phase I will help inform the placement of these wells. Locations for 500-series wells are limited by accessibility and drill crew safety considerations.

The scope for step-in and step-out well locations will be presented to USEPA as a brief letter and figure addendum to this Work Plan to facilitate a rapid review and approval. The timing of the Work Plan addenda is discussed in Section 9.2.

5.3.2.6 PROPOSED PIEZOMETERS

In addition to 78 new monitoring wells, four shallow alluvial piezometers will be installed near the groundwater model domain boundaries to support the groundwater modeling. Proposed piezometer locations are shown on Figure 5-4b.

These piezometers will be installed in Phase II if the well inventory in Section 5.2.1 does not identify wells already installed and available for this purpose.

Registered sites shown on Figure 5-4b will be evaluated to determine whether existing monitoring wells are present and accessible. The piezometers will be constructed using the same procedures as shallow alluvial wells and used for water level gauging to calibrate the groundwater model. They will be identified using the "PZ" prefix and will be designated a part of the 700-series.

5.3.3 ADEQUACY OF MONITORING WELL NETWORK

As discussed in Section 5.3.1, a total of 80 existing monitoring wells were identified for inclusion in the proposed OU-3 monitoring well network, in addition to the 65 Phase I proposed new wells and 13 potential Phase II monitoring wells noted above in Section 5.3.2 as shown on Figure 5-5a. Piezometers are not included as part of the monitoring well network, since they are not included in routine sampling. A description of the proposed monitoring well network is included as Table 5-4. The network will be used to monitor site conditions under a routine frequency, which is discussed in Section 5.4.15, until the investigation is complete and, as warranted, until a remedial action is selected and implemented at the site.

The proposed monitoring program is preliminary and subject to access agreements. It is likely that additional monitoring wells will be installed to fill the data gaps listed in the *OU-3 ASAOC SOW* and answer the PSQs. It is also possible that several existing monitoring wells can be removed from the monitoring network in the future. Thus, the monitoring network will be modified in collaboration with USEPA and with USEPA approval as site characterization activities continue over time.

The proposed groundwater monitoring network is comprised of 162 total wells, including 80 existing wells, 78 proposed new wells, and 4 piezometers. Coverage of the monitoring well network by hydrogeologic zone is shown on Figure 5-5b through Figure 5-5f. Coverage of the piezometers with respect to the modeling domain is shown on Figure 5-5g. Additional monitoring wells may be added if OU-1 activities result in the need for well replacement. However, the proposed well list was created in coordination with OU-1 to provide sufficient monitoring well network coverage and reflects both wells that are currently expected to be abandoned as outlined in Section 5.3.2.3 and wells that are expected to remain in place following OU-1 remedial activities.

5.3.4 PROPOSED STAFF GAUGES

Eight staff gauges will be installed to evaluate the temporal and spatial variability in groundwater levels and flow direction in response to potential influences of the Missouri River, impounded water, and other nearby surface water bodies. The proposed staff gauges are shown on Figure 5-6. The staff gauges will be installed and continuously monitored. Missouri River stage data will be downloaded from the USGS. Installation of the staff gauges is subject to securing access agreements with off-site property owners.

Two staff gauges equipped with transducers and telemetry already exist in the Earth City ponds and are used to operate pumps that maintain a constant elevation in the ponds. These will be evaluated as replacements to the staff gauges proposed in the Earth City ponds if access to the data is granted and they meet the requirements in the QAPP.

5.4 FIELD INVESTIGATION

The field investigation has been designed to determine, along with other objectives, if site COPCs in groundwater have migrated beyond the site boundaries at concentrations exceeding risk-based screening levels or USEPA MCLs. Per the specifications of this Work Plan, the FSP, and the QAPP, the field investigation will include monitoring well installation, downhole geophysics, staff gauge installation, groundwater sampling, aquifer matrix sampling, leachate sampling, and vapor sampling. The following subsections include a detailed discussion on:

- Preparatory activities
- Site reconnaissance
- Well inventory, repair, replacement, and abandonment
- HPT pilot test
- Drill rig selection
- Continuous coring and field logging
- Alluvium and bedrock aquifer matrix sampling
- Borehole geophysical logging
- Packer testing
- Monitoring well installation
- Monitoring well development
- Slug testing

- Aquifer pumping test
- Groundwater monitoring
- Staff gauge installation
- Leachate collection system sampling
- Vapor intrusion assessment
- Ecological survey
- Surveying and mapping of the investigation areas
- IDW management
- Additional site characterization

Additional information related to well construction diagrams, boring logs, field sampling sheets, and field books will be retained and, as appropriate, included with other data to provide a summary of field activities. Details on the field investigation are included in the FSP (Volume 2). The field work will be prioritized based on the PSQs they are intended to answer.

5.4.1 FIELD INVESTIGATION PHASING

The field investigation is proposed to be completed using a phased, iterative, flexible, and collaborative approach with USEPA that supports changes in scope as new data become available to inform decisions on the placement of additional monitoring wells as discussed in Section 5.0 and collection of additional data to answer the PSQs. Data will be continuously evaluated as they are collected and presented to USEPA, so further phases of work can be implemented efficiently in general accordance with this Work Plan without unnecessary pauses. Phasing of the Work Plan is designed to address the PSQs in a logical fashion that allows for decision making based on the questions that data from the monitoring wells are intended to answer.

The results of Phase I monitoring well installation will be evaluated and used to optimize well placement during Phase II monitoring well installation and characterization activities. This will allow for efficient allocation of resources to answer PSQs and protect human health and the environment. The locations of Phase II monitoring wells may be moved based on new information collected during Phase I to optimize the potential for obtaining relevant data to address certain PSQs. Modifications to the OU-3 RI/FS work scope will be presented to USEPA for review and approval.

5.4.2 PREPARATORY ACTIVITIES

A field schedule for the investigative work will be provided to USEPA and MDNR within 7 days in advance of those activities occurring. Soil boring permits, right-of-way permits, and access agreements will be obtained from property owners prior to finalizing the off-site well locations. The drilling subcontractor will create a Missouri One Call System ticket at least 72 working hours before the start of field activities. This will notify public utilities of the excavation activities in the area. Additionally, a private utility locator will be used to check for other subsurface infrastructure and anomalies at the drilling locations.

5.4.3 SITE RECONNAISSANCE

Reconnaissance activities will be conducted to document the current conditions of the site and the on- and off-site proposed drilling locations. Field personnel and subcontractors will inspect and photo-document the site and proposed monitoring well locations to identify any potential issues with either access or utilities. A handheld global positioning system (GPS) will be used to survey proposed locations. Additional detail on site reconnaissance is provided Section 3.1 of the FSP.

5.4.4 WELL INVENTORY, REPAIR, REPLACEMENT, AND ABANDONMENT

A full monitoring well inventory will be conducted to review the existing monitoring well network and to re-survey existing well locations. The inventory will document each well's current condition and will include surveying and recording construction details on the existing and new wells in accordance with the procedures described in FSP Section 3.2. A downhole inspection camera will be used in each existing well to evaluate whether screens or riser pipes appear compromised. This information will be compared to the existing well construction summary table (Table 3-2) to evaluate the integrity of the monitoring well. Nearby residential wells, industrial wells, municipal wells, and water intake structures within 2 miles of the site, identified in Section 5.2.1, will also be located during the well inventory to identify any potential receptors. Locations of wells not included in the OU-3 monitoring network will be surveyed using a handheld GPS, recorded on field forms, and photo-documented.

Wells with turbidity over 10 NTU or well screen occlusion greater than 10% of the screened interval will be considered for redevelopment as described in the FSP Section 3.10. Wells that are either damaged or are missing parts will be repaired. Wells with significant damage which prevents gauging or sampling will either be replaced (with the original well properly abandoned), or the location abandoned entirely, as appropriate. The Missouri Well Code will be used to assist with well integrity evaluations, well installation requirements, and well abandonment requirements. Well redevelopment and repair will be completed during the monitoring well inventory. Recommendations for replacement or abandonment will be provided in the Well Inventory Summary Report. Following the USEPA review and approval of this report, wells deemed non-beneficial, damaged beyond repair, or inoperative will be replaced or abandoned according to applicable MDNR requirements.

The well inventory will also identify wells at the site that may potentially be removed due to remedy implementation for OU-1, as well as other potential future site-related work that could impact the overall existing groundwater monitoring well network. Additional detail on the monitoring well inventory, repair, replacement, and abandonment is provided in Section 3.2 of the FSP.

5.4.5 HYDRAULIC PROFILING TOOL PILOT TEST

An HPT pilot test will be performed in the buffer zone to optimize placement of the monitoring well MW-400 cluster at the location with the highest hydraulic conductivity. HPT measures the injection pressure and flow rate of water into soil, providing a continuous vertical estimate of hydraulic conductivity. The HPT pilot test will consist of a transect of four borings near monitoring well D-6 within the buffer zone as shown on Figure 5-7. In addition to selecting the optimum location, HPT results will also be used to select screened intervals for shallow, intermediate, and deep alluvial monitoring wells at the selected location. If the HPT pilot test is not successfully advanced to the top of the deep alluvium, continuous core logs will be used to select the screened intervals in accordance with Section 5.4.11.

5.4.6 DRILL RIG SELECTION

Several drilling techniques were considered for the HPT pilot test and well installation, including direct-push technology (DPT) drilling, cone penetrometer test (CPT) drilling, hollow stem auger drilling, mud rotary drilling, and sonic drilling methods. DPT drilling may not be technically feasible for the OU-3 RI drilling program due to limitations on the achievable depths, the smaller diameter of the borehole, and the inability to drill within gravel and bedrock.

The CPT drilling rig is similar to a DPT drilling rig in that it is hydraulically driven, limited in its achievable depths, and limited to unconsolidated materials. However, CPT uses a larger and heavier drilling rig than a DPT rig, resulting in greater success at pushing through gravel zones and larger borehole diameters. The HPT probe noted in Section 5.4.5 can be driven with either a DPT or CPT rig. CPT drilling rig was selected for the HPT probe assessment work in order to achieve greater drilling depths than the DPT rig.

The hollow stem auger drilling method is potentially feasible but would require a large 14-inch diameter auger to accommodate the proposed well construction, and flowing sands may be encountered that could result in binding of or inability to remove the augers. Lastly, mud rotary drilling was evaluated as technically feasible for achieving the desired depths and borehole diameter, but was eliminated from consideration due to the large volume of IDW generated in comparison to the other drilling methods. Additionally, there are concerns of introducing radionuclides into boreholes through naturally-occurring levels present in some drilling muds.

Sonic drilling will be used to install the monitoring wells. Sonic was chosen to achieve the desired well construction dimensions, reach total depths within bedrock, and provide undisturbed core samples for lithologic logging. In addition, sonic drilling does not generate excessive IDW. Sonic drilling can limit the use of downhole geophysics, which cannot be run within the alluvium due to the presence of the steel casing. Additional detail on borehole advancement is provided in Section 3.5.2 of the FSP.

5.4.7 CONTINUOUS CORING AND FIELD LOGGING

The deepest borehole for each proposed well series will be advanced to total depth at each location. The deepest borehole at each location will be continuous cored, logged by a field geologist, field screened, sampled, and logged using geophysical techniques. Borehole advancement will be performed by an MDNR-certified well installation contractor and drilling company. The geophysical techniques are discussed in Section 5.4.9.

At each drilling site, the soil and bedrock horizons will be continuous cored during advancement of the deepest borehole. Recovered cores will be inspected by a field geologist. Alluvial descriptions will include the Unified Soil Classification System (USCS), color, grain size, stiffness or density, moisture content, sorting, angularity, mineralogy, and plasticity as applicable. Alluvial cores will be labeled and archived onsite for future use.

Bedrock descriptions will include weathering, bedding, color, grain/crystal size, strength, lithologic description, geologic formation, and geologic formation. Bedrock borehole logs will also include core recovery, RQD, fractures per foot, weathering index, strength index, and discontinuity data. Cores will be field screened using a 10.6 eV photoionization detector (PID). Additional detail on continuous coring and field logging is provided in Section 3.5.2 of the FSP. Bedrock cores will be labeled and archived onsite for future use.

5.4.8 ALLUVIUM AND BEDROCK AQUIFER MATRIX SAMPLING

Alluvium (unconsolidated) and bedrock samples will be collected from the water-bearing zones in the deepest borehole at select drilling locations as shown on Figure 5-8a. Saturated alluvium and bedrock samples will be collected approximately every 20-feet. Based on the anticipated thickness of the alluvium and bedrock zones, this sample frequency will generate an estimated 45 alluvial and 73 bedrock samples. Additional alluvial and bedrock samples may be collected as part of subsequent phases of the RI process. Residual soil cores will be saved from each drilling location for potential future analysis.

Samples will be collected in accordance with procedures in Section 3.6.1 and 3.6.2 of the FSP, labeled, properly preserved, and submitted for laboratory analysis. The list of alluvial and bedrock aquifer matrix parameters are listed in Tables 2-2b and 2-2c, respectively of the QAPP. The sample results will be compared to similar work conducted previously in OU-1 for RIM and non-RIM sample matrices from the solid waste mass. They will be evaluated specifically to:

- Obtain data for use in the fate and transport evaluations.
- Identify the chemical composition of materials that contain radionuclides and the speciation of the radionuclides.
- Provide data to parameterize the geochemical fate and transport model.

Additional information regarding the field sampling procedures for evaluating the alluvial and bedrock aquifer matrix is described in Section 3.6 of the FSP. This list of analyses will be run on the alluvium and bedrock matrix samples along with a brief description of the analytical objectives:

- Uranium, thorium, and radium isotopes: The results of these analyses will be used to determine the activity level of the radiological isotopes in the background and down-gradient location samples.
- Major cations and anions (including calcium, magnesium, manganese, sodium, potassium, barium, carbonate, sulfate, fluoride and phosphate): The results of these analyses (conducted on background and downgradient samples) will be used to quantify the presence of cations and anions, assist in determining solid phase mineralogy, and allow for the comparison with radiological isotopes.
- pH: The pH will be used as baseline condition data for comparison with subsequent leaching tests.
- Fe(II) and Fe(III): Examination of contents of ferrous (Fe(II)) and ferric (Fe(III)) iron to total iron in a sample will be used as an indicator of the oxidizing-reducing conditions to which the solid phase materials have been exposed, or under which were formed. The presence of Fe(III), as measured by amorphous-iron results, is an indicator presence of ferric iron oxides, which are strong sorbents/coprecipitates for radiological constituents. Also, microbial degradation of organic matter in a landfill can result in reduction of ferric iron to ferrous iron and dissolution of ferric iron minerals and their sorbed radionuclides. Ferric iron reduces before sulfate; therefore, if abundant ferric iron phases are present, it would indicate that sulfate minerals and phases may be more stable.
- Sulfides: The presence of sulfides will also be used as an indicator of the oxidizing-reducing conditions to which the solid phase materials have been exposed or under which they were formed. The presence of sulfide is a possible indicator of the stability of sulfate compounds (e.g., if not present, this indicates limited sulfate reduction and that sulfate minerals phases may be more stable; conversely, if present, sulfate reduction and, therefore, dissolution of solid sulfate salts, such as radium-bearing barium sulfate (barite), is possible).

- TOC: TOC results will be used to assess the levels of humic and fulvic acids that affect the partitioning and mobility of radionuclides (as well as the longevity of potentially-reducing conditions within the landfill).
- Cation-Exchange-Capacity (CEC): CEC results will be used to estimate the potential capacity of the alluvium and bedrock to adsorb and exchange charged cations and charged radionuclides from solution to the solid-phase surfaces.
- Geotechnical Samples: Grain size will be used to provide inputs for fate and transport evaluations.

In addition to the analytes above, a subset of 18 samples will be collected for specialty analysis from the locations upgradient, onsite, and downgradient from the site as shown on Figure 5-8b for analysis of mineralogy by X-Ray Diffraction (XRD), Scanning Electron Microscope with Energy Dispersive X-ray Spectrometry (SEM-EDS), leachability by Sequential Extraction, and select geotechnical samples. These locations were selected to provide spatial coverage of the different areas likely to be incorporated into fate and transport modeling. These specialty analyses will achieve these analytical objectives:

- XRD: XRD results are used to quantify the abundance of the major minerals in a sample (e.g., barite and calcite in RIM) that could potentially affect leachate composition and radionuclide speciation by their dissolution. The XRD results also provide a semi-quantitative description of the primary crystalline minerals in a sample and corroborate the mineralogy based on comparisons with the cation and anion analyses. The limitation is that the technique cannot detect minerals present in trace amounts (meaning about 3-5% or less). In addition, XRD has limited capability to detect amorphous substances. XRD analysis will provide information on naturally-occurring radionuclide activity levels and isotopic ratios, and their phase associations in aquifer materials and support an evaluation of the potential migration from the site.
- SEM-EDS: The SEM-EDS analyses provide a semi-quantitative method for elemental mapping and determining the composition of selected grains in a sample (e.g., barite, gypsum, calcite, oxides, or even amorphous non-crystalline materials). The SEM-EDS results can be used to correlate and corroborate the mineralogy based on comparisons with XRD and cation and anion analyses or provide information on the possible nature of amorphous material, and potentially pinpoint the sources of the more abundant trace elements. Mineralogical analysis by SEM-EDS analysis will provide information on naturally-occurring radionuclide activity levels and isotopic ratios, and their phase associations in aquifer materials and support an evaluation of the potential migration from the site.
- Sequential Extraction Analysis: The sequential extraction analysis consists of sample digestion in a series of sequential extraction steps. Each step uses a different solution, designed to dissolve specific solid or mineral phases (as described in the QAPP). Following each extraction process, anion/cation indicator analyses (e.g., barium, calcium, manganese, and sulfur) and radionuclide analyses (uranium, thorium, and radium) are conducted

so that the results will be used to assess the presence of radionuclides in the various phases targeted by the specific extraction procedure. The results will be compared to XRD and SEM-EDS analyses to determine solid-phase associations of radionuclides. The sequential extraction analysis of aquifer matrix samples will be collected to understand the relation between water quality and geochemistry to aquifer matrix (mineralogy, chemical composition, organic carbon, and phase association of radionuclides and their ratios).

- Geotechnical Samples: Geotechnical samples, including Atterberg limits, specific gravity, porosity, moisture content, and density will be used to provide inputs for fate and transport evaluations.

The concentrations of the various analytes will be compared from within the study area to adequately evaluate redox conditions at the site (e.g., Fe2+ >1 mg/L as an indicator of anaerobic degradation). Consideration will be given to the complexity of aquifer geochemistry, particularly with respect to chemical equilibrium and kinetics of iron and sulfide. Iron oxides can be present in the aquifer adjacent to water samples that contain ferric iron and hydrogen sulfides, whereas iron disulfide (pyrite) can be present in the absence of sulfate-reducing conditions. Data evaluation is discussed in Section 6.2. See Tables 2-2b and 2-2c of the QAPP for a list of analytes for alluvium and bedrock sampling, respectively.

5.4.9 BOREHOLE GEOPHYSICAL LOGGING

Downhole geophysical logging will be conducted after the borehole is advanced to total depth through the cased portion of the alluvium and the open borehole in bedrock to evaluate bedrock well placement and hydrogeologic properties. Geophysical tools include some or all of the following: 1) an acoustic televiewer, 2) spontaneous potential (SP)/resistivity, 3) induction/conductivity, 4) heat pulse flow meter, 5) fluid temperature and resistivity, 6) gamma-gamma-density, 7) natural gamma, 8) spectral gamma and 9) caliper as applicable for open and cased holes. Additional detail on each of these methods is provided in Section 3.7.2 of the FSP.

5.4.10 PACKER TESTING

Packer testing will be conducted on all deep bedrock boreholes to evaluate the aquifer properties of the bedrock and to identify higher transmissivity zones for screen placement. Constant head injection packer tests will be conducted in all open bedrock holes on select intervals identified during continuous coring based on based on fracture frequency and porosity, and intervals identified during borehole geophysical logging. Double (straddle) and single downhole packer assemblies will be lowered to the desired depth using the sonic drilling rig based on the presence or absence of fractures and the porosity. Straddle packer tests will generally isolate 5 to 10 feet of borehole. Downhole packer testing equipment will be connected via the drilling rods to a surface assembly consisting of a variable-rate water pump, a flow meter manifold, a pressure gauge, valving, and hoses. Step tests will be conducted where possible.

Additional detail on the packer testing methods is provided in Section 3.8.2 of the FSP. Vertical borehole flux meters will be considered during later phases of the OU-3 RI/FS if the straddle packer testing is unsuccessful.

5.4.11 MONITORING WELL INSTALLATION

Screened intervals will be selected based on the most transmissive zones identified during HPT testing (alluvial zones only), geologic logging or geophysical analysis (bedrock zones only), or at the preliminary target depth by zone. Preliminary target depths, which are identified in Table 5-2, are based on geologic cross sections prepared during preparation of this RI/FS Work Plan. Additional information on monitoring well installation is provided in Section 3.9 of the FSP.

5.4.11.1 ALLUVIAL WELL INSTALLATION

The shallow and intermediate alluvial monitoring wells will be constructed as nested wells within a single borehole, which will be approximately 12 inches in diameter. The deep alluvial monitoring wells will be constructed within a single borehole that is approximately 6 inches in diameter. Example monitoring well construction diagrams for the alluvial wells are included as Figures 5-9a and 5-9b.

If the HPT results indicate that there is less than 13 ft of vertical space exists between proposed screened intervals for the shallow and intermediate wells, the intermediate alluvial well will be nested with the deep alluvial well within a single borehole, which is approximately 12 inches in diameter. Deep alluvial wells will be constructed using a 2-inch diameter 10-foot Schedule (Sch.) 80 polyvinyl chloride (PVC) 0.010-inch factory-slotted screen and 2-inch diameter Sch. 80 PVC blank riser. A 10/20 silica sand pack or similar will be placed around the well screen. Shallow and intermediate alluvial wells (<100 ft deep) will be constructed using a 2-inch diameter 10-foot Sch. 40 PVC 0.010-inch factory-slotted screen and 2-inch diameter Sch. 40 PVC blank riser. A 16/35 silica sand pack or similar will be placed around the well screen. Surface completions for the wells will be selected based on individual proposed well location requirements.

5.4.11.2 BEDROCK WELL INSTALLATION

The bedrock monitoring wells will be double cased to provide hydraulic separation from the alluvium and prevent introduction of overlying alluvial groundwater into the bedrock zones. The bedrock wells will be constructed using a 2-inch diameter 10-foot Schedule (Sch.) 80 polyvinyl chloride (PVC) 0.010-inch factory-slotted screen and 2-inch diameter Sch. 80 PVC blank riser. A 10/20 silica sand pack or similar will be placed around the well screen. Surface completions for the wells will be selected based on individual proposed well location requirements. Example bedrock monitoring well construction diagrams are included as Figure 5-9c.

5.4.12 MONITORING WELL DEVELOPMENT

The objectives of the well development are to:

- Allow groundwater to enter the well screen freely, thus yielding a representative groundwater sample and water level measurements.
- Remove water that may have been introduced or disturbed during drilling, downhole testing (e.g. packer testing), or well installation activities.
- Remove fine-grained sediment in the filter pack to minimize the turbidity of the groundwater sample turbidity and decrease the likelihood of silting of the well.
- Maximize the efficiency of the filter pack.

The monitoring wells will be developed, no sooner than 48 hours after the grouting is completed. The wells will be developed by mechanically surging the well, followed by pumping. Surging will consist of forcing water into and out of the formation using a surge block. The surging action will be relatively gentle to avoid causing formation material to enter into the screen. The surging will be concentrated over 5-foot intervals, starting at the top of the screen, to avoid sand locking the surge block. In addition to the newly installed monitoring wells, existing wells, which are included as part of the groundwater quality monitoring network, will also be redeveloped in a similar manner as needed based on results of the monitoring well inventory.

Immediately after surging, the groundwater and any sediment in the bottom of the well will be evacuated using a bailer or pump. The volume evacuated from each well, and physical characteristics of the purge water (color, relative turbidity, sediments, etc.) will be recorded during regular intervals during development. If natural recharge rates are adequate, development will continue until the extracted water is visibly free of sediment or until parameters (pH, temperature, and turbidity) are stable. The field procedures are included in Section 3.10 of the FSP. Water levels and total depths will be measured before and after well development and documented on the well development form. IDW management is discussed in Section 5.4.21.

5.4.13 SLUG TESTING

Slug testing will be conducted on a subset of 40 new wells and 32 existing monitoring wells which were not previously tested. The slug testing will be performed after the monitoring wells are developed to determine the hydraulic conductivity of the formation materials near each well. Wells proposed for slug testing are shown in Table 5-5. Additional slug testing will be performed on other wells as necessary for development of the groundwater model and refinement of the CSM. Testing will be conducted using pneumatic slug techniques where possible and conventional slug testing if the screened interval intersects the water table. Two rising head tests will be performed on all monitoring wells that have not previously been tested. Slug tests will be evaluated to calculate hydraulic conductivity using AQTESOLV software. Additional information on slug testing methods is provided in Section 3.12 of the FSP.

5.4.14 AQUIFER PUMPING TEST

In order to estimate storativity of the water-bearing zones, a multi-well aquifer pumping test will be conducted during the latter stages of the OU-3 RI. The aquifer pumping test will be conducted at one of the well locations which has all five vertical intervals represented. The well location will be selected based on the representativeness of the geology and hydrogeology relative to the groundwater model, and at a location that is unimpacted to avoid the generation of impacted purge water. Therefore, the proposed aquifer pumping test will occur after the initial data quality and water level information are collected at the new monitoring wells as part of a later phase of work. The aquifer pumping test procedures will include a constant rate test and step drawdown test for each water-bearing zone. Additional details on the aquifer pumping test procedures will be submitted within the Annual Hydrogeologic Investigation and Groundwater Characterization Report or an addendum to this Work Plan.

5.4.15 GROUNDWATER MONITORING

A quarterly groundwater monitoring is proposed at 158 wells for a minimum of eight quarters to meet the needs of the RI and BRA, and as warranted, will likely continue at a reduced frequency (e.g., annual) from selected wells thereafter. Two monitoring events will be conducted during drilling activities to provide interim groundwater data for the existing wells plus any proposed wells that have been drilled, developed, and are ready to be sampled. Six monitoring events will be conducted after drilling activities are complete. Groundwater monitoring will continue until the investigation is complete, or until a remedial action is selected and implemented at the site. The purpose of the groundwater monitoring is to determine radionuclide and other constituent concentrations in aquifers located at and near the site. The groundwater monitoring program will measure COPC concentrations in order to determine the nature and extent of groundwater impacts and assess risk to human health and the environment. Additionally, samples will be collected and analyzed for geochemical indicators, major ion suite, and landfill leachate indicators (including tritium). Landfill leachate indicators and redox parameters are summarized on Table 5-6. Additional information on the individual COPCs is included in the QAPP Table 2-2a; they are also summarized in Section 5.4.15.3.

5.4.15.1 WATER-LEVEL MEASUREMENTS

Each month, the depth to static groundwater will be measured at each groundwater monitoring well, as well as prior to purging groundwater during sampling events. The monthly well gauging of the existing and proposed monitoring wells in Table 5-4 will be completed for least 24 consecutive months upon well installation. An electronic water level probe, accurate to the nearest +/- 0.01 ft, will be used to measure depth to water in each well. Depth to dedicated pump will be measured biannually to minimize the potential to increase turbidity in the monitoring well prior to sampling. The need to collect total depth measurements will be determined at least annually based on multiple lines of evidence, including anomalous field parameter readings, analytical results, and turbidity readings.

After completing the initial round of water level measurements and groundwater sampling, pressure transducers/data loggers (DLs) will be placed in 88 select wells that provide sufficient horizontal and vertical spatial coverage. Two barometric pressure loggers will be placed onsite. Table 5-7 identifies the wells where DLs will be used. The DLs will measure groundwater levels and temperature. These DLs and barometric pressure loggers will remain within the wells, while the quarterly groundwater monitoring and monthly water level gauging occur. The DLs will be programmed to collect synchronized readings every hour. During each quarterly groundwater monitoring event, the data will be downloaded from the transducers and saved within the project files. The location and quantity of DLs will be evaluated after one year of monitoring and temporal analysis has been completed. Additional information on water level measurements is provided in Section 3.16 of the FSP.

5.4.15.2 PURGING

Purging of monitoring wells prior to sampling is necessary to remove stagnant or thermally stratified groundwater from the well casing and sand pack that may not be representative of groundwater within the aquifer. If possible, purging will be performed at a flow rate at or below the well's recovery rate to minimize inflow of groundwater from above the well screen. Purged water will be considered IDW, containerized, and stored on-site within a temporary tank pending waste characterization analytical results as described in Section 6.0 of the FSP. All wells will be purged prior to sampling utilizing a dedicated bladder pump. Bladder pumps are currently installed in all of the active Bridgeton Landfill monitoring wells. New bladder pumps will be installed in the new monitoring wells and in existing wells identified for the OU-3 well network as necessary based on the condition of the existing pumps (if present). Additional information on bladder pump installation is provided in Section 3.14.1 of the FSP.

Bladder pump intakes will be placed at the most transmissive zone or impacted zone identified during well installation. If there are concerns with the well pumping dry, pumps will be placed 2 to 3 ft from the bottom of the well to permit reasonable draw down while preventing cascading conditions. For most of the monitored groundwater zones, the pump will be set within the well's screened interval. The exception is within wells with very deep screened intervals (e.g., the Keokuk Zone wells) where drop tubes are set within the screened interval. Pumping rates will be regulated or controlled to minimize turbulent flow, prevent damage to the monitoring well components, and minimize the introduction of sediment into the well.

Throughout the purging process, groundwater will be monitored for the following field parameters: pH, specific conductance, temperature, turbidity, DO and ORP. A flow-through cell will be used for field parameter measurements to ensure that the water quality meter's sensors are in contact with flowing water. Purging will continue until field parameter equilibrium is achieved. Equilibrium is achieved when parameters exhibit variation equal to or less than the USEPA-prescribed tolerances for low-flow sampling, with special attention paid to turbidity (USEPA 1996). Additional information on well purging is provided in Section 3.14.2 of the FSP.

5.4.15.3 MONITORING WELL SAMPLING

A groundwater monitoring well may be sampled as soon as the field parameters have stabilized, or if purged to dry, as soon as it has recovered sufficiently, but typically no more than 24 hours after purging. The same methods used for well purging will be utilized for sample collection. The pump's discharge tube will be disconnected from the flow through cell and sample bottles will be filled directly from the pump's discharge tube to minimize agitation and aeration. The final set of parameter values will be used for the sampling. If the well is sampled later, a new set of parameter values will be measured and recorded concurrently with sampling.

Individual sample containers will be filled in order of decreasing sensitivity to potential volatilization of the analytical constituents. Groundwater samples will be transferred directly into the appropriate sample containers with preservative, if required, chilled if appropriate, and processed for shipment to the laboratory.

Both filtered and unfiltered samples will be collected for metals and isotope analyses due to the potential for these analytes to sorb or exchange with suspended colloids. An in-line disposable 0.45-micron filter will be used to remove particles that have been entrained in the water sample. A clean, unused filter will be used for each filtered sample collected. Groundwater samples will be transferred from the filter directly into the appropriate sample containers with a preservative and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the filter to the sample container. Depending on the viability of the proposed filtration process, this methodology may be altered as necessary in the field. Proposed alterations will be discussed with the OU-3 Respondents and submitted to USEPA for review and approval prior to implementation. Additional information on monitoring well sampling is provided in Section 3.14.3 of the FSP.

Groundwater samples will be submitted to laboratories for analysis as outlined in the Table 2-2a of the QAPP and Section 2.0 of the FSP. COPCs and leachate indicators will be analyzed each event to evaluate the nature and extent of impacts. The groundwater COPC list was identified based on historical groundwater data from existing onsite wells, waste managed at the site, typical MSW leachate parameters (Table 5-8), and Missouri CSR Section 80.3010

Appendices I, II, III, and IV. This list will be evaluated throughout the investigation and may be modified based on results and with approval from the USEPA as discussed in Section 6.2.5.

5.4.16 STAFF GAUGE INSTALLATION

Staff gauges will be located in onsite and offsite surface water bodies near existing and newly installed shallow alluvial monitoring wells. The staff gauges will be installed in the locations shown on Figure 5-6. Transducers will be installed in all staff gauges and synced to record with transducers deployed in monitoring wells so that interconnection of the surface water and groundwater can be evaluated. Surface water elevation data will also be compared to groundwater elevation data collected during monthly gauging events. Rain events (duration, rate, and totals) will be noted in the logbook for the project and downloaded from Lambert Field and the on-site precipitation gauge. Transducers installed in staff gauges will be programmed to record elevations at hourly intervals and downloaded quarterly during manual calibration. Additional information on staff gauge construction is provided in Section 3.17 of the FSP.

5.4.17 LEACHATE COLLECTION SYSTEM SAMPLING

The current leachate collection system is comprised of LCS within the North Quarry (LCS-5A, LCS-5B, and LCS-6B) and South Quarry (LCS-1D, LCS-2D, LCS-3D, and LCS-4B). These locations are shown on Figure 3-9 and are documented in the March 2019 Operation, Maintenance and Monitoring Plan (CECI 2019). Each sump has been installed towards the base of the quarry floor at approximately 270 ft bgs, except LCS-3D, which is installed approximately 140 ft bgs. The screens for the LCS range in length from 60 to 150 ft. Dedicated pumps were installed in each LCS point. Due to the SSR, some of the South Quarry sump pumps are no longer operational.

Eight quarters of leachate sampling will be conducted. Samples will be collected from LCS points which are safe to access, and which produce fluid. If a pump is not operational, the LCS point will not be sampled unless it is still identified as a data gap after the first phase of site characterization and is not a health and safety concern. Based on the most recent leachate report from Bridgeton Landfill, LCS-3D, LCS-4B, LCS-5A, LCS-5B, and LCS-6B were viable for sampling. Dedicated pumps in LCS-1D and LCS-2D are presently not operable. Leachate sampling will be conducted to identify geochemical, inorganic, and organic characteristics, which may be compared to groundwater data for evaluation of the effects of the Bridgeton Landfill on nearby groundwater. Leachate sampling will include the same analytical suite of COPCs as noted in Section 5.4.15.3 for groundwater.

At the time of the OU-3 RI field work, information will be obtained on operational status of the leachate collection and treatment system, including LCS points with fluid available for sampling without access issues, construction, operational history, frequency of use, pumping rates from each LCS point, pump configuration, and influent and effluent concentrations. Ground temperature, vadose zone pressure, and gas extraction data which are currently collected by Bridgeton Landfill will also be compiled. Pumping information will be used to populate the groundwater flow model and complete a water balance for the site as discussed in Section 5.5.

5.4.18 VAPOR INTRUSION ASSESSMENT

The COPCs historically detected in on-site groundwater include vapor-forming VOC compounds such as benzene and chlorobenzene. Radon and polonium may also be present in air due to the presence of radium isotopes in soil/groundwater and anthropogenic sources deposited within OU-1. Methane has also been detected in landfill gas monitoring probes. Historical groundwater data were used to evaluate whether other vapor-forming compounds may be present based on volatility and toxicity as summarized in Table 5-9. No additional vapor-forming compounds were identified based on historical groundwater data for the site. Therefore, data will be collected to evaluate the risk resulting from potential vapor intrusion of subsurface vapor-forming VOC compounds, methane gas, as well as radon and polonium in air into on-site and off-site occupied buildings.

5.4.18.1 VAPOR INTRUSION ASSESSMENT BOUNDARIES

The spatial boundary for the proposed vapor sampling is the study area shown on Figure 3-17. The proposed vapor sampling spatial boundary will extend approximately 100 feet from the perimeter of the estimated extent of vapor-forming COPC occurrences in groundwater above levels that could pose a risk of vapor intrusion. The zone of inclusion for the offsite vapor intrusion evaluation will be extended beyond the 100-foot distance based on several potential factors, including the presence of landfill gas pressure readings which may indicate an outward vapor gradient away from the landfill and the presence of utility corridors, and fracture zones in bedrock which could also be potential preferential vapor pathway for buildings overlying bedrock east of the edge of the alluvium. The vertical boundary for indoor air sampling is the above grade spaces within enclosed and occupied spaces of the study area.

If subslab and nearslab vapor sampling are proposed as part of the vapor intrusion addendum, vapor-related data quality objectives will be included in the addendum to address the additional scope. The anticipated vertical boundary for the subslab soil gas sampling will be proposed to be from 0-2 ft immediately below the building slabs below enclosed and occupied spaces of the study area. The vertical boundary for nearslab sampling will be proposed to be from 2 ft to the top of the upper-most water bearing zone. The temporal boundary is limited to data from the previous 5 years.

5.4.18.2 INDOOR AIR

Indoor air sampling will be conducted during site characterization within four enclosed, occupied on-site structures with part- to full-time worker occupancy (i.e., commercial / industrial worker scenario): the Engineering Office, Scale

House, Pump House, and a structure associated with the asphalt plant as shown on Figure 5-10. One indoor air sample will be collected per 2,000 square feet of applicable building space for methane, VOCs, radon and polonium. Based on initial estimates of building dimensions, a total of six indoor air samples, one from each building plus two additional samples from the Engineering Office due to its size, plus one ambient air sample will be collected per event. However, the quantity of samples may be adjusted following completion of an initial building survey and inspection of each structure.

Both short-term and long-term radon testing will be completed within each building. The short-term radon and polonium testing will be conducted with real-time measurements to provide timely information for on-site worker safety. Due to the ongoing facility operations within on-site buildings, worst-case radon sampling is not achievable using real-time measurements. Therefore, long-term radon testing will be performed to obtain realistic radon exposure concentrations.

The procedures for indoor air testing are included in Section 3.18 of the FSP and will follow the latest USEPA vapor sampling guidance (USEPA 1992b; USEPA 1993; USEPA 2015b; USEPA 2015c). Results of the onsite indoor air testing will be compared to current composite worker USEPA RSLs based on the results of the USEPA's decisions relative to the OU-1 Updated BRA (Auxier 2018), which concluded that residential, construction work, and commercial building uses are not reasonable uses for a solid waste landfill.

5.4.18.3 VADOSE ZONE SOIL GAS

Vadose zone soil gas sampling will be conducted if there are impacts to indoor air or a potential for vapor migration from the landfill units to provide multiple lines of evidence to evaluate whether the vapor intrusion pathway is complete and poses a current or future risk to human health. One round of indoor air testing will be conducted prior to collection of vadose zone soil gas samples to evaluate whether vadose zone sampling is warranted. The scope of work for the vadose zone sampling (if necessary) will be presented in an addendum based on the results of the initial indoor air testing. Methods for subslab soil gas and nearslab sampling are summarized in FSP Section 3.18.

5.4.18.4 GROUNDWATER TO INDOOR AIR ASSESSMENT

In addition to the proposed on-site indoor air testing noted above, an assessment will be performed to determine the current and future potential for completion of vapor intrusion pathways in on-site and off-site occupied residential and commercial/industrial structures. A vapor intrusion pathway is considered complete when the following conditions are met:

- A subsurface source of vapor-forming chemicals is present underneath or near the buildings.
- There are vapors that have a route along which to migrate toward the building.
- The buildings are susceptible to soil gas entry, which means there are openings for the vapors to enter the building and driving forces exist to draw the vapors from the subsurface through the openings of the buildings.
- One or more vapor-forming chemicals, comprising the subsurface vapor sources, is present in the indoor environment.
- The buildings are occupied by one or more individuals when the vapor forming chemicals are present indoors.

The results from the investigation after each groundwater monitoring event will be used to evaluate the need for off-site vapor testing, which may include passive soil gas vapor sampling, installation of soil gas vapor wells, soil gas vapor sampling, subslab vapor sampling, indoor air quality sampling, and/or installation of mitigation systems. This vapor intrusion evaluation will include comparison of groundwater data to target groundwater concentrations estimated by the latest version of the USEPA vapor intrusion screening level (VISL) calculator (USEPA 2019b) or using Henry's Law to estimate vapor phase concentrations (if no VISL target level is available). Also, as part of this task, information on potentially affected off-site properties will be compiled, including land ownership, site use, zoning, and deed restrictions (if present).

The results will be evaluated based on the potential future use of each property, which may include residential land use in off-site areas. The results of the vapor intrusion evaluation and recommendations will be submitted in the Annual Hydrogeologic Investigation and Groundwater Characterization Report in accordance with the schedule included in Section 10.3.

5.4.19 ECOLOGICAL SURVEY

An ecological survey will occur in two steps that will result in a baseline characterization of existing ecological and biological conditions within and adjacent to the site. A desktop assessment will be conducted first to characterize current habitat types, overall quality, and regional/landscape position by evaluating the existing OU-1 and OU-2 data, and best publicly available information at the regional, local, and site-specific scale. The desktop assessment will identify the anticipated ecological communities and habitat types, and biota likely to occur within those habitats.

Following the desktop assessment, an ecological survey of the flora and fauna onsite and surrounding the site will be conducted by a biologist. The survey will build upon the results of the desktop assessment, by verifying the existing vegetation communities; the nature, location, and extent of aquatic resources surrounding the site (focusing on the general area that has the potential to be connected to site-impacted groundwater and/or receives site runoff); and the identification of potential ecological receptors that use these general habitats. Data collection will include photographs, field notes, and GPS coordinates delineating notable points or boundaries. It is anticipated that a SLERA will need to be completed, and the ecological receptor evaluation will provide the basis for this. A work plan for the SLERA will be developed as an addendum to this document after the groundwater and surface water evaluations are completed and potential exposure pathways have been elucidated. At present, it is assumed that potential ecological exposure points for OU-3 include: 1) the vadose zone in select areas outside the landfill units and 2) off-site surface water bodies that are hydrologically connected to groundwater or receive surface water runoff that originates within the site. Waste disposal units will be excluded from the SLERA. Information from OU-1 and OU-2 will be considered in the development of the CSM for the SLERA, and any remaining data gaps will be identified at that time. Additional site-specific information may be obtained (as needed) through the design and implementation of potential targeted sampling events (e.g. vegetation surveys, wildlife inventories, characterization of benthic macroinvertebrate assemblages, plant or animal tissue sampling, etc.). The SLERA will be used to evaluate the need for the Ecological Risk Assessment (ERA). Additional information on the ecological survey is provided Section 3.19 of the FSP.

5.4.20 SURVEYING AND MAPPING OF THE INVESTIGATION AREAS

A site-wide monitoring well location and elevation survey will be performed after new wells are installed and repairs are completed on existing wells. Staff gauges will also be surveyed for location and elevation data as described in Section 3.4.1 of the FSP. The OU-3 Respondents will develop updated maps of the area that include topographic information and physical features on and near the site. Aerial photographs will be used along with information gathered during previous investigations to identify physical features of the investigation area. Sample locations (wells, piezometers, sample points, etc.) will be surveyed by a State of Missouri licensed land surveyor and the geospatial information will be summarized and provided to the USEPA in specified/acceptable formats. A bathymetric survey of surface water bodies will also be conducted on surface water bodies where staff gauges are proposed and where existing bathymetric data is not already available. The collection and management of geospatial data will be in accordance with Section 5.1.2.1.4, 5.3.3, 6.1.4, and 6.2.3 of the QAPP.

5.4.21 INVESTIGATION DERIVED WASTE

In the process of collecting environmental samples, the sampling team will generate different types of potentially contaminated IDW that include the following:

- Used personal protective equipment (PPE)
- Disposable sampling equipment

- Decontamination fluids
- Soil cuttings from soil
- Purged groundwater and excess groundwater collected for sample container filling

The USEPA's NCP requires that management of IDW generated during sampling comply with all ARARs to the extent practicable. The sampling plan will follow the *Office of Emergency and Remedial Response (OERR) Directive 9345.3-02* (USEPA 1991), which provides the guidance for the management of IDW. In addition, other legal and practical considerations that may affect the handling of IDW will be considered. The following process for IDW management is proposed:

- Used PPE and disposable equipment will be double-bagged and placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of which can still be reused will be rendered inoperable before disposal in the refuse dumpster. Any PPE generated within OU-1 Areas 1 and 2 will be frisked to verify the absence of radionuclides and predisposed of as municipal solid waste as per the most recent *OU-1 Radiation Safety Plan* (Ameriphysics 2020).
- Decontamination fluids that will be generated in the sampling event will consist of distilled water, residual contaminants, and water with non-phosphate detergent. The decontamination fluid will be containerized and stored onsite within a temporary tank pending analytical data. The fluid will be characterized for off-site disposal, or transferred to the on-site leachate water treatment system for discharge pending approval from MSD.
- Soil cuttings generated during the subsurface sampling will be characterized and disposed of in an appropriate manner.
- Purged groundwater will be containerized and stored onsite within a temporary tank pending analytical data. The purge water will be characterized for off-site disposal, or transferred to the on-site leachate water treatment system for discharge pending approval from MSD.

5.4.22 ADDITIONAL SITE CHARACTERIZATION

Additional site characterization will be performed as part of the OU-3 RI field activities once Phase I and II data collection and preliminary evaluation of the resultant data are completed. In addition to the aquifer pumping test noted above, examples of potential additional activities include installation of additional monitoring wells to help delineate the current nature and extent or predict the future nature and extent of groundwater impacts, collection of soil gas, subslab or indoor air sampling, and collection of sediment pore water, sediment or surface water samples to evaluate potential exposure pathways.

Recommendations for additional site characterization will be included in the addendums outlined in Section 9.2 to allow for a more flexible and iterative approach or with the Annual Hydrogeologic Investigation and Groundwater Characterization Report. A schedule is included in Section 10.3.

5.5 GROUNDWATER MODELING

Groundwater flow and fate and transport modeling will be conducted during the investigation after the collection of sufficient groundwater hydrologic and chemical data, which will allow the modeling objectives and requirements to be determined. To date there is not a complete understanding of site conditions beyond the site boundaries, making the specifics of a larger modeling program difficult to ascertain. Results of the field activities described above in Section 5.4 will be used to populate input parameters for a 3-D groundwater flow and fate and transport model, which will be constructed to assist with refinement and understanding of the CSM, used as a predictive tool to evaluate long-term human health and ecological risks, and to assist with remedy evaluation and selection (if necessary). The scope, type (numerical, analytic) and modeling code of fate and transport modeling will be defined following initial data collection activities. A preliminary discussion of currently anticipated modeling objectives, conceptual framework, potentially applicable software, and calibration goals is provided in Section 6.2.1, and will be amended within the forthcoming Groundwater Modeling Work Plan. A preliminary process flow diagram of the modeling approach is included as Figure 5-11.

Before a detailed modeling approach can be scoped, additional spatial and temporal geologic, hydrogeologic, geochemical, and analytical data will be collected during site characterization to support a representative groundwater flow model and fate and transport evaluation. Geologic data required to sufficiently parameterize a flow model and support fate and transport evaluations include the 3-D distribution of hydrostratigraphic units, as well as material properties such as grain size, fraction organic carbon, cation exchange capacity, bulk density, and mineralogy.

Hydrogeologic data include aquifer properties, groundwater elevation data sets, surface water elevation data sets, and hydraulic gradient data sets. Geochemical data important for fate and transport evaluations include pH, DO, ORP, and temperature. Analytical data necessary for fate and transport modeling include COPC distribution and phase associations. Existing and new data will be used to update and refine the CSM as the investigation progresses. Data from site characterization will be incorporated into maps and cross sections, potentiometric surface maps, geochemical diagrams, and COPC distribution figures. A water balance will be completed that evaluates the changes in groundwater storage due to the various fluxes into and out of the groundwater system. Fluxes into and out of the system include percolation of precipitation or irrigation, evapotranspiration, surface water recharge, surface water discharge, groundwater recharge, groundwater discharge, and pumping. The water balance will include the effects of site infrastructure such as landfill covers, surface water control structures, leachate extraction, and vegetation or other surface cover material.

Geochemical and contaminant analytical data will be analyzed to assess contaminant mobility. The common geochemical redox conditions and species and reactive minerals associated with landfills can affect radionuclide transport via exchange-adsorption/desorption and precipitation/co-precipitation or dissolution over time scales on the order of seconds to months. Radioactive decay occurs over much longer time scales. Therefore, it is important that both of these mechanisms are characterized and understood.

The Groundwater Modeling Work Plan will be developed following the first two groundwater monitoring events which include the entire well network. The Groundwater Modeling Work Plan will integrate the understanding of groundwater flow and contaminant transport following the evaluation of the data sets collected during site characterization. Additional information on the Groundwater Modeling Work Plan will be provided in the March 2021 Annual Hydrogeologic Investigation and Groundwater Characterization Report. The updated CSM will address groundwater flow in and around the site and in off-site areas that are impacted by COPCs. The updated CSM will also address how the alluvial aquifer, the Missouri River, and the hydraulic relationship between the alluvial and bedrock aquifers affect groundwater flow directions and gradients. Evaluation of the analytical data sets will also be important to the development of a fate and transport modeling strategy.

Where appropriate, preliminary fate and transport modeling, possibly including calculations or preliminary models, will be developed to support the CSM and to develop fate and transport modeling requirements within the Groundwater Modeling Work Plan. A more specific strategy will be developed following collection of the appropriate data sets and included in the Groundwater Modeling Work Plan.

5.6 ENGINEERING AND INSTITUTIONAL CONTROLS

As characterization proceeds, existing mechanisms, engineering controls, and other existing legal instruments will be reviewed to ensure appropriate actions are implemented in accordance with federal, state, and local regulatory requirements that mitigate human health exposures. The engineering/institutional controls will be determined based upon results of the initial investigation results where potential exposures exceed risk-based cleanup objectives.

5.7 HEALTH AND SAFETY PLAN

A HASP, which includes the most current *OU-1 RSP* and *OU-1 Emergency Response Plan* for work conducted within the boundaries of OU-1 Areas 1 and 2 is included as Volume 3. The HASP provides a summary of personnel responsibilities, protective equipment, health and safety procedures and protocols, decontamination procedures, personnel training, and type and extent of medical surveillance. The plan identifies problems or hazards that may be encountered during performance of the RI and how these are to be addressed. Additionally, procedures for protecting third parties, such as site visitors, vehicular or pedestrian traffic near drilling locations or sampling crews, and for the surrounding community, in general, is also described in the HASP.

6.0 DATA MANAGEMENT AND EVALUATION

The RI/FS will generate and compile an extensive amount of information that will require proper management to support both the risk assessment and the remedy selection decisions. Procedures will be followed to ensure the quality, validity, and security of the data. Additional details and SOPs are included in the SAP. Data will also be evaluated and compiled into text, tables, figures, and 3-D visualizations to help evaluate and identify any remaining data gaps.

6.1 DATA MANAGEMENT

Project Direct (proprietary to Trihydro) is already being used to manage existing data. This data management system will organize these data sets: field logs, boring logs, field note scans, GPS/survey data, sample management and tracking procedures, document control procedures, laboratory data, field measurements, and other relevant data. The goal is to ensure that the data are of adequate quality and quantity to support the conclusions derived from the investigation, the risk assessment, and the remedial decision-making process. The data will be exported directly from Project Direct into accommodate various other output formats.

6.1.1 DATA VALIDATION

The collected data will be reviewed and validated at the appropriate quality control (QC) levels to determine whether it is adequate for its intended use. Analytical laboratories and their data management protocols are described in detail in the QAPP.

The geotechnical, XRD, SEM-EDS, and sequential extraction data are specialty laboratory services for non-regulated data that will be used in fate and transport groundwater modeling. These data will be validated using Tier I data validation. Groundwater, leachate, and vapor analytical data provided will be validated with at least a Tier III data validation, and the specific level of data validation will be determined by the final use of the data as discussed in the QAPP Section 7.1.

Task management objectives and the QC procedures will be provided, consistent with the FSP and QAPP. The data validation documentation will be included incorporated into the RI and FS reports, appendices, and other related project deliverables, as appropriate.

6.1.2 PROJECT DATABASE

The project database will be provided for USEPA's use. The database will be updated as new, reviewed, and validated data becomes available. The USEPA will be notified, in writing, whenever new data has been uploaded to the database.

In general, the OU-3 database will include well construction details, well development data, survey information, geochemical data, field data, analytical results and field parameters, fluid levels, laboratory qualifiers, additional qualifiers, and other summary information relevant to the investigation. Uploading sampling, monitoring, and spatial data into database in the appropriate formats will be considered a submittal once USEPA is notified of its availability.

6.1.3 SPATIAL DATA

Data will be submitted to the USEPA in an appropriate Electronic Data Deliverable (EDD) format. Spatial data will be submitted in the ESRI File Geodatabase format and as un-projected geographic coordinates in decimal degree format using North American Datum 1983 (NAD83). Spatial data will be accompanied by metadata, which will be compliant with the Federal Geographic Data Committee (FGDC), Content Standard for Digital Geospatial Metadata and its USEPA profile, the USEPA Geospatial Metadata Technical Specification.

An add-on metadata editor for ESRI software, the USEPA Metadata Editor (EME), will be used, as needed. Each file will include an attribute name for each site unit or sub-unit. Spatial data that will be submitted does not, and is not, intended to define the boundaries of the site.

6.1.4 FIELD RECORD KEEPING

Field logbooks and datasheets will record the data collection. All field logbooks and field datasheets will be scanned to create PDF files for electronic archiving in the central file. A SOP for field records is in the FSP.

6.1.4.1 FIELD LOGBOOKS

Logbooks will be used to document field observations and activities. The field notes will be clear, with sufficient detail so that events can be reconstructed, if necessary. Field logbooks will document any deviations from the RI/FS WP or FSP, as well as the reason for the changes. The requirements for logbook entries are included in the FSP.

6.1.4.2 FIELD DATASHEETS

Field datasheets and forms will be used to achieve efficient and standardized recording of field measurements and observations. The type of field data sheets, and the information recorded on them may vary by activity. Information from the field datasheets, including water levels and stabilized field parameters, will be entered into the database. A reference date and activity will be entered in the logbook to refer to the field datasheets being generated. The datasheets will be scanned into a PDF and, thus, become a permanent record within the project file. Details regarding field datasheets, which may be used, and example datasheets are included in the FSP.

6.2 DATA EVALUATION

Data evaluation will be conducted once it is verified that the data are of acceptable accuracy and precision. The investigation data will be reviewed and analyzed, and the results of the analyses will be presented to the USEPA. Summaries of the data shall include:

- Descriptions of the locations, quantities, and concentrations of specific chemicals at the study area
- A discussion of background conditions and concentrations for the study area
- Descriptions of the number, locations and types of nearby populations
- A discussion of the influence of the leachate collection system and other related infrastructure on the hydrogeologic system
- An evaluation of the potential transport mechanism and the expected fate of the contaminants

The data evaluation and validation processes will be performed and properly documented in accordance with the approved QAPP.

6.2.1 GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODELING

A 3-D numerical groundwater flow and transport model will be prepared to refine the CSM, predict future groundwater conditions, evaluate human health and ecological risks, and evaluate potential remedies.

The objectives and scope of the groundwater modeling effort will be further defined in the modeling work plan, which will be developed after review of data collected in the first phase of the RI/FS. The Groundwater Modeling Work Plan will include detailed descriptions of the following elements:

- Purpose and Objectives
- Modeling Code and Software

- Model Conceptualization, Boundary Conditions, Grid Extent
- Grid Dimensions and Layering
- Temporal Domain (Calibration and Prediction)
- Calibration
- Methods to Determine Parameter Sensitivity
- Predictive Simulations
- Reporting

Preliminary details regarding the groundwater model are presented below, including potential modeling software packages, a preliminary hydrologic conceptual model and proposed model domain, a proposed geochemical fate and transport approach, and calibration procedures. Additional details will be provided in the Groundwater Modeling Work Plan as described in Section 9.4.

6.2.1.1 MODELING OBJECTIVES

Tentatively, these three following objectives will drive the modeling effort:

1. Refine the CSM for groundwater conditions by simulating flow conditions and transport between the contaminants and potential receptors.
2. Predict potential future COPC groundwater migration in off-site areas under various stress scenarios.
3. Determine whether human and ecological exposure routes are potentially complete and evaluate the risk to human health and ecological receptors based on predicted COPC concentrations.
4. Evaluate and compare remedial alternatives for the site.

6.2.1.2 PROPOSED MODELING SOFTWARE

The selection of appropriate groundwater flow and transport modeling codes cannot be conducted at this time. However, it is anticipated that a flow model within the suite of USGS MODFLOW codes will be the most appropriate flow modeling code. An appropriate transport code will be determined based on the results of groundwater chemical analyses, and will be capable of simulating relevant chemical reactions, sorption, and other relevant processes. A more definitive statement on the selection of flow and transport modeling software will be provided in the Groundwater Modeling Work Plan.

6.2.1.3 CONCEPTUAL MODEL AND INITIAL MODELING DOMAIN

The conceptual domain of the anticipated groundwater flow model is shown on Figure 3-17. The details related to boundary conditions, layering strategies, grid spacing (discretization), and flow budgets will be determined and discussed in the Groundwater Modeling Work Plan. The current conceptual model for the site includes two bedrock hydrologic units (St. Louis Formation and Salem Formation) and three alluvial hydrologic units (shallow, intermediate, and deep alluvium) as discussed in Section 3.1.3. This model will be updated based on the additional data collected during the first phase of OU-3 RI/FS site investigation. The computer model will be constructed, with sufficient 3-D discretization and vertical layering, to accurately simulate groundwater flow and transport within this hydrogeologic setting. Interactions between the alluvial aquifers and the Missouri River are dynamic and the effect of these interactions on groundwater flow directions and gradients will also be incorporated into the modeling to account for base flow (riverward) and underflow (down valley). Groundwater withdrawals by the leachate collection system (described in Section 3.1.5.7.2), will be simulated. The effect of pumping on the hydraulic heads and gradients in the alluvial aquifers will be compared to available data observational records.

6.2.1.4 GEOCHEMICAL AND FATE AND TRANSPORT MODEL(S)

As part of the modeling effort, an evaluation of geochemical processes that affect fate and transport of solutes such as adsorption/desorption, mineral precipitation and dissolution, and ingrowth and decay of radionuclides, will be performed. Additional data are being collected during site characterization that influence and control geochemical fate and transport considerations, and these data will affect the CSM. However, data evaluation may determine that certain processes are not relevant to COPC transport. Therefore, following consultation and approval by the USEPA, the Groundwater Modeling Work Plan will provide a plan to include and address the appropriate geochemical processes determination on which processes are appropriate for inclusion in the transport simulation.

6.2.1.5 ANTICIPATED CALIBRATION GOALS

While details will be developed in the Groundwater Modeling Work Plan, the model will be calibrated to historical water level and river stage measurements and allowed to reach equilibrium at steady state prior to calibrating with "current" conditions. Model calibration will also include transient hydrologic events, such as transient surface water-groundwater interactions, or changes in pumping conditions. In model calibration, simulated heads, fluxes, concentrations, and other model-computed variables are compared to field measured values and estimates (Woessner and Andersen 1992). Aquifer parameters and stresses are adjusted repeatedly to reduce the residual error between simulated and measured values. This process generally continues until the remaining residual errors are subjectively judged to be "acceptable."

The effort that is required in to calibrate a groundwater flow model is dependent upon the intended objective of the model (that is, the modeling objectives). The Groundwater Modeling Work Plan will provide more detailed calibration objectives.

6.2.2 GEOLOGIC DATABASE

A database that incorporates the geologic data is under development and near completion. This geologic database includes the historical dataset presented on Table 2-2. The database will be used to support the groundwater modeling efforts. As discussed in Section 5.2 and Section 5.4.3, additional local and regional historical hydrogeologic and hydrologic records within the preliminary groundwater modeling domain will be reviewed as part of this investigation. The USEPA-accessible database will be updated as new data become available and are incorporated. The results will be included in the Well Inventory Summary Report and the Groundwater Modeling Work Plan.

6.2.3 DATA EVALUATION

The data will be reviewed and compared to:

- Current USEPA MCLs
- ARARs
- MDNR Groundwater Protection Standards (GWPS)
- Current USEPA RSLs
- Ecological screening levels
- Other risk-based standards
- Background levels and concentrations of COPCs

Additionally, laboratory testing, geochemical evaluation or modeling, and other sources of site-related data will be evaluated to develop a more in-depth understanding of the landfill's geochemical conditions.

6.2.4 REFINEMENT OF THE CSM

Tasks will be conducted during and after site characterization to refine the CSM. Data will be evaluated and compiled into text, tables, figures, and 3-D visualizations to help identify and address data gaps, refine the current understanding of the hydrogeologic system, calculate a water balance for the hydrogeologic system, evaluate background groundwater quality, determine the extent of groundwater impacts, provide predictive tools/models to evaluate potential future impacts, and identify potential remedies as needed. Fate and transport processes will be evaluated to develop a representative CSM. Examples of figures and diagrams that will be created and updated to convey information include but are not limited to potentiometric surface figures, hydrogeologic cross-sections, isopach diagrams, Stiff diagrams, Piper diagrams, modified Stiff diagrams, and 3-D site visualizations. Data will be updated and evaluated iteratively to refine the CSM and database as new information becomes available. Additional data collection may be completed to support the Baseline Risk Assessment (described in Section 7.0) and groundwater model, which will be outlined within an addendum to this Work Plan.

6.2.5 GROUNDWATER MONITORING PROGRAM

Throughout the course of the OU-3 RI/FS process, the Respondents and USEPA will review data to evaluate where the constituents included in the routine groundwater monitoring program warrant continued monitoring. This may be done to: 1) reduce the number of analytes that are being analyzed during routine monitoring events, and to focus on those constituents that may be carried through to the risk assessment.

A decision regarding exclusion or inclusion of each of these constituents will be made based on the overall weight of evidence as to the potential for a constituent to present a risk to human health or the environment. For those constituents that are excluded based on this process, a narrative describing the rationale will be presented to the USEPA. The final selection of COPCs will be conducted by evaluating the analytical results using both qualitative and quantitative lines of evidence. This methodology is appropriate for the West Lake Landfill, since the site has historically accepted a wide range of waste. These following factors that will be considered for a recommendation for a COPC reduction:

- The COPC does not exceed current USEPA MCLs, ARARs, MDNR GWPS, or current USEPA RSLs over multiple monitoring events.
- The COPC does not exceed background COPC calculations, in accordance with Section 4.2.7 of the QAPP.
- The COPC is detected less than 5% of the time in a given study area.
- The COPC does not exceed screening levels or has not been detected historically.

The request to reduce the analytical suite will be submitted to USEPA, for their review and approval, prior to modifying the sampling plan.

6.2.5.1 EXCEEDANCE OF SCREENING LEVELS

The screening levels for groundwater include the current USEPA RSLs for water for both the total hazard quotient (THQ) of 1.0 and MCL for screening purposes (USEPA 2019c). Use of the USEPA RSL with the THQ of 1.0 or 0.1 will be determined based on the number of constituents detected in a given exposure area. The USEPA RSLs are conservative risk-based screening values because they assume a carcinogenic risk of 1E-06 and a noncarcinogenic hazard quotient of 1.0 or 0.1. For COPCs that are not detected, and for which the method detection limit is greater than the respective current USEPA RSL, the MDL will be used as the regulatory screening level.

If required, the indoor air removal management level (RML) for trichloroethylene (TCE) in air will be 6 micrograms per cubic meter ($\mu g/m^3$) for an industrial/commercial scenario (8-hour), 2 $\mu g/m^3$ for a residential scenario (24-hour), or as calculated for another specific exposure duration (USEPA 2016). For constituents other than TCE, the RMLs will be the most current USEPA RSLs for indoor air at a cancer risk of 1E-04 and a hazard quotient of 1. Subslab soil gas removal management levels will be derived by applying a generic attenuation factor of 0.03 to the indoor air removal management levels. To assess potential for vapor intrusion, screening levels for groundwater and exterior soil gas are based on a cancer risk of 1E-05, a hazard quotient of 0.1, and a groundwater temperature of 20°C to address the uncertainty of using exterior soil gas and groundwater concentrations to estimate indoor air concentrations. The attenuation factor for groundwater will be 0.001 (0.0005 for fine-grained soil) and the attenuation factor for soil gas remains 0.03. The need for subslab or exterior soil gas sampling will be evaluated in an addendum to the Work Plan.

6.2.5.2 EXCEEDANCE OF NATURAL BACKGROUND CALCULATIONS

For each constituent, a site-specific Background Threshold Value (BTV) will be calculated (See QAPP Section 4.0). The BTV will be compare the constituent concentration to the screening level. If the calculated BTV and RSL are less than the constituent concentration, the constituent will be retained as a COPC. If there is a COPC that exceeds the RSL, but is less than the BTV, then that constituent may not be retained as a COPC, but will be discussed in the Risk Assessment Work Plan.

6.2.5.3 DETECTION FREQUENCY

COPCs that are not detected at concentrations that exceed laboratory-reported detection limits will be compared to the detection limit of the respective screening levels. For detected COPCs, analytes with a detection frequency greater than 5% will be retained unless evidence of hot-spots or clustering or other concern related to the data (i.e. other secondary and tertiary qualitative lines of evidence) are observed.

6.2.5.4 OTHER FACTORS IN COPC SELECTION PROCESS

The other factors listed above (essential nutrients, mobility, persistence, and bioaccumulation, and concentration and toxicity) will also be considered as additional lines-of-evidence in the COPC selection or rejection process for those constituents with less than 5% detection frequency, no screening levels available, or small sample sizes (discussed in QAPP Section 4.0). For example, constituents with a frequency of detection (FOD) of less than 5% may be highly toxic, bioaccumulative, or mobile in the given environment for a specific receptor and would not be considered for removal as a COPC until further assessed as part of the Risk Assessment Work Plan.

7.0 BASELINE RISK ASSESSMENT

The results of the site characterization and the CSM will be used to evaluate whether the concentrations in the subsurface pose a risk to human health and the environment. The concentrations will be compared to the USEPA's most current RSLs, USEPA MCLs, and background concentrations.

For the purpose of the screening step for human receptors, the BRA will use the current USEPA RSLs for tapwater (USEPA 2019c) set to a cancer risk of 1E-06 and a non-cancer hazard quotient of 0.1 or 1, depending on the number of detected and co-occurring constituents. Central tendency and reasonable maximum exposure scenarios will be included in this analysis. The risk evaluation will also include a qualitative assessment of the bioaccumulative and cumulative effects for the COPCs.

The BRA will be used to evaluate the potential for receptors to be exposed to COPCs due to background groundwater quality. Background concentrations will be established through statistical methods. If COPCs exceed ecological or human health screening levels, then a comparison to background conditions will be completed so that background can appropriately be taken into consideration when evaluating potential risk to receptors.

The BRA will be comprised of the Human Health Risk Assessment (HHRA), the SLERA, and an ERA (if warranted). A BRAWP will be developed and submitted to the USEPA for their review and approval prior to beginning the human health and ecological risk assessments. The ERA will be completed in accordance with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997c). Information from this task will be incorporated into the RI/FS Report.

7.1 BASELINE RISK ASSESSMENT

A BRA will be conducted to assess the potential current and potential future human health and environmental risks posed by groundwater at, and near, the site in the absence of any remedial action. A separate BRAWP will be generated and submitted to USEPA for the human health and ecological risk assessments. Specifically, a regional and local background determination will be made to determine what portion of the overall COPC levels are likely attributable to site impacts versus local background concentrations. The data to support this effort will be sourced from the historical reports and databases, as well as the planned sampling efforts. The results will be subjected to statistical analysis to determine background levels for each COPC, as applicable and appropriate. Background levels will be part of the screening-level data evaluation. Site-specific BTVs will be determined for background COPCs and used in the screening-level as well as the baseline risk assessments (See QAPP Section 4.2.7).

Depending on the data richness for a given COPC and exposure area, the background assessment may consist of straightforward comparisons between the maximum/average/95% upper confidence limit exposure point concentrations and BTVs as well as statistical tests of significance between the site COPC concentrations and background levels. Information on background chemicals will be obtained from both the background samples and literature (e.g., USGS soil surveys for inorganic constituents). While the background assessment is typically conducted for inorganic analytes, some organic constituents such as PAHs may have local anthropogenic origins (i.e., atmospheric deposition, forest/grass fires, asphalt/road runoff). If the background and site concentration data suggest the presence of local anthropogenic inputs, the baseline risk assessment will assess the relative risk contribution of non-site sources to inform risk management decisions.

The risk assessments will be conducted according to the USEPA guidance, including the *Risk Assessment Guidance for Superfund (RAGS)* (USEPA 1989b). Part D tables will be included as part of the HHRA, per the USEPA RAGS Part D guidance (USEPA 2001b). This effort will involve four components: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization. The BRA will include a SLERA followed by an ERA if warranted. A preliminary CSM for the BRA is shown on Figure 3-16. These components of the BRA are described in the following subsections.

7.1.1 DATA COLLECTION AND EVALUATION

The site data will be compared to human health and ecological screening criteria. COPCs will be selected based on exceedances of screening levels, as described in RAGS Part A (USEPA 1989b), where maximum concentrations of chemicals detected at the site are compared to their respective current USEPA RSLs. Previous studies and investigations conducted for the site will be used in conjunction with data from the OU-3 investigation to determine the specific COPCs in groundwater. Ecological screening criteria will be submitted for review and approval in advance of completing screening level comparisons.

7.1.2 EXPOSURE ASSESSMENT

The magnitude of actual or potential human and ecological exposures, the frequency and duration of these exposures, and the pathways by which humans and ecological receptors are potentially exposed will be calculated. The existing and predicted nature and extent of impacts will be evaluated and these calculations compared to potential exposure pathways identified during the OU-3 well inventory and RI/FS process.

Potential ecological risk will be evaluated based on the nature and extent of connectivity of pathways between groundwater and surface water bodies within or in close proximity to the site and the conveyance of site-related constituents to those water bodies. Additional COPC migration pathways and the associated exposure scenarios may include:

- Surface soil runoff to sediments and, from there, to groundwater recharge zones
- Groundwater to sediments at discharge zones, where reverse flow occurs
- Migration of vapor-forming/particulate COPCs into the vadose zone

Hydrogeological data will be used to identify surface water bodies where site-related constituents could migrate. For surface water bodies in which there is no potential connection to groundwater, no further consideration of potential ecological exposure will be completed. For surface water bodies in which there is potential (historical, present, or future) connection to groundwater, constituent concentrations in groundwater from the closest groundwater well locations will be compared to freshwater ecological screening levels, recognizing that this is a conservative estimate of potential risk. Some COPCs will be identified for further evaluation and additional sampling of surface water and sediment. Additionally, the connection of surface water bodies to groundwater will be evaluated if results of the OU-1 sediment sampling in the drainage leading to the North Surface Water Body or the North Surface Water Body itself suggest sediment could leach to groundwater. The process for assessing the migration of vapors in the vadose zone was discussed in Section 5.4.18.3.

If necessary, the procedures for data collection to support an ecological assessment will be proposed as an addendum to this Work Plan. The addendum would include procedures for data collection and performing an ecological screening level evaluation. The resulting data would then be used to further define the list of COPCs.

A SLERA will be completed prior to the BRA after four complete rounds of groundwater data are available from the groundwater monitoring program. The scope of work for the SLERA will be outlined in an addendum to this Work Plan, which will consider the results contained in the existing SLERA, which was completed at the site (Auxier 2018). The results from the SLERA will be used to inform the OU-3 BRAWP scope of work.

7.1.3 TOXICITY ASSESSMENT

A toxicity assessment of those chemicals identified to be of potential concern will be conducted. The toxicity assessment will consider:

- The types of adverse health effects associated with chemical exposures as reported in literature reviews/compendia/databases and linked to the published toxicity reference values and/or screening levels.

- The relationship between magnitude of exposure and adverse effects, i.e., available dose-response information, threshold limits.
- Related uncertainties such as the weight of evidence, systematic review, and evidence-based toxicology of a particular chemical's effects on the receptors of interest.

The ecological toxicity assessment of the BRA will focus on potential constituents, ecological receptors, and habitats that may present, and the pathways by which exposure could potentially occur. Identifying complete exposure pathways, prior to a quantitative evaluation of toxicity, will allow the assessment to focus on only those contaminants that can reach ecological receptors. The assessment will account for exposure routes as they differ for ecological receptors and the specific chemical and physical properties of constituents that influence their relative toxicity for (1) different groups of organisms, and (2) exposure pathways and routes that are unique to those constituents. Other considerations will include federally and state-listed threatened and endangered species, in addition to the presence of sensitive environmental areas (including wetlands and other aquatic resources) both within and in close proximity to the site. Both direct and indirect exposure pathways will also be examined in conjunction with potential toxicity, with a focus on the assessment endpoint of populations of receptors.

For each complete exposure pathway, route, and contaminant, screening ecotoxicity values based on no observed adverse effect levels will be developed and proposed to USEPA in advance of performing a screen. After the screening level evaluation has been completed, exposure duration, bioaccumulation, bioavailability, and dose will be included into the quantification of risk. Finally, the uncertainty associated with these elements, as they impact toxicity, will be considered.

7.1.4 RISK CHARACTERIZATION

Outputs of the exposure and toxicity assessments will be summarized and combined to characterize the baseline risk, both in quantitative expressions and qualitative statements. During the risk characterization, chemical-specific toxicity information will be compared against both measured contaminant exposure levels and those levels predicted through appropriate modeling to determine whether current or future levels at and/or near the site are of potential concern. Further, the BRA shall be separated into two components: HHRA and ERA (if needed). Any modeling used to calculate contaminant exposure levels will be described in the BRAWP and approved by the USEPA prior to use.

7.1.5 HUMAN HEALTH RISK ASSESSMENT

The HHRA shall address:

- Hazard identification
- Dose-response
- Exposure assessment
- Risk characterization
- Limitations and uncertainties

7.1.6 ECOLOGICAL RISK ASSESSMENT

The ERA may be conducted based on results of the SLERA according to the 8-step ecological risk assessment process (USEPA 1997c):

- Screening-Level Problem Formulation
- Screening-Level Exposure Estimate and Risk Calculation
- Baseline Problem Formulation
- Baseline Study Design and DQO Process
- Baseline FSP Verification
- Baseline Site Investigation and Data Analysis
- Baseline Risk Characterization
- Risk Management

The BRA will be submitted to the USEPA as part of the RI Report. Additionally, the methods that are used to evaluate risks in this assessment will be consistent with current USEPA guidelines for HHRA and ERA at Superfund sites (USEPA 1997c; USEPA 2001b).

7.2 RI REPORT

The RI Report will summarize the findings of the RI process and provide information to assess risks to human health and the environment and, as warranted, support the development, evaluation, and selection of appropriate response alternatives. This task will be completed once sufficient data has been collected and fully evaluated and the CSM has been updated. The task includes all draft and final reports. The RI Report, at a minimum, will include the following sections.

7.2.1 INTRODUCTION AND SITE BACKGROUND

The RI Report will include an introduction and site background section that presents a brief description of the site, including the location, an overview of past and current operations, a summary of previous investigations, and a discussion of activities occurring adjacent to the site. A summary of pertinent information, which will expand upon Section 2 of this Work Plan will be provided.

7.2.2 STUDY AREA INVESTIGATION

Site characterization activities will be summarized in this section. The field investigation and technical rationale will be presented. Surface features, contaminant sources, surface water, geological, soil and vadose zone, groundwater, and ecological investigations will be compiled, and the analytical results will be provided.

7.2.3 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

An updated CSM will be presented in this section of the RI Report. The CSM will include geology, hydrogeology, geochemistry, meteorology, ecology, demographics, land use, and groundwater use in the area.

7.2.4 NATURE AND EXTENT OF CONTAMINATION

The results of the site characterization will be presented in this section of the RI Report. The COPCs in each of the media that were found as part of the remedial investigation will be discussed. Contaminant distribution and trends, and background groundwater quality will be included.

7.2.5 CONTAMINANT FATE AND TRANSPORT

Potential routes of migration, contaminant persistence, and contaminant migration will be reported in this section of the RI Report. If applicable, the estimated persistence of the COPCs in the study area environment and physical, chemical, and biological factors of importance for the media of interest will be reviewed. Factors affecting contaminant migration for the affected media of importance will be reviewed. The fate and transport modeling methods and results will be discussed. Future radium concentrations will also be estimated.

7.2.6 BASELINE RISK ASSESSMENT

Results of the BRA, including the HHRA and ERA (if conducted), will be included in this section of the RI Report.

7.2.7 SUMMARY AND CONCLUSIONS

A summary of the nature and extent of contamination, fate and transport and risk assessment will be presented in this section of the RI Report. Conclusions will include data limitations and recommendations for future investigations as well as recommended remedial action objectives.

8.0 FEASIBILITY STUDY

An FS will be conducted based upon the findings of the RI, once the results of the investigation are analyzed and complete. This work element includes the preparation and presentation of findings for potential remedial alternatives that have been screened and evaluated. The FS Report for OU-3 shall include, but is not limited to, a discussion of the following content.

8.1 INTRODUCTION AND BACKGROUND INFORMATION

This section will present the purpose and organization of the report and summarize the background information presented in the RI Report. The objectives of the Feasibility Study Objectives will also be presented.

8.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section will present the remedial action objectives for each medium of interest (e.g., groundwater, surface water, etc.). For each medium, the contaminants of interest, the allowable exposure based on risk assessment (including ARARs), and the development of remediation goals will be discussed. General response actions will be presented and for each medium of interest, and an estimation of areas or volumes will be described to which treatment, containment, or exposure technologies may be applied. For each medium of interest, an identification and screening of technologies will be discussed, and an evaluation will be performed for a selection of technologies.

8.3 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section will describe the rationale for the combination of technologies/media into alternatives. The screening of alternatives will present each option, provide a description, and discuss the evaluation.

8.4 DETAILED ANALYSIS OF ALTERNATIVES

Individual analysis of alternatives will be presented in this section, including, but not limited to, the presentation of the alternative, a description, and an assessment of the alternative. A comparative analysis will be presented for all of the alternatives, including institutional controls and screenings. This will include a summary and conclusions.

9.0 RI/FS REPORTING

This section summarizes the deliverables that will document the results of the OU-3 RI/FS at the site. Additional submittals may be added based upon the interactive scoping process, with ongoing USEPA approvals, that will continue throughout the project. The deliverables required during the course of the project, will be initially submitted to the USEPA as draft documents. Following the receipt of USEPA's comments, the documents will be revised as needed and submitted in final form for approval by USEPA. A summary of the submittals, including a schedule for each submittal, is provided in Section 10.3.

9.1 WELL INVENTORY SUMMARY REPORT

The Well Inventory Summary Report will provide a narrative summary of each well's current condition. The summary will include survey and GPS coordinates; construction details on the existing site wells; and any redevelopment, repair, or abandonment of existing wells that were completed as part of the well inventory.

The report will document off-site wells identified during the review of historical local and regional studies outlined in Section 5.2. The Well Inventory Summary Report will be used to document findings that could affect the usability of historical on-site and off-site data; the evaluation of historical data usability will be conducted on an as-needed basis prior to the use of the historical data. The adequacy of the existing and proposed OU-3 monitoring network will be presented and off-site wells will be identified. Recommendations for replacement of abandoned wells will be included.

Following the USEPA's review and approval of this report, the unsuitable or inoperative wells will be replaced or abandoned according to applicable state requirements. Recommendations will be provided to address identified data gaps at the abandoned well locations. Additional monitoring wells may be proposed in addenda to this Work Plan.

9.2 WORK PLAN ADDENDA

Addenda to this Work Plan will be submitted to the USEPA for their review and approval to allow for a flexible, iterative, and collaborative approach to the OU-3 RI/FS. Data collected and evaluated during site characterization will be presented to USEPA and used to inform decisions on how to proceed to adequately answer the PSQs. If Work Plan addenda require data collection procedures are not included in Work Plan and FSP, the addenda will include supplemental field procedures and revised DQOs as appropriate. Currently anticipated addenda are summarized in the following subsections.

9.2.1 PHASE II MONITORING WELL INSTALLATION ADDENDUM

This addendum may be submitted to propose recommended changes to the currently anticipated Phase II monitoring well locations, including the bedrock wells within the 500-series wells and the four piezometers described in Section 5.3.3. This addendum will refer directly to this Work Plan for procedures and will consist of a brief narrative, and a figure that summarizes the rationale for the revised locations for the Phase II monitoring wells.

9.2.2 STEP-IN/STEP-OUT ADDENDUM

This addendum will be submitted after one interim round of groundwater data from the existing wells and a portion of the Phase I wells has been collected, analyzed by the laboratory and validated; however, the need for additional step-in/step-out addenda will be evaluated as part of each groundwater monitoring event in order to make informed decisions outlined in Section 5.3.2.5 to facilitate a continuous well installation program. In order to facilitate rapid agency review, this addendum is anticipated to consist of a brief letter and figure with proposed new well locations. The addendum will be submitted to USEPA for review and approval prior to proceeding with the proposed additional wells. Step-in/step-out wells will be installed based on the procedures, outlined in Section 5.3.2.5.

9.2.3 VAPOR INTRUSION ADDENDUM

The potential for radon gas migration is currently being evaluated as part of the OU-1 scope of work. Landfill gas migration is currently being evaluated as part of the OU-2 scope of work. Therefore, this addendum scope will be submitted after review of the results of these investigations, as well as the results from the proposed groundwater sampling and onsite indoor air testing. The scope of work for the vapor intrusion addendum could include additional onsite vapor sampling (indoor air, subslab, nearslab) and offsite vapor sampling as described in Section 5.4.18.

9.2.4 SEDIMENT PORE WATER/SEDIMENT/SURFACE WATER ADDENDUM

Sediment is currently being evaluated as part of OU-1 activities. Results from this assessment will be evaluated prior to determining the scope of work for potential sediment pore water/sediment/surface water sampling. In addition, data from groundwater and surface water bodies will be evaluated to determine where there may be a hydraulic connection and discharge from groundwater to surface water and vice versa. As a preliminary screening step, constituent concentrations in the groundwater well, in closest proximity to potential surface water exposure points, will be compared to freshwater ecological screening criteria to develop a preliminary COPC list.

This addendum will detail the plan for collecting sediment pore water, sediment, and surface water samples from surface water bodies that are hydrologically connected to groundwater. The sampling plan will be developed to characterize constituent concentrations at exposure points identified within a CSM that includes both terrestrial and aquatic receptors.

9.2.5 SLERA ADDENDUM

Additional information from the landfill gas evaluation and sediment sampling for OU-1 and perimeter landfill gas sampling for OU-2, as well as the initial groundwater elevation and groundwater quality data, will be evaluated to determine the scope of work for the SLERA. The SLERA Addendum will outline the procedures for screening-level problem formulation and ecological effects, screening level exposure estimates and risk calculation, and decision points for whether an ERA is needed.

9.3 ANNUAL HYDROGEOLOGIC INVESTIGATION AND GROUNDWATER CHARACTERIZATION REPORT

An Annual Hydrogeologic Investigation and Groundwater Characterization Report will be submitted on March 1 of each calendar year to summarize the prior year's results of the hydrogeologic investigation and groundwater characterization activities necessary to support the CSM, groundwater model, and other remedial investigation tasks at, and near, the site. Monthly potentiometric surface and flow figures will also be provided to USEPA as an informal deliverable on a quarterly basis within 60 days from completion of monthly data collection for that quarter. Development of groundwater recharge/flow and evaluation of natural attenuation processes will be performed in accordance with approved planning documents.

Results from the sampling program will provide a detailed estimate of the horizontal and vertical distribution of contaminants, the mobility of contaminants, estimates of attenuation rates from well transects, and prediction of long-term disposition of contaminants. This will include the collection of sufficient data in, and near, the site to produce a statistically valid range of background concentrations of COPCs and a statistically valid baseline range of contaminant concentrations and geochemistry parameters. This effort may provide a means to potentially differentiate leachate-induced and landfill gas-induced effects on water quality from background concentrations onsite, or near, the site.

9.4 GROUNDWATER MODELING WORK PLAN

As noted above in Section 6.2, the Groundwater Modeling Work Plan will establish the approach, and methods, for groundwater modeling, and will incorporate relevant site data available at the time of preparation. The Groundwater Modeling Work Plan will be based on a revised CSM that incorporates existing data and site information and will follow USEPA guidance (USEPA 2002). The Groundwater Modeling Work Plan will address the simulation of both groundwater flow and the fate and transport of COPCs.

The Groundwater Modeling Work Plan will describe the modeling software to be used, the conceptual model of the flow system and how it will be represented in the modeling software to include: the extent of the model area, model discretization (number of model layers, cell size, stress period lengths), model boundaries and boundary conditions (recharge, faults, streams, springs, lakes, no flow, head dependent, etc.), model calibration (manual and/or parameter estimation, closure criteria, rules for comparison of simulated and measured head and flow targets), model stresses (historical and future pumping, recharge, river stage changes, lake stage changes, impervious surface changes, etc.), model aquifer and confining unit hydraulic properties, and predictive scenarios to be evaluated.

The Groundwater Modeling Work Plan will also address methods to be used for corroborating data that supports model construction or calibration, and for sensitivity analysis and uncertainty analysis. The Groundwater Modeling Work Pla*n* will detail how the model will be used to simulate contaminant transport, describe the methods of determining calibration and predictive uncertainty in the model, and model archival processes. The groundwater model will also be used to further update the CSM and to evaluate current site conditions, provide future prediction simulations on potential long-term groundwater impacts, and assist with the placement of additional monitoring wells for long-term understanding of groundwater.

9.5 GROUNDWATER MODELING REPORT

The Groundwater Modeling Report will document the groundwater modeling approach and outputs. It will include the modeling software used, the conceptual model of the flow system and how it was represented in the modeling software based on model extent, model discretization, model boundaries and boundary conditions, model calibration, model stresses, model aquifer and confining unit hydraulic properties, and predictive scenarios that were evaluated. The report will also detail how the model was used to simulate contaminant transport, describe the methods of determining calibration and predictive uncertainty in the model, and model archival processes. The report will: provide an updated CSM; evaluate current site conditions; provide future prediction simulations on potential long-term groundwater impacts; discuss the findings of data corroboration, sensitivity analysis, and uncertainty analysis; and assist with the placement of additional monitoring wells for long-term understanding of groundwater.

9.6 OU-1 AND OU-2 REPORTING

Although the individual Operable Unit planning documents include details regarding groundwater monitoring, the groundwater monitoring activities, including but not limited to installation and development of additional monitoring wells, water level data collection, groundwater sample collection and analysis, laboratory data validation, well hydrograph and potentiometric surface map preparation, and similar tasks, will be performed as part of the OU-3 investigations. Data collected by the OU-3 investigations for monitoring wells specifically identified for either the OU-1 or the OU-2 groundwater monitoring program will be provided to the OU-1 and OU-2 teams so that such data can be assembled, tabulated, and evaluated, as appropriate, to meet the specific requirements of the OU-1 and OU-2 groundwater monitoring programs (e.g., assembly and evaluation of baseline data sets). The OU-1 and OU-2 reporting will be conducted using the laboratory analytical reports, and pre-validated analytical data; and as required by the AOCs for the three OUs. The reporting will be achieved through submission of the laboratory analytical reports and EDDs for the OU-3 monthly reports.

9.7 BASELINE RISK ASSESSMENT WORK PLAN

A BRAWP will be prepared following the completion of the Annual Hydrogeologic Investigation and Groundwater Characterization Reports, the Groundwater Modeling Report, and additional field investigation to sufficiently characterize the site. Data gaps, relevant to the risk assessment, that are identified based upon the review of the groundwater characterization and modeling, as well as the nature and extent of COPC pathways between groundwater and surface water, rainwater drainage conveyances, surface soil runoff-impacted sediments at recharge and discharge zones, and vapor-forming/particulate COPCs in the vadose zone, if any, will be identified and discussed in the BRAWP.

The nature of the data gap analysis will consist of assessing the results and conclusions of the Annual Hydrogeologic Investigation and Groundwater Characterization Reports, and the Groundwater Modeling Report in the context of the needs of human health and ecological risk assessments. Specifically, each report will be reviewed by the human health and ecological risk assessors to gauge the quality and quantity of the various exposure media data (i.e., groundwater, sediment, porewater, and vadose zone soil gas) and information on the potentially complete exposure pathways. For example, if groundwater modeling shows that there is a complete exposure pathway to surface water and sediments, the ecological risk assessment will need to address potential aquatic receptors. Similarly, if there is potential presence of vapor-forming COPCs in soil gas, burrowing animal vadose zone exposure assessment will be considered outside the waste disposal units using quantitative methods. A draft CSM, including potential exposure pathways, is included as Figure 3-16.

The BRAWP will discuss, in detail, the data, exposure assessment, hazard evaluation, and risk assessment for USEPA's review and approval. Briefly, the BRAWP will include a section on data availability and usability for the risk assessment, latest CSM that identifies potentially-complete exposure pathways, media, and routes, toxicity reference values, risk and hazard thresholds, selection of COPC methodology, exposure equations and inputs, and exposure units and exposure point concentration statistical methods as recommended by RAGS and other USEPA risk assessment guidance.

9.8 RI REPORT

After completion of all phases of the RI, a comprehensive RI report will be prepared to present and evaluate the data for meeting the stated objectives of the RI. The RI report will include the site background, investigation, site characteristics, nature and extent of contamination, fate and transport evaluation, and the results of the BRA. The RI Report will be prepared in accordance with the Work Plan and SOW.

9.9 FEASIBILITY STUDY REPORT

A FS Report will be prepared to document the process if a FS is deemed appropriate. The FS Report will be consistent with the most recent USEPA guidelines. The FS Report will include detailed evaluation of alternatives as discussed in Section 8.0.

10.0 PROJECT MANAGEMENT PLAN

A project management plan (PMP) was developed for internal use by the OU-3 RI/FS project team. The PMP includes the work breakdown structure, personnel resources loading, project team roles and responsibilities, project communication, document distribution, subcontracted services, materials, and equipment, which will be implemented to assist the OU-3 Respondents and USEPA with the RI/FS process. The proposed project personnel, coordination plan with USEPA and project schedule is summarized in this section.

10.1 PROJECT PERSONNEL

OU-3 Respondents designated Trihydro Corporation as the contractor for overall support of the RI/FS process. A team of individuals and subcontractors will provide additional support and be involved in the collection, management, and evaluation of data. Project team members will have designated responsibilities throughout the RI/FS process. Detailed descriptions of the roles and responsibilities is included in Section 2.0 of the QAPP. Personnel with designated responsibilities are shown on Figure 10-1.

10.2 COORDINATION WITH USEPA

Community involvement activities, to support the USEPA, will be provided by the OU-3 Respondents, as requested by USEPA. The USEPA will provide information and direction regarding the need for support within the community as the OU-3 investigation progresses. The support will largely focus on communications with community members and other stakeholders as OU-3 related milestones and associated information becomes available.

10.3 PROJECT SCHEDULE

A proposed schedule in Microsoft Project format that details proposed investigative work, such as new well and piezometer installations, groundwater sampling, and vapor sampling upon approval of the RI/FS Work Plan is included as Figure 10-2. The schedule will be updated upon final Work Plan approval, and then monthly, thereafter, throughout the life of the project. Details regarding planned sampling events and/or supplemental sampling events will be included with the FSP or included with other project documents.

Milestones for the major project tasks are currently estimated as follows based on the assumption that the OU-3 RI/FS Work Plan will be approved by July 1, 2020:

- Initial Tasks (Well Inventory, Staff Gauge Installation, Access Agreements, Permitting, Fluid Level Monitoring) – Spring 2020 pending USEPA approval to expedite tasks

- Well Inventory Summary Report – Summer 2020
- Interim Groundwater Sampling – Summer 2020 and Early 2021*
- Quarterly Groundwater Sampling – Spring 2021 through Summer 2022*
- Phase I and II Well Installation – Summer 2020 – Spring 2021*
- Addendum to RI Work Plan – Late 2020
- Additional RI Well Installation – Spring 2021*
- Groundwater Modeling Work Plan – Late 2021
- Groundwater Modeling Report – Early 2023
- Baseline Risk Assessment Work Plan – Fall 2022
- RI Report – Late 2023
- Baseline Risk Assessment Report – Late 2023
- Feasibility Study – Spring 2025

**Major field events denoted with an asterisk.*

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TABLES

TABLE 1-1. DOCUMENT DIRECTORY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Scope of Work	WP Section	FSP Section	QAPP Section
Project Background and Setting	2.1, 2.2, 2.3, 2.4	1.1, 1.2	--
Project Personnel and Team Responsibilities	10.1, Figure 10-1	1.5, Figure 1-7	2.0, Figure 2-1, Table 3-1
Project Schedule	10.3, Figure 10-2	7.0	Table 3-1
Historical Datasets	2.5	--	Table 3-1
Conceptual Site Model	3.0	--	3.1.2, Table 3-1
Data Quality Objectives	4.1, 4.2	1.3	3.0, Table 3-1
Field Instrument Calibration	5.1.2	4.0	5.1.5.1
Compile Existing Data	5.2	3.20	4.2, Table 3-1
Existing Monitoring Well Network	5.3.1, Figure 5-1, Appendix B	3.2	Table 3-1
Proposed Monitoring Well Network	5.3, 5.3.2, 5.3.3, 5.3.4, and Figures 5-2 through 5-5	3.5	5.0, 6.0, and 7.0[1]
Phased Approach	1.1, 4.0, 4.3, 5.0, 5.3.2.1, 5.4.1	1.3	1.2
Site Reconnaissance, Well Inventory, Repair, Replacement, and Abandonment	5.4.3, 5.4.4, 9.1	3.2, 3.11	--
Hydraulic Profiling Tool Pilot Test	5.4.5	3.5.2.1, Appendix H	5.0, 6.0, and 7.0[1], Table 3-1
Drill Rig Selection	5.4.6	3.5.2	--
Continuous Coring and Field Logging	5.4.7	3.5.2.2, 3.5.2.3, Appendix H and I	Table 3-1
Alluvium and Bedrock Aquifer Matrix Sampling	5.4.8	3.6, Appendix I	5.1.2.1.2, Table 3-1
Borehole Geophysical Logging	5.4.9	3.7, Appendix H	Table 3-1
Packer Testing	5.4.10	3.8	Table 3-1
Monitoring Well Installation	5.4.11	3.9, Appendix K	Table 3-1
Monitoring Well Development	5.4.12	3.10, Appendix K	Table 3-1
Slug Testing	5.4.13	3.12, Appendix L	Table 3-1
Aquifer Pumping Test	5.4.14	3.13, Appendix L	Table 3-1
Water-level Measurements	5.4.15.1	3.16, Appendix F	Table 3-1
Monitoring Well Purging	5.4.15.2	3.14.1, 3.14.2, Appendix K	Table 3-1
Monitoring Well Sampling	5.4.15.3	3.14.3, Appendix K	5.1.2.1.1, Table 3-1
Staff Gauge Installation	5.4.16, Figure 5-6	3.17	Table 3-1
Leachate Collection System Sampling	5.4.17	3.15	5.1.2.1.1, Table 3-1
On-site Vapor Intrusion Assessment	5.4.18, Figure 5-10	3.18, Appendix M	5.1.2.1.3, Table 3-1
Ecological Survey	5.4.19	3.19	--
Surveying and Mapping of the Investigation Areas	5.4.20	3.4	5.1.2.1.4, 5.3.3, 6.1.4, 6.2.3, 7.1.2.5

TABLE 1-1. DOCUMENT DIRECTORY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Scope of Work	WP Section	FSP Section	QAPP Section
Investigation Derived Waste	5.4.21	6.0	--
Decontamination Procedures	5.4.21	5.0, Appendix N	6.1.1
Additional Site Characterization	5.4.22	--	Table 3-1
Groundwater Modeling and Fate and Transport	5.5, 6.2.1	--	Table 3-1
Health and Safety (see Health and Safety Plan)	5.7	--	--
Data Management	6.1	--	5.3
Data Validation	6.1.1	--	4.1, 4.2, 7.0
Project Database	6.1.2, 6.2.2	--	5.3
Spatial Data	6.1.3	--	5.1.2.1.4, 5.3.3, 6.1.4, 6.2.3, 7.1.2.5
Field Logbooks	6.1.4.1	3.21.1, Appendix A	3.11
Field Datasheets	6.1.4.2	3.21.2, Appendix A	3.11
Data Evaluation	6.2	--	4.0, Table 3-1
Baseline Risk Assessment and RI Report	7.0	--	4.0, Table 3-1
Feasibility Study	8.0	--	--
RI/FS Report	9.0	--	--

Notes:

This table is not meant to be all inclusive but as a guide to help find the major components of these Scope of Work Items. Tables, Appendices, and Figures were only referenced if they contained a large portion of the information for that component.

1: Section 5.0, 6.0, and 7.0 of the QAPP addresses groundwater, leachate, alluvium, bedrock and vapor in the following sections:

5.1.1 - Sample Handling and Custody, 5.1.2 - Analytical Methods, 5.1.3 - Quality Control, 5.1.4/5.1.5 - Field Instrument/Equipment Procedures. 5.1.6 - Supplies and Consumables, 5.3 - Data Management, 6.1.1 - Field Audits, 6.2.1 - Field Data Reporting, 7.1.1 - Field Data Validation

Highlighted column indicates where the majority of information for that topic is discussed.

Abbreviations:

FSP: Field Sampling Plan

QAPP: Quality Assurance Project Plan

WP: Work Plan

RI: Remedial Investigation

FS: Feasibility Study

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Year(s)	Investigation Conducted for:	Description
1973	West Lake Landfill	Four wells at unknown locations were sampled for five sampling rounds; samples were analyzed for general inorganic parameters, metals, and phenol.
1976	West Lake Quarry	Three wells along the western property boundary were sampled in one sampling round; samples were analyzed for general inorganic parameters, metals, and phenol.
1976-1984	West Lake Quarry	Wells around the perimeter of the inactive landfill on the western portion of the site, and after 1981 near the leachate retention pond, were sampled intermittently. Samples were analyzed for a varying list of parameters which included general inorganic parameters, ions, metals, and radionuclides.
1979-1982	Missouri Department of Natural Resources	Wells around the perimeter of the inactive landfill and the perimeter of the site, as well as site surface water bodies and off-site private wells, were sample intermittently. The samples were analyzed for a varying list of general inorganic parameters, ions, metals, and radionuclides.
1982	Nuclear Regulatory Commission	The Radiological Survey of the West Lake Landfill, St, Louis County, Missouri identified two areas of radiological contamination on-site, and concluded that there is no indication of off-site migration of the contaminants.
1983	College of Engineering, University of Missouri-Columbia	The Engineering Evaluation of Options for Disposition of Radioactively Contaminated Residues Presently in the West Lake Landfill, St. Louis County, Missouri, Draft identified radiological contamination and concluded that radon gas release from the site would increase.
1984	Nuclear Regulatory Commission	The perimeter berm around the northern extent of the site was surveyed for radiological contamination and inspected for erosion. Migration of contamination and slope failure were observed on selected portions of the berm west of OU-2 Area 2.
1986	West Lake Landfill	Existing and new wells around the inactive landfill on the western portion of the site, and the leachate retention pond, were included in a thorough hydrogeologic investigation. The hydrogeologic characterization concluded that three levels of the alluvial aquifer (shallow, intermediate, and deep) were in complete communication, and that groundwater flow was generally towards the northwest. Groundwater samples were collected and analyzed for volatile organic compounds, acid-base neutral extractables, pesticides and polychlorinated biphenyls, phenol, cyanide, and metals. Concentrations of certain parameters exceeded applicable standards, but the distribution was erratic and generally could not be attributed specifically to site activities. Concentrations of parameters which exceeded standards were likely to be diluted below standards prior to exposure to any downgradient uses.
1986	Nuclear Regulatory Commission	Eighteen groundwater monitoring wells were sampled and analyzed for radionuclides.
1989 and 1991	USEPA	A review of historical aerial photographs, from 1941 through 1991, was conducted to identify areas of potential environmental concern. Solid waste and mine spoils areas were identified.

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Year(s)	Investigation Conducted for:	Description
1989 to Present	Laidlaw Waste Systems	Groundwater samples were collected from wells throughout the site on an intermittent basis, focusing specifically on wells around the active landfill area in recent years. Samples were analyzed for a variable list of parameters, including general inorganics, metals, radionuclides, volatile organic compounds, pesticides, herbicides, polychlorinated biphenyls, cyanide, and phenol.
1990-1991	Earth City Industrial Park	An investigation of potential radiological impacts to neighboring properties was conducted in three phases. Radiological contamination reportedly originating from OU-1 Area 2 was identified in soils at two hot spots near the property boundary.
1991	Agency for Toxic Substances and Disease Registry	A review of available information concluded that the site presented no apparent health hazard, although exposure could occur if groundwater contamination increased and migrated off-site.
1991	Laidlaw Waste Systems	A subsurface soil gas survey conducted in the vicinity of MW-F2 identified BTEX and TPH impacts to subsurface soils in an area extending 150 feet north and 300 feet south of MW-F2.
1992	Laidlaw Waste Systems	An environmental investigation for the development of a site Health and Safety Plan identified radon in the landfill gas collection system.
1992	Laidlaw Waste Systems	The slope of the berm along the western portion of the inactive landfill was reworked to 3H:1V slope, recovered, and revegetated.
1993	Laidlaw Waste Systems	A health impact assessment concluded that radiological contaminants from site sources were not a threat to site workers, the general public, or the environment.
1994	Laidlaw Waste Systems	A health assessment analyzed chemical constituents of the landfill gas collection system and concluded that landfill gas composition was similar to EPA-reported averages, and that exposures to site workers were below analytical detection limits.
1994	OU-1 Respondent Group	An overland gamma survey conducted in and in the immediate vicinity of OU-1 identified radiologically-contaminated hot spots both inside and outside of OU-1 boundaries, and recommended alteration of those boundaries.
1996	Laidlaw Waste Systems	A hydrogeology study of the West Lake Landfill site and proposed sampling locations for groundwater, leachate, surface water and sediments.
1996	West Lake Respondent Group	A study of the installation of groundwater monitoring wells, collection of groundwater samples, groundwater elevation monitoring, and aquifer testing in and adjacent to Radiological Areas 1 and 2 at the West Lake Landfill.
1997	West Lake OU-1 Respondents Group	A summary to present the various site characterization activities for use in completing the RI, BRA and FS for OU-1. Summarized investigative activities that have taken place, description and display of the data documenting the location and characteristics of subsurface and surface features, description and display of the data documenting contamination at the Site including the affected media, location, types, physical state, contaminant concentrations and quantities, and documentation of the location, dimensions, physical condition, and varying concentration of each contaminant throughout each source and the extent of contaminant migration through each of the affected media.

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Year(s)	Investigation Conducted for:	Description
1997	Allied Waste Industries, Inc.	Results of site characterization activities conducted as par of the West Lake Landfill OU-2 RI/FS. A review of investigative activities that have taken place, a description of data collected to document the location and characteristics of surface and subsurface features and contamination including affected media, location, types, physical state, concentration of the contamination, and quantity, and the location, dimensions, physical condition and varying concentrations of each contaminant throughout each source and the extent of contaminant migration through each of the affected media.
2000	West Lake OU-1 Respondents Group	Presents the results of the various site cauterization activities for OU-1 at the West Lake Landfill. The report summarizes the results of field activities conducted to characterize the conditions at the Site, the sources of contaminants, the nature and extent of contaminants and associated impacts, and the fate and transport of the contaminants.
2005	Allied Waste Industries, Inc.	Present the results of the various site characterization activities for OU-2 at the West Lake Landfill and summarize the results of the activities being conducted to characterize site physical and biological characteristics, sources of contamination, site hydrogeologic conditions, quality of groundwater, surface water and sediments, and prepare a conceptual site model that identifies contaminant migration pathways and potential receptors.
2006	West Lake OU-1 Respondents Group	Feasibility study for OU-1 at West Lake Landfill to develop an appropriate range of waste management options that ensure the protection of human health and the environment and to assess each alternative.
2008	West Lake OU-1 Respondents Group	ROD for OU-1 at West Lake Landfill. Presents the selected remedy from the EPA, and accepted by the MDNR. The major components are installation of a landfill cover, consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroad Property to the containment area, apply groundwater monitoring and protection standards, surface water runoff control, gas monitoring and control, institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill containing long-lived radionuclides, and long term surveillance and maintenance of the remedy.
2008	Allied Waste Industries, Inc.	ROD for OU-2 at West Lake Landfill. Presents the selected remedy from the EPA, and accepted by the MDNR. Major components for the Inactive Sanitary Landfill are install landfill cover, apply groundwater monitoring and protection standards, surface water runoff control, gas monitoring and control, institutional controls to prevent land uses, and long term surveillance and maintenance of the remedy.
2011	West Lake Landfill OU-1 Respondents	The SFS was performed to provide additional evaluation of a select group of potential remedial alternatives for OU-1 at the West Lake Landfill. The EPA requested the SFS consisting of an engineering cost and analysis of the ROD selected remedy, and two remedial alternatives that would remove all material containing radionuclides at levels greater than those that would allow for unrestricted use of the radiologically contaminated areas in OU-1.
2015	USEPA, Region 7	Administrative report prepared by the USGS for the groundwater quality and potential origin of radium at the West Lake Landfill.

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Year(s)	Investigation Conducted for:	Description
2015	Missouri Geological Survey	Groundwater investigation report summarizing existing groundwater data (as of 2015) and conducting additional investigation to determine if groundwater near landfill has been impacted by landfill operations. Focus on south quarry area. In addition to review of previously collected groundwater level and water quality data, five monitoring wells were installed on private property adjacent to BSLF site. Water quality sampling was conducted at the five newly installed wells as well as in 18 existing BSLF monitoring wells.
2016	Bridgeton Landfill, LLC	Technical report regarding the West Lake Landfill's groundwater monitoring network that evaluates groundwater quality at monitoring wells that are located near the North and South Quarry, but are not currently sampled as part of the facility's detection or assessment monitoring programs and an evaluation of the facility's current groundwater monitoring well network.
2017	Bridgeton Landfill, LLC	Evaluation report prepared as a follow-up to 2016 technical report and the additional groundwater monitoring performed at the facility in 2017.
2018	West Lake OU-1 Respondents Group	OU-1 ROD Amendment that provided an Amended Remedy based on a better understanding of the volume, concentration and location of RIM that may present an unacceptable risk, new information regarding the potential for RIM to leach under certain circumstances, concern that should a subsurface heating event occur, the heat could dry and desiccate a cap providing a conduit for increased release of radon from the subsurface and potentially for the leaching of RIM, and a determination that implementation of the 2008 ROD could not be accomplished without disturbance of both putrescible waste and RIM.
2018	West Lake OU-1 Respondents Group	RI Addendum to update discussion of the Site conditions, nature and extent of radionuclide and chemical occurrences, and other evaluations presented in the original RI for OU-1.
2018	West Lake Landfill OU-1 Respondents	Final FS for OU-1 which incorporates four additional measures or performance standards from the EPA, which are: the proposed landfill cover should meet UMTRCA guidance for a 1,000-year design period including additional thickness as necessary to prevent radiation emissions, air monitoring station for radioactive materials should be installed on-site and off-site, groundwater monitoring should be implemented at the waste management unit boundary and also at off-site locations, and flood control measures should meet or exceed design standards for a 500-year storm event under the assumption that the existing levee system is breached.

Abbreviations:
- BRA: Baseline Risk Assessment
- BTEX: Benzene, Toluene, Ethylbenzene, and Xylene
- USEPA: United States Environmental Protection Agency
- FS: Feasibility Study
- MDNR: Missouri Department of Natural Resources
- MW: Monitoring Well
- OU: Operable Unit
- RI: Remedial Investigation
- ROD: Record of Decision
- SFS: Supplemental Feasibility Study
- TPH: Total Petroleum Hydrocarbons
- UMTRCA: Uranium Mill Tailings Radiation Control Act
- USGS: United States Geological Survey

TABLE 2-2. DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Date Ranges	Groundwater Elevations	Analytical Data	Surface Water Elevations	St. Charles USGS River Gauge Elevations	Field Parameters	Slug Tests	Packer Tests	Borehole Logs and Well Construction Diagrams	Report ID Pertinent to Date Ranges
1976-1986	1,053	8,113	-	728	496	-	-	21	1979, Reitz & Jens Inc., Historic Fluid Levels
									1986, Burns & McDonnell, Hydrogeologic Investigation Report
1987-1996	2,053	13,847	28	3,410	94	77	49	86	1989, NRC, Site Characterization and Remedial Action Concepts
									1996, Golder, Physical Characterization Technical Memorandum
									1996, McLaren Hart, Groundwater Conditions Report WLL Areas 1 and 2
1997	277	17,536	109	360	353	-	-	-	1997, EMSI, Site Characterization Summary Report OU-1
									1997, Water Management Consultants, WLL OU-2 RI/FS Site Characterization Summary Report
1998-2011	1,502	46,257	-	5,005	2,188	-	-	-	2000, EMSI, OU-1 RI
									2005, Herst & Associates, OU-2 RI
									2006, EMSI, OU-1 FS
									2008, OU-1 & OU-2 ROD
									2011, EMSI, Supplemental FS
2012-2018	1,927	137,011	-	2,459	4,325	-	-	14	2015, USGS, Background Study
									2015, MGS, Groundwater Investigation Report
									2013, Herst & Associates, Groundwater Statistical Analysis Semi-Annual Report
									2015, Herst & Associates, Quarterly Assessment Monitoring Event Reports (3)
									2016, Feezor Engineering, Groundwater Technical Report
									2016, Feezor Engineering, Quarterly Assessment Monitoring Event Reports (4)
									2016, Jett Environmental Consulting, Quarterly Groundwater Statistical Analysis Reports (4)
									2017, Feezor Engineering, Quarterly Assessment Monitoring Event Reports (4)
									2017, Jett Environmental Consulting, Quarterly Groundwater Statistical Analysis Reports (4)
									2017, Jett Environmental Consulting, Groundwater Annual Assessment Monitoring Report
									2017, Feezor Engineering, Groundwater Evaluation Report
									2018, EMSI, OU-1 RI Addendum
									2018, EMSI, OU-1 Final FS
									2018, USGS St. Charles Stream Gauge Historical Records
Totals:	**6,812**	**222,764**	**137**	**11,962**	**7,456**	**77**	**49**	**121**	

Abbreviations:
EMSI: Engineering Management Support, Inc
FS: Feasibility Study
MGS: Missouri Geological Survey
NRC: Nuclear Regulatory Commission
OU: Operable Unit
RI: Remedial Investigation
USGS: United States Geological Survey
WLL: West Lake Landfill

TABLE 3-1a. GENERALIZED STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

System	Series	Group	Symbo	Formation	Thickness (ft)	Description	Dominant Lithology	Water-Bearing Character
Quaternary	Holocene	-	Qal	Alluvium	10-215	Sand, gravel, silt, and clay on floodplains of major rivers and smaller streams	Sand, gravel, silt, and clay	Some wells yield over 2,000 gpm.
	Pleistocene	-		Loess Glacial Till	1-110 0-55	-	Silt Pebbly clay and silt	Not water yielding.
			Qt	Terrace Deposits	-	Sand, gravel, and silt	Sand, gravel, and silt	-
Tertiary	Pliocene or Miocene	-	Tg	Grover Gravel	-	High level deposits of gravel, sand, and clay	Rounded, polished, light-brown chert pebbles	-
Pennsylvanian	Missourian	Pleasanton	Pp	Undivided	0-100	Shale and sandstone	Shales, siltstones, "dirty" sandstones, coal beds, and thin limestone beds.	Generally yields very small quantities of water to wells between 0 to 10 gpm.
	Desmoinesian	Marmaton	Pm	Undivided	80	Intercalated shale, limestone, clay, and coal		
		Cherokee	Pc	Undivided	0-100	Cycles of sandstone, siltstone, shale, clay, and coal		
		Atokan		Cheltenham Formation	Unknown	-		
Mississippian	Meramecian	-	Msg	Ste. Genevieve Limestone	0-150	White, massive, coarsely crystaline, sandy, clastic limestone with oolitic beds and gray, black, or red chert. Some fine grained calcaerous sandstones separated by argillaceous limestone present in the upper part of the formation.	Argillaceous to arenaceous limestone	Yields small to moderate quantities of water to wells ranging between 5 to 50 gpm. Higher yields are reported locally.
			Msl	St. Louis Limestone	100-250	Dark-gray, finely crystalline to lithographic, thin- to medium-bedded to massive limestone with thin beds of bluish gray shale. Also contains dolomite, cherty limestone, fossiliferous limestone, and evaporites. Some beds are sandy and cross laminated		
			Ms	Salem Formation	70-180	Fossiliferous calcarenite consisting of broken fossil fragments and small fossils set in a matrix that ranges from micrite to sparite with common banded overgrowths around fossils. Also contains minor lithologies including fine-grained limestone, sandstone, chert, and evaporites.		
			Mw	Warsaw Formation	60-100	Dark, fissile shale and intercalated argillaceous and silty dolomite or dolomitic limestone in upper half; shaly to argillaceous, cherty, very fossiliferous, finely crystalline, dolomitic limestone in the lower half. Contains abundance of corkscrew byrozoan *Archimedes* .	Shales and silty dolomite in upper half, dolomitic limestone in lower half	
	Osagean	-	Mkbf	eokuk and Burlington Limestone	175-200	Keokuk Limestone - Medium crystalline limestone and lesser finely and coarsely crystalline limestone with common crinoidal fossil horizons and light-gray, nodular chert. Keokuk contains greater heterogeneity of fossils with more abundant bryozoans, corals, and brachiopods. Burlington Limestone - Light-colored, medium to coarsely crystalline limestone with abundant large crinoid stems. Medium to thick beds are commonly cross stratified and occasionally glauconitic. Erratic occurrence of 1-10 ft chert zones separated by 30-50 ft of chert free zones.	Cherty limestone	
			Mkbf	Fern Glen Formation	30-60	Red and green calcareous shale, shaly limestone, and a basal bed of massive, dolomitic limestone.	Red limestone and shale	
	Kinderhookian	-	Mc	Chouteau Limestone	3-70	Gray, argillaceous limestone in irregular beds less than 1 ft thick that have wavy bedding planes and shale partings. Beds are fossiliferous with crinoids dominant.	Argillaceous limestone	
Devonian	Upper	Sulphur Springs	Du	Bushberg Sandstone	0-60	Limestone, sandstone, calcareous siltstone, and hard fissile, carbonaceous shale. Uppermost beds are non-calcareous friable sandstone or very sandy limestone. Lower beds are massive well-indurated, very fossiliferous, crystalline limestone and fine-grained, poorly indurated, cherty, moderately fossiliferous sandy limestone.	Limestone and sandstone	
			Du	Glen Park Limestone				
			Du	Grassy Creek Shale	0-50		Fissile, carbonaceous shale	

TABLE 3-1a. GENERALIZED STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

System	Series	Group	Symbo	Formation	Thickness (ft)	Description	Dominant Lithology	Water-Bearing Character
Silurian			Sou	Undivided	0-200	Dolomite containing sparse fossils and oolitic limestone.	Cherty limestone	-
Ordovician	Cincinnation	-	Om	Maquoketa Shale	0-150	Massive platy mudstone to fissile claystone or shale with basal argillaceous dolomite and calcareous mudstone. Thin layers in lowermost beds contain small phosphatic grains and microscopic fossils.	Silty, calcareous or dolomititc shale	Probably constitutes an confining influence of water movement
			-	Cape Limestone	0-5		Argillaceous limestone	Yields small to moderate quantities of water to wells ranging between 3 to 50 gpm.
	Champlainian	-	Ok	Kimmswick Formation	60-120	Coarsely crystalline, light-colored, medium-bedded to massive fossiliferous limestone. *Receptaculites* is an index fossil	Massive limestone	-
			Od	Decorah Formation	30-60	Guttenberg Limestone - light-gray, thick-bedded, sublithographic limestone and intercalated red to reddish-brown shale. Kings Lake Limestone - thinly bedded, silty and dolomitic, fossiliferous, finely crystalline to coquinoidal limestone with shale partings. Spechts Ferry Formation - green to brown shale and minor calcarenite, argillaceous limestone, and limestone over massive bed of fine-grained, slightly argillaceous limestone with basal shale.	Shale with interbedded limestone	Probably acts as a confining bed locally.
			Op	Plattin Formation	80-300	Gray mudstone interbedded with thin, laminated to cross-laminated grainstone	Finely crystalline limestone	-
			-	Rock Levee Formation	0-93		Dolomite and limestone, some shale	-
			Oj	Joachim Dolomite	60-160	Consists of five members: Metz, Matson, Defiance, Boles, and Augusta. Metz Member - Yellow-brown, laminated, shaly dolomite with algal stromatolies, mud cracks, scour surfaces, and birdseye structures. Matson Member - Dense, dark-brown, fetid, algal dolomite. Defiance Member - Silty, shaly dolomite Boles Member - Silty, shaly dolomite containing seven discontinuous layers of white to black chert Augusta Member - Alternating layers of shale, siltstone, and dolomitic sandstone.	Primarily argillaceous dolomite	-
			Osp	St. Peter Sandstone	60-165	Well-sorted, medium- to fine-grained quartzose sandstone and orthoquartzite with rounded spherical grains	Silty sandstone, cherty limestone grading upward into quartzose sandstone	Yields moderate quantities of water to wells ranging between 10 to 140 gpm.
			-	Everton Formation	0-130			
	Canadian	-	Opow	Powell Dolomite	30-150	Medium to finely crystalline dolomite containing thin beds of green shale and fine-grained sandstone.	Sandy and cherty dolomites and sandstone	Yields small to large quantities of water to wells ranging between 10 to 300 gpm. Upper part of aquifer group yields only small amounts of water to wells.
			Oc	Cotter Dolomite	180-330	Brown to gray, medium to finely crystalline dolomite containing localized thin beds of green shale and sandstone and highly variable chert content.		
			Ojc	Jefferson City Dolomite	140-275	Brown, medium to finely crystalline dolomite and agrillaceous dolomite and localized lenses of orthoquartzite, conglomerate, and shale.		
			Or	Roubidoux Formation	110-170	Interbedded sandstone, sandy dolomite, chert, sandy chert, and cherty dolomite		
			Og	Gasconade Dolomite Gunter Sandstone Member	230-290	Thin- to medium-beded, medium to finely crystalline dolomite with varying amounts of chert and minor sandstone lenses. Gunter Sandstone Member - 25 to 30 feet of medium-grained quartzose sandstone and sandy dolomite.		

TABLE 3-1a. GENERALIZED STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

System	Series	Group	Symbo	Formation	Thickness (ft)	Description	Dominant Lithology	Water-Bearing Character
Cambrian	Upper	-	OЄe	Eminence Dolomite	110-285	Sandy, fine- to medium-grained dolomitized oolitic to coquinoidal calcarenite.	Cherty dolomites, siltstones, sandstone, and shale	Yields moderate to large quantities to wells ranging between 10 to 400 gpm.
			Єp	Potosi Dolomite	100-550	Slightly argillaceous, medium to finely crystalline dolomite.		
		Elvins	Єdd	Derby-Doerun Dolomite	120-155	Dense, medium to finely crystalline dolomite over irregularly bedded, shaly to silty, glauconitic dolomititzed cacarenite.		
			Єd	Davis Formation	30-240	Repeating sequences of shale, siltstone, and silty dolomite or limestone.		
Precambrian	-	-	Yi	Igneous Crystalline Basement	-	Gabbro, norite, and diorite intruded by granitic dikes and leucogranite.	Igneous and metamorphic rocks	Does not yield water to wells in this area

Notes:
Blue highlighted formations are regional aquifers
Gray shaded formation is an aquitard
Descriptions and Thickness adapted from Harrison 1997
Dominant Lithology and Water-Bearing Character from Miller et al. 1974

Abbreviations:
ft: feet
gpm: gallons per minute

TABLE 3-1b. SITE-SPECIFIC STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Era	System	Series	Formation	Thickness (ft)	Dominant Lithology	Regional Aquifer Unit
Cenozoic	Quaternary	Holocene	Alluvium	10-120	Missouri River deposits consisting primarily of sand and gravel with minor silt interbeds.	Missouri River Alluvial Aquifer
			Terrace Deposit		Sand, gravel and silt deposited during fluvial events; minor lacustrine clay.	
		Pleistocene	Loess		Windblown silt, clayey silt and silty loam.	Not Classified
Unconformity						
Paleozoic	Mississippian	Meramecian	St. Louis Limestone	100-250	Thin to medium-bedded limestone, containing minor dolomite, cherty limestone, fossiliferous limestone, and evaporite lithologies. Thin beds of shale are present throughout the formation.	Post-Maquoketa Aquifer
			Salem	70-180	Fossiliferous calcarenite, characterized by a distinct chert zone near the top of the formation in the St. Louis area. Numerous minor lithologies are present, including fine-grained limestone, sandstone, chert, and evaporites.	
			Warsaw	60-100	Upper half of the formation is comprised of fissile shale and intercalated argillaceous and silty dolomite or dolomitic limestone. Lower half is composed of fossiliferous, dolomitic limestone that is shaly and argillaceous.	
		Osagean	Keokuk-Burlington Limestones (undivided)	175-200	Keokuk limestone is characterized by medium crystalline limestone with an abundance of fossils. Nodular chert is common in the lowermost and uppermost thirds of the formation. The Burlington limestone is similar limestone in composition to the Keokuk into which it grades. Beds are medium to thick and commonly cross-stratified with some glauconite. Chert occurs erratically, in high concentrated zones 1-10 feet thick, separated by chert-free zones 30-50 feet thick.	

Note:
Thickness of the Cenozoic deposits may be greater than 120 ft

Abbreviation:
ft: feet

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Borehole Log Available	Well Construction Description/Log Available	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
D-3	D	3	AD	I	WL-105A	8/1/1995	x	x	1069177.97	836047	468.34	465.12	EMSI 2012 Survey	3.22	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	109.62	106.5	357.798	3.12	96.5	10	96.5	106.5	370.298	360.298	109.62	As-built
D-6	D	6	AD	I	WL-206	8/1/1995	x	x	1070235.1	834723.49	447.62	444.33	EMSI 2012 Survey	3.291	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	109.7	106.5	334.998	3.2	96.5	10	96.5	106.5	347.498	337.498	109.7	As-built
D-12	D	12	AD	I	WL-216A	10/1/1995	x	x	1069877.23	835110.76	479.74	477.16	EMSI 2012 Survey	2.579	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	146.21	143.7	330.798	2.51	133.7	10	133.7	143.7	343.298	333.298	146.21	As-built
D-13	D	13	AD	I	WL-224	10/1/1995	x	x	1070527.02	835776.56	470.25	467.73	EMSI 2012 Survey	2.5123	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	135.7	133	334.998	2.7	123	10	123	133	344.998	334.998	135.7	As-built
D-14	D	14	LR	X	WL-109B	10/1/1995	x	x	1068988.87	836700.02	482.97	480.71	EMSI 2012 Survey	2.2604	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	61.77	58.5	425.098	3.27	53.5	5	53.5	58.5	430.598	425.598	61.77	As-built
D-81	D	81	AD	I	NA	8/13/1984	x	x	1067378.73	834638.55	450.65	448.07	EMSI 2012 Survey	2.58	5" (0 - 15 ft), 4 1/2" (15 - 61.5 ft)	2	PVC	0.01 inch machine slot	NA	NA	61.5	385.898	3	48	15	45	60	402.398	387.398	60	RIA
D-83	D	83	AD	I	NA	8/16/1984	x	x	1070970.86	834807.79	448.21	444.84	EMSI 2012 Survey	3.369	5" (0-15 ft) 4 1/2" (15-115.3 ft)	2	PVC	0.01 inch machine slot	NA	NA	115.3	328.698	3.2	80.2	20	77	97	366.998	346.998	97	RIA
D-85	D	85	AD	A	NA	8/1/1984	x	x	1069667.27	836605.17	457.26	454.26	EMSI 2012 Survey	3.007	5" (0-10 ft) 4 1/2" (10-84.1 ft)	2	PVC	0.01 inch machine slot	NA	NA	84.1	372.648	3	65	20	62	82	390.698	370.698	82	RIA
D-87	D	87	AD	I	NA	8/1/1984	x	x	1069252.38	835579.37	464.47	461.22	EMSI 2012 Survey	3.251	5" (0 - 30 ft) 4 1/2" (30-111.7 ft)	2	PVC	0.01 inch machine slot	NA	NA	111.7	347.898	3	94	20	91	111	368.598	348.598	111	RIA
D-89	D	89	AI	I	NA	8/27/1984	x	x	1067010.97	835274.7	456.7	453.7	EMSI 2018 - Calculated	NA	5" (0-25 ft) 4 1/2" (25-49 ft)	2	PVC	0.01 inch machine slot	NA	NA	49	404.698	3	36	15	33	48	420.698	405.698	48	RIA
D-90	D	90	AI	X	NA	8/7/1985	x	x	1066200.97	834474.7	450.2	445.6	EMSI 2018 - Calculated	NA	4", 3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	47	398.598	NA	NA	NA	37	47	408.598	398.598	47	RIA
D-91	D	91	AI	X	NA	8/1/1985	x	x	1065260.97	833944.7	452.97	447.6	EMSI 2018 - Calculated	NA	4", 3 7/8"	2	Sch 50 PVC Riser, Sch 20 PVC Screen	200 slots	NA	NA	45	402.598	5	40	10	35	45	412.598	402.598	45	RIA
D-92	D	92	AD	X	NA	4/9/1985	x	x	1069800.97	835264.7	474.97	475.1	EMSI 2018 - Calculated	NA	4" (0 - 40 ft), 3 7/8" (40 -143.6 ft)	2	PVC	0.01 inch machine slot	NA	NA	143.6	331.498	-0.2	122.8	20	123	143	352.098	332.098	143	RIA
D-93	D	93	AD	I	NA	4/18/1985	x	x	1069369.76	834443.56	450.84	448.28	EMSI 2012 Survey	2.556	6" (0-8 ft) 4 7/8" (8-119.2ft)	2	PVC	0.01 inch machine slot	NA	NA	119.2	337.798	3.3	95.3	20	92	112	358.298	338.298	112	RIA
D-94	D	94	AD	X	NA	4/1/1985	x	x	1070685.97	835994.7	442.28	438.1	EMSI 2018 - Calculated	NA	3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	109	329.098	2.6	91.6	20	86	106	352.098	332.098	106	RIA
D-95	D	95	AD	X	NA	4/1/1985	x	x	1070861.54	836524.52	452.69	449.6	Georeferenced/ Calculated	NA	3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	101	348.598	3.3	84.3	20	81	101	368.598	348.598	101	RIA
F-1-D	F	1	AD	X	NA	8/1/1990	x	x	1068649.65	836034.74	461.23	458.38	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	NA	79.5	NA	2.85	76.95	5	NA	NA	NA	NA	79.1	RIA
F-1-S	F	1	AS	X	NA	8/1/1990	x	x	1068643.97	836040.05	460.95	458.7	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	34.9	32.9	NA	2.4	22.5	10	22.5	32.5	436.198	426.198	34.9	As-built
F-2	F	2	AS	X	NA	8/10/1990	x	x	1067725.97	834591.7	449.7	447.5	EMSI 2018	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	27.55	25.7	NA	2.25	10.3	15	10.3	25.3	437.198	422.198	27.55	As-built
F-3	F	3	AS	X	NA	8/1/1990	x	x	1070530.77	835994.53	468.83	466.53	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	45.1	46	NA	2.3	32.8	10	32.8	42.8	433.728	423.728	45.1	As-built
I-2	I	2	AI	X	NA	8/2/1995	x	x	1069739.23	834386.88	446.01	442.8	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	52.71	52	393.298	3.21	39.5	10	39.5	49.5	403.298	393.298	52.71	As-built
I-4	I	4	AI	U	WL-105B	8/1/1995	x	x	1069189.97	836064.6	465.74	462.95	EMSI 2012 Survey	2.789	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	79.07	79	389.098	2.57	66.5	10	66.5	76.5	399.098	389.098	79.07	As-built
I-7	I	7	AI	U	WL-207	8/3/1995	x	x	1070784.02	834474.57	446.57	444.1	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	49.97	50	396.598	2.47	37.5	10	37.5	47.5	406.598	396.598	49.97	As-built
I-9	I	9	AI	I	WL-229	9/18/1995	x	x	1069358.4	834444.23	449.88	447.92	EMSI 2012 Survey	1.964	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	55.59	55.6	394.998	2.49	43.1	10	43.1	53.1	404.998	394.998	55.59	As-built
I-11	I	11	AI	I	WL-216C	10/13/1995	x	x	1069860.19	835099.74	480.11	477.58	EMSI 2012 Survey	2.526	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	93.17	93	386.698	2.67	80.5	10	80.5	90.5	396.698	386.698	93.17	As-built
I-50	I	50	AI	X	N-1	10/1/1983			1065231.29	834006.66	453.26	448.6	McLaren Hart 1996	NA	NA	0	0	0	NA	NA	40.6	407.998	4.48	35.08	10	30.6	40.6	417.998	407.998	40.6	RIA
I-55	I	55	AI	X	35	6/26/1978	x		1067827.97	834649.7	NA	471.5	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60	RIA
I-56	I	56	AI	X	34	6/27/1978	x		1068097.97	834661.7	NA	474.7	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60 (61.1 well schedule)	RIA

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Borehole Log Available	Well Construction Description/Log Available	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
I-58	I	58	AI	X	40	6/28/1978	x		1068914.97	834632.7	NA	477.1	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60	RIA
I-59	I	59	AI	X	N-2	10/1/1983	x		1069372.97	834463.7	NA	444.5	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	43.5	NA	NA	NA	NA	NA	NA	NA	NA	43.5	RIA
I-62	I	62	AI	I	N-3	10/1/1983			1070979.15	834821.33	446.14	444.34	EMSI 2012 Survey	1.7984	NA	NA	NA	NA	NA	NA	44	399.698	1.98	35.98	10	34	44	409.698	399.698	44	RIA
I-65	I	65	AI	I	N-4	10/1/1983			1070994.1	835507.99	441.26	438.93	EMSI 2012 Survey	2.3269	NA	NA	NA	NA	NA	NA	36	402.098	3.3	29.3	10	26	36	412.098	402.098	36	RIA
I-66	I	66	AI	I	N-5	10/1/1983			1070645.39	836025.96	441.7	438.96	EMSI 2012 Survey	2.7373	NA	NA	NA	NA	NA	NA	36.9	400.398	4.1	31	10	26.9	36.9	410.398	400.398	36.9	RIA
I-67	I	67	AI	I	N-6	10/1/1983			1070142.39	836418.55	441.68	439.34	EMSI 2012 Survey	2.342	NA	NA	NA	NA	NA	NA	35.4	400.698	2.58	27.98	10	25.4	35.4	410.698	400.698	35.4	RIA
I-68	I	68	AI	A	N-7	10/1/1983			1069612.97	836861.2	450.2	447.41	EMSI 2012 Survey	2.794	NA	NA	NA	NA	NA	NA	31.2	409.298	7.42	28.62	10	21.2	31.2	419.298	409.298	31.2	RIA
I-72	I	72	AI	X	39	6/1/1978	x		1067930.97	835519.7	465	462.3	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	50	412.298	2.7	49.7	3	47	50	415.298	412.298	50	RIA
I-73	I	73	AI	A	38	6/1/1978	x		1067735.84	835745.29	461.08	457.98	EMSI 2012 Survey	3.1019	NA	NA	NA	NA	NA	NA	50	412.298	3.7	50.7	3	43.2	46.2	415.298	412.298	50	RIA
LR-100	LR	100	LR	I	NA	10/4/1995	x	x	1067334.45	835068.65	468.11	465.34	EMSI 2012 Survey	2.77	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	26.72	26	442.298	1.92	19.7	4.8	19.7	24.5	447.098	442.298	26.72	As-built
LR-101	LR	101	LR	X	NA	10/10/1995	x	x	1068443.22	834893.11	NA	NA	Golder 1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	RIA
LR-102	LR	102	LR	X	NA	10/8/1995	x	x	1068978.18	834962.83	513.12	511.6	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	61.52	76	451.898	1.52	54.9	4.8	54.9	59.7	456.698	451.898	61.52	As-built
LR-103	LR	103	LR	U	NA	10/20/1995	x	x	1068567.54	835392.18	470.24	466.87	EMSI 2012 Survey	3.371	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	39.8	40	420.998	1.1	28.6	9.8	28.6	38.4	431.098	421.298	39.8	As-built
LR-104	LR	104	LR	X	NA	10/18/1995	x	x	1068105.76	835808.49	459.65	457.79	EMSI 2012 Survey	1.8591	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	40.23	40	419.098	1.73	28.4	9.8	28.4	38.2	429.198	419.398	40.23	As-built
LR-105	LR	105	LR	X	NA	10/3/1995	x	x	1067750.35	834699.95	485.21	482.36	EMSI 2012 Survey	2.843	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	38.89	38	447.498	2.59	26.2	9.8	26.2	36	457.598	447.798	38.89	As-built
MO-3-SS	MO	3	SS	I	NA	8/12/2015	x		1066537.01	835641	461.69	461.89	MDNR	NA	5 7/8"	NA	NA	NA	NA	169.8	170.00	291.89	-0.2	149.8	20	150.40	170.40	311.49	291.49	169.8	MDNR
MO-3-SDR	MO	3	SD	I	NA	8/14/2015	x		1066547.22	835637	460.85	461.13	MDNR	NA	5 7/8"	NA	NA	NA	NA	209.8	210.08	251.05	-0.28	189.8	20	190.08	210.08	271.05	251.05	209.8	MDNR
MW-41	MW	41	NA	X	NA	6/1/1978			1069327.97	834551.7	NA	NA	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	RIA
MW-101	MW	101	AS	X	NA	4/1/1990	x	x	1070871.45	834598.7	446.43	444.96	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	29.6	25	NA	2.3	17.3	10	17.3	27.3	427.658	417.658	29.6	As-built
MW-102	MW	102	AS	X	NA	4/1/1990	x	x	1070135.68	834707.41	447.83	445.66	EMSI 2012 Survey	2.173	8	2	PVC	0.010 slotted	Locking steel protective cover	29.1	25	NA	2.3	16.8	10	16.8	26.8	428.86	418.86	29.1	As-built
MW-103	MW	103	AS	I	NA	4/1/1990	x	x	1068668.89	834508.8	438.92	437.07	EMSI 2012 Survey	1.85	8	2	PVC	0.010 slotted	Locking steel protective cover	21.1	18	NA	2.7	8.4	10	8.4	18.4	428.665	418.665	21.1	As-built
MW-104	MW	104	AS	I	NA	4/1/1990	x	x	1067565.65	834513.71	440.81	437.81	EMSI 2012 Survey	3.003	8	2	PVC	0.010 slotted	Locking steel protective cover	22.8	17	NA	2.9	9.9	10	9.9	19.9	427.909	417.909	22.8	As-built
MW-105	MW	105	AS	X	NA	4/12/1990	x	x	1067565.65	833405.95	439.77	442.07	McLaren Hart 1996*	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	17.3	15	15	2.3	7.3	10	5	15	437.068	427.068	NA	As-built
MW-106	MW	106	AS	X	NA	4/12/1990	x	x	1065996.72	833791.62	443.38	439.77	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	NA	15		NA	NA	10	5	15	434.768	424.768	NA	As-built
MW-107	MW	107	AS	X	NA	4/1/1990	x	x	1064711.71	833775.82	447.74	NA	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	NA	15	NA	NA	5	10	5	10	NA	NA	na	As-built
MW-1201	MW	1201	SD	U	PZ-1201-SS & 1201	3/1/1985			1067343.97	837077.7	482.44	480.2	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.198	2.24	53	197	53	250	427.198	230.198	250	RIA
MW-1202	MW	1202	SD	X	NA	3/1/1985			1067383.97	837049.7	482.18	480.1	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.098	2.08	NA	NA	NA	NA	NA	NA	250	RIA
MW-1203	MW	1203	SD	X	NA	7/1/1985			1067229.97	837129.7	483.61	480.7	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.698	2.91	NA	NA	NA	NA	NA	NA	250	RIA

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
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REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Borehole Log Available	Well Construction Description/Log Available	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
MW-1204	MW	1204	SD	A	NA	4/1/1991		x	1066461.15	835998.97	485.36	483.09	EMSI 2012 Survey	2.267	8	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	225.8	227	NA	2.3	213.5	10	213.5	223.5	269.591	259.591	225.8	As-built
MW-1205	MW	1205	AS	X	NA	4/1/1991		x	1067428.36	835795.45	386.37	384.1	Foth & Van Dyke 1991	NA	11 and 6	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	125.3	132	NA	2.3	113	10	113	123	271.098	261.098	125.3	As-built
MW-1206	MW	1206	AS	X	NA	3/1/1991		x	1067437.24	835799.07	388.08	385.8	Foth & Van Dyke 1991	NA	8	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	75.3	73	NA	2.3	63	10	63	73	322.798	312.798	75.3	As-built
PZ-100-KS	PZ	100	KS	A	1209	2/17/1995	x	x	1068883.06	837386.27	485.95	484.82	EMSI 2012 Survey	1.134	10 1/4" (0-34 ft) 5 7/8" (34-391 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	386.01	391.2	99.228	1.88	374	9.8	374	383.8	109.358	99.558	386.01	As-built
PZ-100-SD	PZ	100	SD	A	1208	2/23/1995	x	x	1068892.81	837369.99	486.08	484.49	EMSI 2012 Survey	1.592	10 1/4 "(0-51 ft) 5 7/8" (51-246 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	246.4	246	239.018	1.47	234.8	9.8	234.8	244.6	249.148	239.348	246.4	As-built
PZ-100-SS	PZ	100	SS	A	1207	2/25/1995	x	x	1068908.76	837349.65	486.15	484.84	EMSI 2012 Survey	1.312	10 1/4 "(0-51 ft) 5 7/8" (51-94.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	95.42	94.5	390.018	1.49	73.96	19.64	73.96	93.6	409.988	390.348	95.42	As-built
PZ-101-SS	PZ	101	SS	A	1210	3/6/1995	x	x	1068513.92	836797.32	491.16	488.95	EMSI 2012 Survey	2.214	10 1/4 "(0-14 ft) 5 7/8" (14-140 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	141.4	140	334.878	1.79	129.48	9.8	129.48	139.28	345.008	335.208	141.4	As-built
PZ-102R-SS	PZ	102	SS	A	1211	6/18/1995	x	x	1068172.73	837033.55	486.05	484.18	EMSI 2012 Survey	1.874	10 1/4 "(0-35 ft) 5 7/8" (35-90.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	91.08	90.3	394.138	1.12	79.83	9.8	79.83	89.63	404.268	394.468	91.08	As-built
PZ-102-SS	PZ	102	SS	A	NA	3/12/1995	x	x	1068128.68	837062.59	484.25	482.06	EMSI 2012 Survey	2.185	10 1/4 "(0-37 ft) 5 7/8" (37-90.4 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	92.63	90.4	390.818	1.8	79.7	9.8	79.7	89.5	401.948	392.148	92.63	As-built
PZ-103-SS	PZ	103	SS	A	1212	2/26/1995	x	x	1067701.3	836897.82	483.8	479.9	EMSI 2012 Survey	3.899	10 1/4 "(0-51 ft) 5 7/8" (51-145.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	147.22	145.5	332.548	2.39	134.7	9.8	134.7	144.5	342.678	332.878	147.22	As-built
PZ-104-KS	PZ	104	KS	A	1215	6/19/1995	x	x	1067034.02	836995.22	484.2	481.84	EMSI 2012 Survey	2.359	10 1/4 "(0-249 ft) 5 7/8" (249-408 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 483.3 - 233.32	409.22	408	74.418	1.72	397.37	9.8	397.37	407.17	84.548	74.748	409.22	As-built
PZ-104-SD	PZ	104	SD	A	1214	6/17/1995	x	x	1067054.14	837009.27	483.75	481.47	EMSI 2012 Survey	2.277	10 1/4 "(0-38 ft) 5 7/8" (38-252.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	246.92	252.5	236.368	1.59	235.2	9.8	235.2	245	246.498	236.698	246.92	As-built
PZ-104-SS	PZ	104	SS	A	1213	6/4/1995	x	x	1067068.82	837021.99	483.6	481.65	EMSI 2012 Survey	1.948	10 1/4 "(0-37 ft) 5 7/8" (37-145 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	146.7	145	336.528	2.07	134.5	9.8	134.5	144.3	346.658	336.858	146.7	As-built
PZ-105-SS	PZ	105	SS	A	1216	5/24/1995	x	x	1066462.14	836405.05	483.64	480.81	EMSI 2012 Survey	2.83	10 1/4 "(0-45 ft) 5 7/8" (45-149 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 482.7 - 436.22	151.02	149	332.188	2.39	138.5	9.8	138.5	148.3	342.318	332.518	151.02	As-built
PZ-106-KS	PZ	106	KS	A	1219	3/23/1995	x	x	1066744.65	835606.9	464.32	462.14	EMSI 2012 Survey	2.181	10 1/4 "(0-204 ft) 5 7/8" (204-375 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 463.3 - 257.77	376.39	375	87.468	2.49	363.75	9.8	363.75	373.57	97.618	87.798	376.39	As-built
PZ-106-SD	PZ	106	SD	A	1218	3/24/1995	x	x	1066755.69	835590.7	463.44	461.42	EMSI 2012 Survey	2.017	10 1/4 "(0-26 ft) 5 7/8" (26-201.1 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	202.9	201.1	260.118	1.97	190.79	9.8	190.79	200.59	270.258	260.458	202.9	As-built
PZ-106-SS	PZ	106	SS	A	1217	4/5/1995	x	x	1066767.07	835574.64	462.7	460.95	EMSI 2012 Survey	1.752	10 1/4 "(0-23 ft) 5 7/8" (23-165.4 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	297.2	165.4	295.118	1.75	155.3	9.8	155.3	165.1	305.248	295.448	297.2	As-built
PZ-107-SS	PZ	107	SS	A	1220	5/22/1995	x	x	1067204.04	835429.35	465	462.85	EMSI 2012 Survey	2.151	10 1/4 "(0-32ft) 5 7/8" (32-103 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 463.6 - 407.63	104.76	103	359.498	2.03	92.6	9.8	92.6	102.4	369.628	359.828	104.76	As-built
PZ-108-SS	PZ	108	SS	X	1221	3/29/1995	x	x	1067719.34	836147.31	455.8	453.7	Golder 1996	NA	10 1/4 "(0-20ft) 5 7/8" (20-143.9 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	145.76	143.9	310.038	2.08	133.54	9.8	133.54	143.35	320.178	310.368	145.76	As-built
PZ-109-SS	PZ	109	SS	A	1222	4/25/1995	x	x	1068052.31	836318.5	458.9	456.9	EMSI 2012 Survey	2.002	10 1/4 "(0-15ft) 5 7/8" (15-135.7 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	137.56	135.7	320.538	1.73	125.7	9.8	125.7	135.5	330.668	320.868	137.56	As-built
PZ-110-SS	PZ	110	SS	X	1223	5/20/1995	x	x	1068376.97	836094.3	461.06	458.03	EMSI 2012 Survey	3.0292	10 1/4 "(0-61ft) 5 7/8" (61-111.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 457.3 - 395.84	113.37	111.5	345.138	2.07	100.9	9.8	100.9	110.7	355.538	345.738	113.37	As-built
PZ-111-KS	PZ	111	KS	A	1225	5/6/1995	x	x	1068661.96	836025.21	465.4	461.34	EMSI 2012 Survey	4.0621	14 3/4 "(0-84ft) 10" (84.0-215.5) 5 7/8" (215.5-368.8 ft)	2	Sch 80 PVC	0.01 inch machine slot	10 7/8" Steel Casing elev 459.9 - 375.38; 6 5/8" Steel Casing elev 460.2 - 243.88	368.99	368.8	91.478	1.69	357.15	9.8	357.15	366.96	101.628	91.818	368.99	As-built
PZ-111-SD	PZ	111	SD	A	1224	4/21/1995	x	x	1068678.17	836009	466.17	461.95	EMSI 2012 Survey	4.2226	10" (0-98 ft) 5 7/8" (98-210 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 459.7 - 361.22	211.83	210	249.318	2.33	199.4	9.8	199.4	209.2	259.418	249.618	211.83	As-built
PZ-111-SS	PZ	111	SS	A	NA	8/29/2017			1068631.93	835989.4	464.23	461.71	Feezor 2017	NA	8"	2	Sch 80 PVC	0.01 inch machine slot	6" Steel Casing 0 - 93 ft bgs	NA	0	0	0	0	0	462.11	462.11	0	0	0	RIA
PZ-112-AS	PZ	112	AS	A	1226	4/10/1995	x	x	1069042.85	835849.45	462.13	458.41	EMSI 2012 Survey	3.722	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	36.63	36	422.798	1.9	29.6	4.8	29.6	34.4	427.928	423.128	36.63	As-built
PZ-113-AD	PZ	113	AD	A	1228	5/3/1995	x	x	1069273.97	835934.5	461.84	459.47	EMSI 2012 Survey	2.368	10 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	110.33	108.7	350.728	1.6	98.6	9.8	98.6	108.4	360.858	351.058	110.33	As-built
PZ-113-AS	PZ	113	AS	A	1227	4/11/1995	x	x	1069264.97	835922.4	461.78	459.58	EMSI 2012 Survey	2.203	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	40.53	40	420.488	1.5	28.9	9.8	28.9	38.7	430.618	420.818	40.53	As-built

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Borehole Log Available	Well Construction Description/Log Available	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
PZ-113-SS	PZ	113	SS	A	1229	5/20/1995	x	x	1069282.97	835951.3	462.26	459.65	EMSI 2012 Survey	2.601	9 3/4" (0-115 ft) 5 7/8" (115-159 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460.4 - 344.96	160.51	159	300.858	1.81	148.57	9.8	148.57	158.37	310.988	301.188	160.51	As-built
PZ-114-AS	PZ	114	AS	A	1230	4/20/1995	x	x	1069460	836942.99	451.74	449.56	EMSI 2012 Survey	2.175	10 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	31.56	30.5	419.348	1.53	19.9	9.8	19.9	29.7	429.478	419.678	31.56	As-built
PZ-115-SS	PZ	115	SS	A	1231	5/21/1995	x	x	1069449.63	836929.87	452.5	450.21	EMSI 2012 Survey	2.284	9 7/8" (0-39ft) 5 7/8" (39-85ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	86.5	85	365.398	1.69	74.68	9.8	74.68	84.48	375.528	365.728	86.5	As-built
PZ-116-SS	PZ	116	SS	A	1232	6/20/1995	x	x	1066451.15	836018.58	486.04	483.55	EMSI 2012 Survey	2.49	10 1/4 "(0-33ft) 5 7/8" (33-162 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 451.6 - 411.61	163.13	162	321.338	1.8	151.4	9.8	151.4	161	331.268	331.668	163.13	As-built
PZ-200-SS	PZ	200	SS	A	NA	2/28/1995	x	x	1068537.09	837146.56	485.83	483.55	EMSI 2012 Survey	2.28	10 1/4 "(0-27.5ft) 5 7/8" (27.5-98.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	99.99	98.7	385.238	2.02	9.62	88.02	9.62	97.64	473.588	385.568	99.99	As-built
PZ-201A-SS	PZ	201	SS	A	1223	4/23/1995	x	x	1067872.76	837021.16	481.93	479.87	EMSI 2012 Survey	2.058	10 1/4 "(0-33ft) 5 7/8" (33-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	91.94	90	387.818	1.81	80	9.8	80	89.8	397.948	388.148	91.94	As-built
PZ-201-SS	PZ	201	SS	X	NA	3/6/1995	x	x	1067860.52	837036.76	479.93	477.6	Golder 1996	NA	10 1/4 "(0-33ft) 5 7/8" (33-39 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	90.96	89	388.968	2.32	9.75	78.56	9.75	88.31	467.858	389.298	90.96	As-built
PZ-202-SS	PZ	202	SS	A	1234	3/12/1995	x	x	1067361.15	837276.12	481.42	479.47	EMSI 2012 Survey	1.942	10 1/4" (0-33.5 ft) 5 7/8" (33.5-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 480 - 445.01	91.59	90	389.178	2.16	40.2	48.9	40.2	89.1	438.408	389.508	91.59	As-built
PZ-203-SS	PZ	203	SS	A	1235	6/3/1995	x	x	1066702.37	836782.55	486.78	484.12	EMSI 2012 Survey	2.66	10 1/4" (0-56 ft) 5 7/8" (56-110 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 484.7 - 428.08	112.11	110	374.078	2.41	99.6	9.8	99.6	109.4	384.178	374.378	112.11	As-built
PZ-204A-SS	PZ	204A	SS	A	1236	8/21/1995	x	x	1066470.42	835731.27	464.88	464.88	EMSI 2012 Survey	0	10 1/4" (0.0-14 ft) 5 7/8" (14-90 ft)	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	90.93	90	376.828	1.5	79.5	9.6	79.5	89.1	386.758	377.158	90.93	As-built
PZ-204-SS	PZ	204	SS	A	NA	3/10/1995	x	x	1066470.42	835731.27	464.88	464.88	EMSI 2012 Survey	0	10 1/4" (0-14 ft) 5 7/8" (14-90.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	92.28	90.3	376.948	2.6	10.95	78.4	10.95	89.35	455.678	377.278	92.28	As-built
PZ-205-AS	PZ	205	AS	A	1237	5/5/1995	x	x	1067504.51	835637.88	460.48	458.54	EMSI 2012 Survey	1.944	14 3/4 "(0-29ft) 8 1/4" (29-49ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460 - 430.33	50.34	49	410.248	1.66	38.55	9.8	38.55	48.35	420.378	410.578	50.34	As-built
PZ-205-SS	PZ	205	SS	A	1238	5/21/1995	x	x	1067524.52	835652.19	461.87	459.62	EMSI 2012 Survey	2.256	9 3/4" (0-54 ft) 5 7/8" (54-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460.5 - 405.53	100.36	99	360.428	1.66	88.57	9.8	88.57	98.37	370.558	360.758	100.36	As-built
PZ-206-SS	PZ	206	SS	A	1239	4/24/1995	x	x	1068071.82	835984.01	460.39	458.19	EMSI 2012 Survey	2.1958	10" (0-52 ft) 5 7/8" (52-125.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 459.1 - 406.38	126.82	125.5	332.978	1.82	115	9.8	115	124.8	342.978	333.178	126.82	As-built
PZ-207-AS	PZ	207	AS	A	1240	4/10/1995	x	x	1069685.45	836212.47	462.24	460.16	EMSI 2012 Survey	2.088	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	41.72	40	421.448	1.69	34.9	4.8	34.9	39.7	426.578	421.778	41.72	As-built
PZ-208-SS	PZ	208	SS	A	1241	6/18/1995	x	x	1069260.13	837344.08	474.79	472.48	EMSI 2012 Survey	2.311	10 1/4" (0-17 ft) 5 7/8" (17-99.2 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	100.55	99.2	373.298	1.72	88.7	9.8	88.7	98.5	383.428	373.628	100.55	As-built
PZ-209-SS	PZ	209	SS	A	NA	10/15/2013	x	x	1067112.51	837283.27	489.28	486.99	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	152.29	150	336.988	2.29	140	10	140	150	346.988	336.988	152.29	As-built
PZ-209-SD	PZ	209	SD	A	NA	10/4/2013	x	x	1067116.71	837279.12	489.18	486.84	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	252.34	250	236.838	2.34	240	10	240	250	246.838	236.838	252.34	As-built
PZ-210-SS	PZ	210	SS	A	NA	10/16/2013	x	x	1066869.35	836952.11	486.5	484.13	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	150.37	148	336.128	2.37	138	10	138	148	346.128	336.128	150.37	As-built
PZ-210-SD	PZ	210	SD	A	NA	10/16/2013	x	x	1066865.01	836947.82	486.6	484.08	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	250.52	248	236.078	2.52	238	10	238	248	246.078	236.078	250.52	As-built
PZ-211-SS	PZ	211	SS	A	NA	10/8/2013	x	x	1067101.76	837195.85	487.01	484.66	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	149.35	147	337.658	2.35	137	10	137	147	347.658	337.658	149.35	As-built
PZ-211-SD	PZ	211	SD	A	NA	10/7/2013	x	x	1067097.67	837191.31	487.06	484.43	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	240.46	247	237.428	2.63	237	10	237	247	347.428	237.428	240.46	As-built
PZ-212-SS	PZ	212	SS	A	NA	10/18/2013	x	x	1067531.96	838151.16	482.39	479.76	H&A As-Built	NA	9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	146.63	150	329.758	2.63	134	10	134	144	345.758	335.758	146.63	As-built
PZ-212-SD	PZ	212	SD	A	NA	10/21/2013	x	x	1067536.66	838155.08	482.32	480.08	H&A As-Built	NA	7.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	246.24	245	235.078	2.24	234	10	234	244	246.078	236.078	246.24	As-built
PZ-300-AD	PZ	300	AI	X	NA	9/24/1995	x	x	1065254.81	834002.76	449.22	447.7	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	43.72	42.2	405.498	1.52	37.1	4.8	37.1	41.9	410.598	405.798	43.72	As-built
PZ-300-AS	PZ	300	AS	X	NA	9/26/1995	x	x	1065539.41	834042.53	450.26	448.1	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	22.16	20	428.098	2.16	9.9	9.8	9.9	19.7	438.198	428.398	22.16	As-built
PZ-300-SS	PZ	300	SS	X	NA	9/26/1995	x	x	1065245.72	834024.51	449.2	448	Golder 1996	NA	9 7/8" (0-46ft) 5 7/8" (46-93ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 447.6 - 402.4	95.2	94.5	353.998	1.2	83.88	9.8	83.88	93.7	364.118	354.298	95.2	As-built
PZ-301-SS	PZ	301	SS	X	NA	9/23/1995	x	x	1064842.65	835691.69	514.31	512.7	Golder 1996	NA	8 1/4" (0-19 ft) 5 7/8" (19-161.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	162.61	161.5	351.698	1.61	150.9	9.8	150.9	160.7	361.798	351.998	162.61	As-built

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Borehole Log Available	Well Construction Description/Log Available	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
PZ-302-AI	PZ	302	AI	I	NA	9/26/1995	x	x	1067250.87	834895.67	451.19	449.77	EMSI 2012 Survey	1.423	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	43.85	43	406.898	1.15	32.6	9.8	32.6	42.4	416.998	407.198	43.85	As-built
PZ-302-AS	PZ	302	AS	I	NA	9/25/1995	x	x	1067238.22	834912.69	451.57	449.36	EMSI 2012 Survey	2.217	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	24.22	22.3	426.798	1.92	12.2	9.8	12.2	22	436.898	427.098	24.22	As-built
PZ-303-AS	PZ	303	AS	I	NA	10/5/1995	x	x	1067703.94	834600.48	453.28	451.04	EMSI 2012 Survey	2.237	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	28.48	26.5	424.298	2.38	16	9.8	16	25.8	434.398	424.598	28.48	As-built
PZ-304-AI	PZ	304	AI	I	NA	10/2/1995	x	x	1068166.33	834609.4	454.15	451.76	EMSI 2012 Survey	2.395	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	51.52	50	402.098	2.42	39	9.8	39	48.8	412.198	402.398	51.52	As-built
PZ-304-AS	PZ	304	AS	I	NA	9/27/1995	x	x	1068187.02	834609.3	453.89	451.73	EMSI 2012 Survey	2.159	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	29.51	28	423.798	2.31	17.1	9.8	17.1	26.9	433.898	424.098	29.51	As-built
PZ-305-AI	PZ	305	AI	X	NA	10/19/1995	x	x	1068119.66	835797.89	459.98	458.09	EMSI 2012 Survey	1.8917	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	64.98	64	393.898	1.68	53.2	9.8	53.2	63	403.998	394.198	64.98	As-built
PZ-1201-SS	PZ	1201	SS	X	NA	7/7/1995			1067343.39	837078.26	482.02	480	Golder 1996	NA	Unknown (0-53 ft) 5 7/8" (53-250)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 483-427.41	NA	250	229.998	2.01	139.71, 0.3	9.6	137.69	147.29	342.308	332.708	147.63	RIA
S-1	S	1	AS	X	NA	6/3/1905	x	x	1069726.8	834379.71	446.11	442.9	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	25.71	25	417.898	3.21	2.5	20	2.5	22.5	440.398	420.398	25.71	As-built
S-5	S	5	AS	I	WL-105C	8/1/1995	x	x	1069196.97	836075.6	466.23	463.02	EMSI 2012 Survey	3.203	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	42.95	49.3	415.998	2.95	30	10	30	40	435.298	425.298	42.95	As-built
S-8	S	8	AS	I	WI-228	9/1/1995	x	x	1071085.01	834898.67	443.93	441.55	EMSI 2012 Survey	2.3847	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	29.23	29.3	411.898	2.43	6.8	20	6.8	26.8	434.398	414.398	29.23	As-built
S-10	S	10	AS	I	WL-216C; WL-232	9/1/1995	x	x	1069868.79	835106.24	480.1	477.6	EMSI 2012 Survey	2.497	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	49.22	54.5	422.598	2.78	32	20	32	52	445.098	425.098	49.22	As-built
S-51	S	51	AS	X	HL-3	6/3/1905			1066202.28	834495.42	449.17	445.9	McLaren Hart 1996	NA	NA	NA	NA	NA	NA	NA	25.8	420.098	1.42	24.22	3	22.8	25.8	423.098	420.098	25.8	RIA
S-52	S	52	AS	X	HL-2	6/3/1905			1066510.97	834374.7	446.68	444.3	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	25.2	419.098	2.38	24.58	3	22.2	25.2	422.098	419.098	25.2	RIA
S-53	S	53	AS	I	HL-1	6/3/1905			1066911.17	834671.97	444.1	441.04	EMSI 2012 Survey	3.058	NA	NA	NA	NA	NA	NA	23.7	420.698	4.2	24.9	3	20.7	23.7	423.698	420.698	23.7	RIA
S-54	S	54	AS	X	36	Unknown			1067646.97	834642.7	NA	469.6	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.4	RIA
S-60	S	60	AS	X	S-2	7/1/1981			1069790.97	834484.7	446.53	442.7	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	21	421.698	3.83	NA	NA	NA	21	NA	421.698	21	RIA
S-61	S	61	AS	X	S-1	7/1/1981			1070200.94	834754.56	449.2	445.5	EMSI 2012 Survey	3.706	NA	NA	NA	NA	NA	NA	21.5	423.698	4.57	NA	NA	NA	21.5	NA	423.698	21.5	RIA
S-75	S	75	AS	X	37	Unknown			1067291.38	834893.45	461.68	458.4	McLaren Hart 1996	NA	NA	NA	NA	NA	NA	NA	26	432.398	1.1	24.1	3	23	26	435.398	432.398	26	RIA
S-76	S	76	AS	X	37A	6/1/1978	x		1067446.97	834743.7	NA	474	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	RIA
S-80	S	80	AS	X	NA	8/28/1984	x		1065232.74	834033.05	452.71	448	McLaren Hart 1996	NA	5"	2	PVC	0.01 inch machine slot	NA	NA	22	425.998	5	15	10	10	20	437.998	427.998	20	RIA
S-82	S	82	AS	I	NA	8/27/1984	x	x	1069352.64	834447.5	450.11	448.17	EMSI 2012 Survey	1.941	5"	2	PVC	0.01 inch machine slot	NA	NA	26.5	420.798	3	18.5	10	15.5	25.5	431.798	421.798	25.5	RIA
S-84	S	84	AS	A	NA	8/1/1984	x	x	1069674.22	836614.27	457.04	454.24	EMSI 2012 Survey	2.804	5"	2	PVC	0.01 inch machine slot	NA	NA	31.5	420.998	4	24.9	10	20.9	30.9	431.598	421.598	30.9	RIA
S-88	S	88	AS	X	NA	8/1/1984			1068439.36	835408.73	462.36	459.6	McLaren Hart 1996	NA	5" (0-30 ft), 4 1/2" (30-41.5)	2	PVC	0.01 inch machine slot	NA	NA	41.5	418.098	2.7	33	10	30	40	429.598	419.598	40	RIA

Note:
Coordinate system updated to NAD83 State Plane Missouri East using conversion in Work Plan

Abbreviations:
- EMSI: Environmental Management Support, Inc
- RIA: Remedial Investigation Addendum
- MPE: Measuring Point Elevation
- GSE: Ground Surface Elevation
- PVC: Polyvinyl Chloride
- Sch: Schedule
- MDNR: Missouri Department of Natural Resources
- ft: feet
- in: inches
- msl: mean sea level
- NA: Not available

Abbreviations:

Environmental Control Prefix
- D: Deep
- F: Foth
- I: Intermediate
- LR: Leachate Riser
- MW: Monitoring Well
- PZ: Piezometer
- S: Shallow

Monitoring Status
- A: Active
- I: Inactive
- U: Unknown
- X: Abandoned

Abbreviations:

Hydrological Zone
- AD: Deep Alluvial
- AS: Shallow Alluvial
- AI: Intermediate Alluvial
- LR: Leachate Riser
- KS: Keokuk Formation
- SD: Salem Formation
- SS: Upper Salem/St. Louis Formation

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
Shallow Alluvium	PZ-112-AS	RH	AS	1069042.848	835849.449	PZ-112-AS-RH1	1.90E-03	3.70E-03	1.10E-03	2.20E-03	NA	NA	1.50E-03	3.00E-03	4.32	Golder 1996	0.35	97	8.9
	PZ-112-AS	FH[3]	AS	1069042.848	835849.449	PZ-112-AS-FH1	3.00E-03	5.90E-03	1.70E-03	3.30E-03	NA	NA	2.40E-03	4.60E-03	6.62	Golder 1996			
	PZ-113-AS	RH	AS	1069264.97	835922.4	PZ-113-AS-RH1	1.40E-02	2.80E-02	5.30E-02	1.00E-01	NA	NA	3.40E-02	6.60E-02	95.04	Golder 1996			
	PZ-113-AS	FH[3]	AS	1069264.97	835922.4	PZ-113-AS-FH1	8.00E-03	1.60E-02	5.10E-03	1.00E-02	NA	NA	6.60E-03	1.30E-02	18.72	Golder 1996			
	PZ-114-AS	FH	AS	1069459.999	836942.992	PZ-114-AS-FH1	3.10E-03	6.10E-03	1.70E-03	3.30E-03	NA	NA	2.40E-03	4.70E-03	6.77	Golder 1996			
	PZ-114-AS	FH[4]	AS	1069459.999	836942.992	PZ-114-AS-FH2	4.50E-03	8.90E-03	2.70E-03	5.30E-03	NA	NA	3.60E-03	7.10E-03	10.22	Golder 1996			
	PZ-205-AS		AS	1067504.507	835637.878	PZ-205-AS	6.00E-04	1.20E-03	4.40E-04	8.70E-04	NA	NA	5.20E-04	1.00E-03	1.44	Golder 1996			
	PZ-207-AS		AS	1069685.45	836212.47	PZ-207-AS	7.60E-03	1.50E-02	4.80E-03	9.40E-03	NA	NA	6.20E-03	1.20E-02	17.28	Golder 1996			
	PZ-300-AS	FH[2]	AS	1065539.41	834042.53	PZ-300-AS-FH2	5.80E-04	1.10E-03	NA	NA	NA	NA	5.80E-04	1.10E-03	1.58	Golder 1996			
	PZ-300-AS	RH	AS	1065539.41	834042.53	PZ-300-AS-RH	7.10E-04	1.40E-03	2.10E-03	4.10E-03	NA	NA	1.40E-03	2.80E-03	4.03	Golder 1996			
	PZ-302-AS	FH[2]	AS	1067238.22	834912.693	PZ-302-AS-FH2	1.10E-04	2.20E-04	NA	NA	NA	NA	1.10E-04	2.20E-04	0.32	Golder 1996			
	PZ-302-AS	RH	AS	1067238.22	834912.693	PZ-302-AS-RH	1.20E-04	2.40E-04	NA	NA	NA	NA	1.20E-04	2.40E-04	0.35	Golder 1996			
	PZ-303-AS	FH[2]	AS	1067703.94	834600.481	PZ-303-AS-FH12	4.00E-04	7.90E-04	NA	NA	NA	NA	4.00E-04	7.90E-04	1.14	Golder 1996			
	PZ-303-AS	FH[2]	AS	1067703.94	834600.481	PZ-303-AS-FH22	6.00E-04	1.20E-03	NA	NA	NA	NA	6.00E-04	1.20E-03	1.73	Golder 1996			
	PZ-303-AS	RH	AS	1067703.94	834600.481	PZ-303-AS-RH	3.70E-03	7.30E-03	1.50E-02	3.00E-02	NA	NA	9.40E-03	1.80E-02	25.92	Golder 1996			
	PZ-304-AS	FH[2]	AS	1068187.019	834609.304	PZ-304-AS-FH2	8.70E-04	1.70E-03	NA	NA	NA	NA	8.70E-04	1.70E-03	2.45	Golder 1996			
	PZ-304-AS	RH	AS	1068187.019	834609.304	PZ-304-AS-RH	5.90E-03	1.20E-02	1.80E-02	3.50E-02	NA	NA	1.20E-02	2.40E-02	34.56	Golder 1996			
	S-1	RH	AS	1069726.8	834379.71	S-1	NA	NA	3.78E-03	7.44E-03	NA	NA	NA	NA	10.71	McLaren Hart 1996			
	S-5	RH	AS	1069196.97	836075.6	S-5	NA	NA	8.76E-04	1.72E-03	NA	NA	NA	NA	2.48	McLaren Hart 1996			
	S-8	RH	AS	1071085.014	834898.6739	S-8	NA	NA	3.43E-02	6.75E-02	NA	NA	NA	NA	97.23	McLaren Hart 1996			
	S-84	RH	AS	1069674.22	836614.269	S-84	NA	NA	2.32E-03	4.57E-03	NA	NA	NA	NA	6.58	McLaren Hart 1996			
	MW-101	RH	AS	1070871.45	834598.7	MW-101	NA	NA	4.17E-03	8.21E-03	NA	NA	NA	NA	11.82	McLaren Hart 1996			
	F-3	RH	AS	1070530.77	835994.53	MW-F3	NA	NA	3.83E-03	7.54E-03	NA	NA	NA	NA	10.86	McLaren Hart 1996			

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
Intermediate Alluvium	PZ-300-AD	FH[3]	AI	1065254.81	834002.76	PZ-300-AD-FH	3.70E-04	7.30E-04	2.70E-04	5.30E-04	NA	NA	3.20E-04	6.30E-04	0.91	Golder 1996	0.39	189	49
	PZ-300-AD	RH	AI	1065254.81	834002.76	PZ-300-AD-RH	1.60E-04	3.10E-04	1.10E-04	2.20E-04	NA	NA	1.40E-04	2.70E-04	0.39	Golder 1996			
	PZ-302-AI	FH[3]	AI	1067250.868	834895.669	PZ-302-AI-FH	1.50E-02	3.00E-02	9.80E-03	1.90E-02	NA	NA	1.20E-02	2.40E-02	34.56	Golder 1996			
	PZ-302-AI	RH	AI	1067250.868	834895.669	PZ-302-AI-RH	1.50E-02	3.00E-02	1.00E-02	2.00E-02	NA	NA	1.30E-02	2.50E-02	36.00	Golder 1996			
	PZ-304-AI	FH	AI	1068166.325	834609.398	PZ-304-AI-FH	2.40E-02	4.70E-02	1.70E-02	3.30E-02	NA	NA	2.10E-02	4.00E-02	57.60	Golder 1996			
	PZ-305-AI	FH[1]	AI	1068119.659	835797.8921	PZ-305-AI-FH1	1.80E-02	3.50E-02	1.40E-02	2.80E-02	NA	NA	1.60E-02	3.10E-02	44.64	Golder 1996			
	PZ-305-AI	FH[2]	AI	1068119.659	835797.8921	PZ-305-AI-FH2	1.90E-04	3.70E-04	1.70E-04	3.30E-04	NA	NA	1.80E-04	3.50E-04	0.50	Golder 1996			
	I-2	RH	AI	1069739.23	834386.88	I-2	NA	NA	3.27E-02	6.44E-02	NA	NA	NA	NA	92.69	McLaren Hart 1996			
	I-4	RH	AI	1069189.97	836064.6	I-4	NA	NA	5.41E-02	1.06E-01	NA	NA	NA	NA	153.35	McLaren Hart 1996			
	I-7	RH	AI	1070784.02	834474.57	I-7	NA	NA	6.68E-02	1.31E-01	NA	NA	NA	NA	189.35	McLaren Hart 1996			
	I-9	RH	AI	1069358.403	834444.232	I-9	NA	NA	5.47E-02	1.08E-01	NA	NA	NA	NA	155.06	McLaren Hart 1996			
	I-11	RH	AI	1069860.187	835099.736	I-11	NA	NA	4.63E-02	9.11E-02	NA	NA	NA	NA	131.24	McLaren Hart 1996			
	I-68	RH	AI	1069612.97	836861.2	I-68	NA	NA	1.22E-02	2.40E-02	NA	NA	NA	NA	34.58	McLaren Hart 1996			
Deep Alluvium	PZ-113-AD	FH	AD	1069273.97	835934.5	PZ-113-AD-FH1	1.80E-03	3.50E-03	1.50E-03	3.00E-03	NA	NA	1.70E-03	3.20E-03	4.61	Golder 1996	4.6	251	59
	PZ-113-AD	FH[4]	AD	1069273.97	835934.5	PZ-113-AD-FH2	1.90E-03	3.70E-03	1.40E-03	2.80E-03	NA	NA	1.70E-03	3.20E-03	4.61	Golder 1996			
	D-3	RH	AD	1069177.97	836047	D-3	NA	NA	3.15E-02	6.20E-02	NA	NA	NA	NA	89.29	McLaren Hart 1996			
	D-6	RH	AD	1070235.1	834723.492	D-6	NA	NA	4.29E-02	8.44E-02	NA	NA	NA	NA	121.61	McLaren Hart 1996			
	D-12	RH	AD	1069877.227	835110.755	D-12	NA	NA	4.14E-02	8.15E-02	NA	NA	NA	NA	117.35	McLaren Hart 1996			
	D-13	RH	AD	1070527.015	835776.5617	D-13	NA	NA	8.85E-02	1.74E-01	NA	NA	NA	NA	250.87	McLaren Hart 1996			
	D-85	RH	AD	1069667.265	836605.173	D-85	NA	NA	4.50E-03	8.86E-03	NA	NA	NA	NA	12.76	McLaren Hart 1996			
	D-93	RH	AD	1069369.757	834443.556	D-93	NA	NA	4.78E-02	9.41E-02	NA	NA	NA	NA	135.50	McLaren Hart 1996			

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
	PZ-100-SS		SS	1068908.761	837349.65	PZ-100-SS	1.00E-07	2.00E-07	5.70E-08	1.10E-07	NA	NA	7.90E-08	1.50E-07	0.00	Golder 1996			
	PZ-101-SS		SS	1068513.92	836797.322	PZ-101-SS	8.60E-07	1.70E-06	5.10E-07	1.00E-06	NA	NA	6.90E-07	1.30E-06	0.00	Golder 1996			
	PZ-102R-SS		SS	1068172.734	837033.545	PZ-102R-SS	4.70E-08	9.30E-08	3.00E-08	5.90E-08	NA	NA	3.90E-08	7.60E-08	0.00	Golder 1996			
	PZ-103-SS		SS	1067701.303	836897.822	PZ-103-SS	8.40E-07	1.70E-06	1.70E-06	3.30E-06	NA	NA	1.30E-06	2.50E-06	0.00	Golder 1996			
	PZ-104-SS		SS	1067068.815	837021.987	PZ-104-SS	6.00E-07	1.20E-06	1.30E-06	2.60E-06	NA	NA	9.50E-07	1.90E-06	0.00	Golder 1996			
	PZ-105-SS		SS	1066462.138	836405.054	PZ-105-SS	3.50E-06	6.90E-06	8.50E-06	1.70E-05	NA	NA	6.00E-06	1.20E-05	0.02	Golder 1996			
	PZ-106-SS		SS	1066767.07	835574.642	PZ-106-SS	3.90E-06	7.70E-06	2.50E-06	4.90E-06	NA	NA	3.20E-06	6.30E-06	0.01	Golder 1996			
	PZ-107-SS		SS	1067204.044	835429.345	PZ-107-SS	1.60E-06	3.10E-06	1.20E-06	2.40E-06	NA	NA	1.40E-06	2.80E-06	0.00	Golder 1996			
	PZ-108-SS		SS	1067719.34	836147.31	PZ-108-SS	6.30E-07	1.20E-06	4.30E-07	8.50E-07	NA	NA	5.30E-07	1.00E-06	0.00	Golder 1996			
	PZ-109-SS		SS	1068052.306	836318.4981	PZ-109-SS	1.80E-07	3.50E-07	8.70E-08	1.70E-07	NA	NA	1.30E-07	2.60E-07	0.00	Golder 1996			
	PZ-110-SS		SS	1068376.97	836094.3	PZ-110-SS1	1.60E-06	3.10E-06	8.90E-07	1.80E-06	NA	NA	1.20E-06	2.50E-06	0.00	Golder 1996			
	PZ-113-SS		SS	1069282.97	835951.3	PZ-113-SS	5.20E-06	1.00E-05	4.90E-06	9.60E-06	NA	NA	5.10E-06	9.90E-06	0.01	Golder 1996			
St. Louis Form.	PZ-115-SS		SS	1069449.628	836929.871	PZ-115-SS	2.90E-05	5.70E-05	2.40E-05	4.70E-05	NA	NA	2.70E-05	5.2E-05	0.07	Golder 1996	0.000065	7.8	0.0037
	PZ-116-SS		SS	1066451.146	836018.584	PZ-116-SS	2.90E-08	5.70E-08	1.70E-08	3.30E-08	NA	NA	2.30E-08	4.50E-08	0.00	Golder 1996			
	PZ-200-SS		SS	1068537.089	837146.557	PZ-200-SS	1.50E-06	3.00E-06	2.80E-06	5.50E-06	NA	NA	2.20E-06	4.20E-06	0.01	Golder 1996			
	PZ-201-SS		SS	1067860.52	837036.76	PZ-201-SS	3.30E-05	6.50E-05	5.40E-05	1.10E-04	NA	NA	4.40E-05	8.60E-05	0.12	Golder 1996			
	PZ-201A-SS		SS	1067872.76	837021.163	PZ-201A-SS	1.30E-07	2.60E-07	8.30E-08	1.60E-07	NA	NA	1.10E-07	2.10E-07	0.00	Golder 1996			
	PZ-202-SS		SS	1067361.152	837276.124	PZ-202-SS	3.00E-03	5.90E-03	2.50E-03	4.90E-03	NA	NA	2.80E-03	5.40E-03	7.78	Golder 1996			
	PZ-204-SS		SS	1066470.424	835731.2717	PZ-204-SS	1.80E-06	3.50E-06	2.80E-06	5.50E-06	NA	NA	2.30E-06	4.50E-06	0.01	Golder 1996			
	PZ-204A-SS		SS	1066470.424	835731.2717	PZ-204A-SS	3.50E-07	6.90E-07	2.30E-07	4.50E-07	NA	NA	2.90E-07	5.70E-07	0.00	Golder 1996			
	PZ-205-SS		SS	1067524.521	835652.192	PZ-205-SS	4.40E-07	8.70E-07	3.90E-07	7.70E-07	NA	NA	4.20E-07	8.20E-07	0.00	Golder 1996			
	PZ-206-SS		SS	1068071.821	835984.0148	PZ-206-SS	1.80E-05	3.50E-05	1.10E-05	2.20E-05	NA	NA	1.50E-05	2.90E-05	0.04	Golder 1996			
	PZ-208-SS		SS	1069260.125	837344.084	PZ-208-SS	4.30E-07	8.50E-07	2.70E-07	5.30E-07	NA	NA	3.50E-07	6.90E-07	0.00	Golder 1996			
	PZ-300-SS		SS	1065245.72	834024.51	PZ-300-SS	9.00E-07	1.80E-06	7.70E-07	1.50E-06	NA	NA	8.40E-07	1.60E-06	0.00	Golder 1996			
	PZ-301-SS		SS	1064842.65	835691.69	PZ-301-SS1	7.50E-07	1.50E-06	NA	NA	NA	NA	7.50E-07	1.50E-06	0.00	Golder 1996			

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
Salem Form.	PZ-100-SD		SD	1068892.808	837369.99	PZ-100-SD	9.10E-07	1.80E-06	6.40E-07	1.30E-06	NA	NA	7.80E-07	1.50E-06	0.00	Golder 1996	0.00024	0.042	0.0019
	PZ-104-SD		SD	1067054.135	837009.268	PZ-104-SD	1.80E-05	3.50E-05	1.20E-05	2.30E-05	NA	NA	1.50E-05	2.90E-05	0.04	Golder 1996			
	PZ-106-SD		SD	1066755.685	835590.703	PZ-106-SD	3.00E-07	5.90E-07	1.60E-07	3.10E-07	NA	NA	2.30E-07	4.50E-07	0.00	Golder 1996			
	PZ-111-SD		SD	1068678.166	836009.0044	PZ-111-SD	1.00E-07	2.00E-07	6.80E-08	1.30E-07	NA	NA	8.40E-08	1.70E-07	0.00	Golder 1996			
Keokuk Form.	PZ-100-KS		KS	1068883.062	837386.265	PZ-100-KS	NA	NA	NA	NA	6.00E-07	1.20E-06	NA	NA	0.00	Golder 1996	0.0017	0.011	0.0058
	PZ-104-KS		KS	1067034.018	836995.216	PZ-104-KS	NA	NA	NA	NA	2.50E-06	4.90E-06	NA	NA	0.01	Golder 1996			
	PZ-106-KS		KS	1066744.652	835606.899	PZ-106-KS	NA	NA	NA	NA	3.10E-06	6.10E-06	NA	NA	0.01	Golder 1996			
	PZ-111-KS		KS	1068661.958	836025.2057	PZ-111-KS	NA	NA	NA	NA	3.80E-06	7.50E-06	NA	NA	0.01	Golder 1996			

Notes:
1: Slug tests conducted before piezometer reached equilibrium; data presented but not included in geometric means.
2: Falling head slug tests conducted within sand pack zone of well; data presented but not included in geometric means.
3: Rising Head test used to calculate geometric mean; falling head test used if rising head test unavailable
4: Duplicate test not included in geometric mean
Wells shown in gray not included in geometric mean as explained in footnotes 1, 2, 3 and 4
Burns & McDonnell slug testing results not included in summary

Abbreviations:
cm/sec: centimeters per second
ft/min: feet per minute
ft/day: feet per day
Form.: Formation
RH: Rising Head
FH: Falling Head
B-R: Bouwer & Rice
C-P: Cooper Papadopulos
Min: minimum
Max: maximum

TABLE 3-4. PACKER TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	GSE (ft msl)	Test Interval (ft bgs)	Interval Top (ft bgs)	Interval Bottom (ft bgs)	Interval Top (ft msl)	Interval Bottom (ft msl)	Interval Mid Point (ft msl)	Interval Thickness (ft)	K (cm/s)	K (ft/min)	K (ft/day)	Formation	Comments	Minimum (ft/day)	Maximum (ft/day)	Geometric Mean (ft/day)
PZ-100-KS	438.3	37.3-42.3	37.3	42.3	447.5	442.5	445.0	5	7.50E-04	1.50E-03	2.16E+00	St. Louis	Unsaturated			
PZ-100-KS	438.3	50.0-55.0	50.0	55.0	434.8	429.8	432.3	5	3.30E-06	6.60E-06	9.50E-03	St. Louis	Unsaturated			
PZ-104-KS	482.3	50.0-55.0	50.0	55.0	431.8	426.8	429.3	5	2.90E-06	5.70E-06	8.21E-03	St. Louis	Unsaturated			
PZ-106-KS	460.8	42.0-47.0	42.0	47.0	420.1	415.1	417.6	5	6.00E-06	1.20E-05	1.73E-02	St. Louis	Unsaturated			
PZ-106-KS	460.8	61.0-66.0	61.0	66.0	401.1	396.1	398.6	5	2.10E-06	4.10E-06	5.90E-03	St. Louis	Unsaturated	0.0010	0.0124	0.0027
PZ-100-KS	438.3	110.0-115.0	110.0	115.0	374.8	369.8	372.3	5	3.70E-07	7.20E-07	1.04E-03	St. Louis	Saturated			
PZ-104-KS	482.3	113.0-118.0	113.0	118.0	368.8	363.8	366.3	5	1.50E-07	2.90E-07	4.18E-04	St. Louis	Unsaturated			
PZ-111-KS	459.2	105.0-127.0	105.0	127.0	356.3	334.3	345.3	22	4.40E-06	8.60E-06	1.24E-02	St. Louis	Saturated			
PZ-111-KS	459.2	125.0-130.0	125.0	130.0	336.3	331.3	333.8	5	5.40E-07	1.10E-06	1.58E-03	St. Louis	Saturated			
PZ-106-KS	460.8	148.0-153.0	148.0	153.0	314.1	309.1	311.6	5	4.50E-06	8.80E-06	1.27E-02	Salem	-			
PZ-111-KS	459.2	162.0-167.0	162.0	167.0	299.3	294.3	296.8	5	7.90E-07	1.50E-06	2.16E-03	Salem	-			
PZ-111-KS	459.2	127.0-210.0	127.0	210.0	334.3	251.3	292.8	83	1.30E-06	2.60E-06	3.74E-03	Salem	-			
PZ-106-KS	460.8	140.0-201.0	140.0	201.0	322.1	261.1	291.6	61	2.50E-05	5.00E-05	7.20E-02	Salem	-			
PZ-100-KS	438.3	195.0-200.0	195.0	200.0	289.8	284.8	287.3	5	3.90E-06	7.70E-06	1.11E-02	Salem	-			
PZ-111-KS	459.2	140.0-210.0	140.0	210.0	321.3	251.3	286.3	70	3.30E-06	6.40E-06	9.22E-03	Salem	-			
PZ-104-KS	482.3	162.0-252.5	162.0	252.5	319.8	229.3	274.6	90.5	4.90E-06	9.70E-06	1.40E-02	Salem	-	0.00016	0.0720	0.0046
PZ-104-KS	482.3	208.0-213.0	208.0	213.0	273.8	268.8	271.3	5	8.40E-06	1.70E-05	2.45E-02	Salem	-			
PZ-111-KS	459.2	175.0-210.0	175.0	210.0	286.3	251.3	268.8	35	1.20E-06	2.40E-06	3.46E-03	Salem	-			
PZ-106-KS	460.8	187.0-201.0	187.0	201.0	275.1	261.1	268.1	14	1.80E-07	3.50E-07	5.04E-04	Salem	-			
PZ-111-KS	459.2	195.0-200.0	195.0	200.0	266.3	261.3	263.8	5	5.80E-08	1.10E-07	1.58E-04	Salem	-			
PZ-100-KS	438.3	220.0-225.0	220.0	225.0	264.8	259.8	262.3	5	2.10E-06	4.10E-06	5.90E-03	Salem	-			
PZ-104-KS	482.3	235.0-252.5	235.0	252.5	246.8	229.3	238.1	17.5	3.20E-07	6.40E-07	9.22E-04	Salem	-			

TABLE 3-4. PACKER TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	GSE (ft msl)	Test Interval (ft bgs)	Interval Top (ft bgs)	Interval Bottom (ft bgs)	Interval Top (ft msl)	Interval Bottom (ft msl)	Interval Mid Point (ft msl)	Interval Thickness (ft)	K (cm/s)	K (ft/min)	K (ft/day)	Formation	Comments	Minimum (ft/day)	Maximum (ft/day)	Geometric Mean (ft/day)
PZ-106-KS	460.8	215.0-220.0	215.0	220.0	247.1	242.1	244.6	5	2.60E-07	5.10E-07	7.34E-04	Warsaw	-	0.00073	0.158	0.0055
PZ-111-KS	459.2	221.0-226.0	221.0	226.0	240.3	235.3	237.8	5	9.50E-07	1.90E-06	2.74E-03	Warsaw	-			
PZ-111-KS	459.2	226.0-231.0	226.0	231.0	235.3	230.3	232.8	5	1.70E-06	3.30E-06	4.75E-03	Warsaw	-			
PZ-106-KS	460.8	237.0-242.0	237.0	242.0	225.1	220.1	222.6	5	2.40E-06	4.80E-06	6.91E-03	Warsaw	-			
PZ-111-KS	459.2	220.0-260.0	220.0	260.0	241.3	201.3	221.3	40	1.30E-06	2.50E-06	3.60E-03	Warsaw	-			
PZ-104-KS	482.3	270.0-290.0	270.0	290.0	211.8	191.8	201.8	20	4.40E-06	8.70E-07	1.25E-03	Warsaw	-			
PZ-111-KS	459.2	260.0-265.0	260.0	265.0	201.3	196.3	198.8	5	2.00E-06	3.80E-06	5.47E-03	Warsaw	-			
PZ-100-KS	438.3	290.0-295.0	290.0	295.0	194.8	189.8	192.3	5	5.60E+05	1.10E-04	1.58E-01	Warsaw	-			
PZ-104-KS	482.3	287.0-292.5	287.0	292.5	194.8	189.3	192.1	5.5	2.70E-06	5.30E-06	7.63E-03	Warsaw	-			
PZ-111-KS	459.2	260.0-290.0	260.0	290.0	201.3	171.3	186.3	30	1.10E-06	2.20E-06	3.17E-03	Warsaw	-			
PZ-104-KS	482.3	290.0-320.0	290.0	320.0	191.8	161.8	176.8	30	7.10E-07	1.40E-06	2.02E-03	Warsaw	-			
PZ-100-KS	438.3	265.0-357.6	265.0	357.6	219.8	127.2	173.5	92.6	5.30E-06	1.00E-05	1.44E-02	Warsaw	-			
PZ-111-KS	459.2	290.0-343.7	290.0	343.7	171.3	117.6	144.5	53.7	3.10E-06	6.10E-06	8.78E-03	Warsaw	-			
PZ-104-KS	482.3	320.0-358.3	320.0	358.3	161.8	123.5	142.7	38.3	3.40E-06	6.60E-07	9.50E-04	Warsaw	-			
PZ-106-KS	460.8	301.0-346.4	301.0	346.4	161.1	115.7	138.4	45.4	3.30E-05	6.60E-05	9.50E-02	Warsaw	-			
PZ-104-KS	482.3	343.0-348.0	343.0	348.0	138.8	133.8	136.3	5	1.90E-06	3.70E-06	5.33E-03	Warsaw	-			

TABLE 3-4. PACKER TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Borehole ID	GSE (ft msl)	Test Interval (ft bgs)	Interval Top (ft bgs)	Interval Bottom (ft bgs)	Interval Top (ft msl)	Interval Bottom (ft msl)	Interval Mid Point (ft msl)	Interval Thickness (ft)	K (cm/s)	K (ft/min)	K (ft/day)	Formation	Comments	Minimum (ft/day)	Maximum (ft/day)	Geometric Mean (ft/day)
PZ-111-KS	459.2	343.0-348.0	343.0	348.0	118.3	113.3	115.8	5	2.50E-05	4.90E-05	7.06E-02	Keokuk	-			
PZ-104-KS	482.3	366.0-371.0	366.0	371.0	115.8	110.8	113.3	5	4.00E-06	7.90E-06	1.14E-02	Keokuk	-			
PZ-100-KS	438.3	366.0-391.0	366.0	391.0	118.8	93.8	106.3	25	7.60E-07	1.50E-06	2.16E-03	Keokuk	-			
PZ-111-KS	459.2	343.0-368.0	343.0	368.0	118.3	93.3	105.8	25	2.10E-05	4.10E-05	5.90E-02	Keokuk	-			
PZ-111-KS	459.2	355.0-360.0	355.0	360.0	106.3	101.3	103.8	5	4.30E-05	8.50E-05	1.22E-01	Keokuk	-			
PZ-106-KS	460.8	357.0-362.2	357.0	362.2	105.1	99.9	102.5	5.2	2.80E-05	5.50E-05	7.92E-02	Keokuk	-	0.0022	0.122	0.028
PZ-106-KS	460.8	346.0-374.1	346.0	374.1	116.1	88.0	102.1	28.1	2.20E-05	4.30E-05	6.19E-02	Keokuk	-			
PZ-100-KS	438.3	377.0-391.0	377.0	391.0	107.8	93.8	100.8	14	1.40E-06	2.70E-06	3.89E-03	Keokuk	-			
PZ-104-KS	482.3	360.0-408.0	360.0	408.0	121.8	73.8	97.8	48	5.70E-06	1.10E-05	1.58E-02	Keokuk	-			
PZ-106-KS	460.8	364.0-374.0	364.0	374.0	98.1	88.1	93.1	10	1.70E-05	3.40E-05	4.90E-02	Keokuk	-			
PZ-104-KS	482.3	390.0-408.0	390.0	408.0	91.8	73.8	82.8	18	1.30E-05	2.60E-05	3.74E-02	Keokuk	-			

Note:
Minimum, maximum, and geometric means calculated using saturated intervals

Abbreviations:
ft : feet
min: minute
cm/sec: centimeters per second
bgs: below ground surface
msl: above mean sea level
GSE: Ground Surface Elevation
K: Hydraulic Conductivity

TABLE 3-5. LABORATORY PERMEABILITY TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Sample Number	Description	Sample Length (cm)	Sample Diameter (cm)	Sample Dry Density (pcf)	Maximum Dry Density (pcf)	Compaction (%)	Initial Moisture Content (%)	Optimum Moisture Content (%)	Effective Pressure (psi)	Back Pressure (psi)	Gradient	Average Permeability (cm/sec)	Average Permeability (ft/day)
PZ-101-SS 6-8	Loess	7.99	7.22	91.7	---	---	24.4	---	6	94	2	3×10^{-4}	0.850
PZ-102-SS 4-6	Loess	8.82	7.07	92.2	---	---	28.2	---	5	95	9	8×10^{-7}	0.0023
PZ-103-SS 14-16	Loess	7.73	7.18	97.7	---	---	28.3	---	13	87	4	2×10^{-6}	0.0057
PZ-104-KS 6-8	Loess	9.11	7.14	95.7	---	---	23.6	---	6	94	24	2×10^{-7}	0.0006
PZ-106-KS 6-8	Loess	8.89	7.14	103.0	---	---	22.2	---	6	94	5	3×10^{-6}	0.0085
PZ-106-KS GTS-1 201.9-202.5	Calcareous Claystone (Warsaw Formation)	7.63	4.50	151.9	---	---	4.5	---	153	98	129	$<1.1 \times 10^{-10}$	0.0000003
PZ-106-KS GTS-2 229.6-230.1	Calcareous Claystone (Warsaw Formation)	7.66	4.47	148.0	---	---	4.4	---	170	88	94	1.5×10^{-10}	0.0000004
PZ-200-SS 6-8	Loess	9.59	7.17	95.3	---	---	27.5	---	6	94	4	2×10^{-6}	0.0057
PZ-201-SS 26-28	Lacustrine Clayey Silt	8.11	7.13	86.4	---	---	34.5	---	23	77	14	3×10^{-6}	0.0085
PZ-202-SS 6-8	Loess	8.08	7.10	96.4	---	---	26.7	---	6	94	10	3×10^{-7}	0.0009
PS-1 10	NA	9.56	7.23	100.8	105.0	96	18.4	19.0	5	95	6	2×10^{-7}	0.0006
PS-2 7	NA	9.55	7.24	101.7	106.0	96	17.5	17.5	5	95	10	3×10^{-7}	0.0009
LR-103	NA	10.16	7.22	79.9	---	---	37.4	17.5	5	95	3	2×10^{-4}	0.567

Abbreviation:
NA: not available

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
40 C.F.R. Part 192, Subpart A Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Material from Inactive Uranium Processing Sites; 40 C.F.R. Appendix Table 1 to Subpart A of Part 192, Maximum Concentration of Constituents for Groundwater Protection	Radium, uranium, and trace metals in groundwater, Radium-226 (Radium-228) in soil	Maximum constituent concentration:		Not applicable, but potentially relevant and appropriate for OU- 3.
		Combined Ra-226 and Ra-228	5 pCi/L	
		Combined U-234 and U-238	30 pCi/L	
		Gross alpha (excluding radon & uranium)	15 pCi/L	
		Arsenic	0.05 mg/L	
		Barium	1.0 mg/L	
		Cadmium	0.01 mg/L	
		Chromium	0.05 mg/L	
		Lead	0.05 mg/L	
		Mercury	0.002 mg/L	
		Selenium	0.01 mg/L	
		Silver	0.05 mg/L	
		Nitrate (as N)	10 mg/L	
		Molybdenum	0.1 mg/L	
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Groundwater	Water contaminants shall not cause or contribute to an exceedance of the following:		Not applicable, but potentially relevant and appropriate for OU-3.
		Inorganics (mg/L)		
		Fluoride	4	
		Nitrate	10	
		Trace metals (µg/L)		
		Antimony	6	
		Arsenic	50	
		Barium	2000	
		Beryllium	4	
		Boron	2000	
		Cadmium	5	
		Chromium III	100	
		Cobalt	1000	
		Copper	1300	
		Iron	300	
		Lead	15	
		Manganese	50	
		Mercury	2	
		Nickel	100	
		Selenium	50	
		Silver	50	
		Thallium	2	
		Zinc	5000	
		Organics (µg/L)		
		Acrolein	320	
		Bis-2-chloroisopropyl ether	1400	
		2, chlorophenol	0.1	
		2,4-dichlorophenol	93	
		2,4-dinitrophenol	70	
		2,4-dimethylphenol	540	
		2,4,5-trichlorophenol	2600	
		2,4,6-trichlorophenol	2	
		2-methyl-4,6-dinitrophenol	13	
		Ethylbenzene	700	
		Hexachlorocyclopentadiene	50	
		Isophorone	36	
		Nitrobenzene	17	
		Phenol	300	
		Dichloropropene	87	
		Para(1,4)-dichlorobenzene	75	
		Other Dichlorobenzenes	600	
		1,2,4-trichlorobenzene	70	
		1,2,4,5-tetrachlorobenzene	2.3	
		Pentachlorobenzene	3.5	
		1,1,1-trichloroethane	200	
		1,1,2-trichloroethane	0.04	
		2,4-dinitrotoluene	0.04	
		1,2-diphenylhydrazine	0.04	
		di (2-ethylhexyl) adipate	400	
		Pesticides (µg/L)		
		2,4-D	70	
		2,4,5-TP	50	
		Alachlor	2	
		Atrazine	3	
		Carbofuran	40	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Groundwater (cont.)	Dalapon	200	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Dibromochloropropane	0.2	
		Dinoseb	7	
		Diquat	20	
		Endothall	100	
		Ethylene dibromide	0.05	
		Oxamyl (vydate)	200	
		Picloram	500	
		Simazine	4	
		Glyphosate	700	
		Bioaccumulative Anthropogenic Toxics (µg/L)		
		PCBs	0.000045	
		DDT	0.00059	
		DDE	0.00059	
		DDD	0.00083	
		Endrin	2	
		Endrin aldehyde	0.75	
		Aldrin	0.00013	
		Dieldrin	0.00014	
		Heptachlor	0.4	
		Heptachlor epoxide	0.2	
		Methoxychlor	40	
		Toxaphene	3	
		Lindane (gamma-BHC)	0.2	
		Alpha,beta,delta-BHC	0.0022	
		Chlordane	2	
		Benzidine	0.00012	
		2,3,7,8-TCDD (dioxin)	0.000000013	
		Pentachlorophenol	1	
		Anthropogenic Carcinogens (µg/L)		
		Acrylonitrile	0.058	
		Hexachlorobenzene	1	
		Bis (2-chloroethyl) ether	0.03	
		Bis (chloromethyl) ether	0.00013	
		Hexachloroethane	1.9	
		3,3'-dichlorobenzidine	0.04	
		Hexachlorobutadiene	0.456	
		n-nitrosodimethylamine	0.0007	
		Volatile Organic Compounds (µg/L)		
		Chlorobenzene	100	
		Carbon Tetrachloride	5	
		Trihalomethanes	80	
		Bromoform	4.3	
		Chlorodibromomethane	0.41	
		Dichlorobromomethane	0.56	
		Chloroform	5.7	
		Methyl Bromide	48	
		Methyl Chloride	5	
		Methylene Chloride	4.7	
		1,2-dichloroethane	5	
		1,1,2,2-tetrachloroethane	0.17	
		1,1-dichloroethylene	7	
		1,2-trans-dichloroethylene	100	
		1,2-cis-dichloroethylene	70	
		Trichloroethylene	5	
		Tetrachloroethylene	0.8	
		Benzene	5	
		Toluene	1000	
		Xylenes (total)	10000	
		Vinyl chloride	2	
		Styrene	100	
		1,2-dichloropropane	0.52	
		Polynuclear Aromatic Hydrocarbons (µg/L)		
		Anthracene	9600	
		Fluoranthene	300	
		Fluorene	1300	
		Pyrene	960	
		Benzo(a)pyrene	0.2	
		Other polynuclear aromatic hydrocarbons	0.0044	

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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Groundwater (cont.)	Acenaphthene	1200	Not applicable, but potentially relevant and appropriate for OU-3.
		Phthalate Esters (µg/L)		
		Bis(2-ethylhexyl) phthalate	6	
		Butylbenzyl phthalate	3000	
		Diethyl phthalate	23000	
		Dimethyl phthalate	313000	
		Di-n-butyl phthalate	2700	
		Health Advisory Levels (µg/L)		
		Ametryn	60	
		Baygon	3	
		Bentazon	20	
		Bis-2-chloroisopropyl ether	300	
		Bromacil	90	
		Bromochloromethane	90	
		Bromomethane	10	
		Butylate	350	
		Carbaryl	700	
		Carboxin	700	
		Chloramben	100	
		o-chlorotoluene	100	
		p-chlorotoluene	100	
		Chlorpyrifos	20	
		DCPA (dacthal)	4000	
		Diazinon	0.6	
		Dicamba	200	
		Diisopropyl methylphosphonate	600	
		Dimethyl methylphosphonate	100	
		1,3-dinitrobenzene	1	
		Diphenamid	200	
		Diphenylamine	200	
		Disulfoton	0.3	
		1,4-dithiane	80	
		Diuron	10	
		Fenamiphos	2	
		Fluometron	90	
		Fluorotrichloromethane	2000	
		Fonofos	10	
		Hexazinone	200	
		Malathion	200	
		Maleic hydrazide	4000	
		MCPA	10	
		Methyl parathion	2	
		Metolachlor	70	
		Metribuzin	100	
		Naphthalene	20	
		Nitroguanidine	700	
		p-nitrophenol	60	
		Paraquat	30	
		Pronamide	50	
		Propachlor	90	
		Propazine	10	
		Propham	100	
		2,4,5-T	70	
		Tebuthiuron	500	
		Terbacil	90	
		Terbufos	0.9	
		1,1,1,2-Tetrachloroethane	70	
		1,2,3-trichloropropane	40	
		Trifluralin	5	
		Trinitroglycerol	5	
		Trinitrotoluene	2	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Aquatic Life Protection (medium unspecified)		Acute	Chronic	Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water.
		Metals (uglL)			
		Aluminum (pH 6.5-9.0)	750		
		Arsenic	340	150	
		Beryllium		5	
		Cadmium	Hardness Dependent	Hardness Dependent	
		Chromium (III)	Hardness Dependent	Hardness Dependent	
		Chromium (VI)	16	11	
		Copper	Hardness Dependent	Hardness Dependent	
		Iron		1000	
		Lead	Hardness Dependent	Hardness Dependent	
		Mercury	1.4	0.77	
		Methylmercury	1.4	0.77	
		Nickel	Hardness Dependent	Hardness Dependent	
		Selenium		5	
		Silver	Hardness Dependent	Hardness Dependent	
		Zinc	Hardness Dependent	Hardness Dependent	
		Other Inorganic Substances (µg/L unless otherwise noted)			
		Alkalinity (minimum CaCO3)		20000	
		Ammonia	pH dependent	Temperature and pH dependent	
		Chloride	860	230	
		Chloride + sulfate	10 CSR 20-7.031(5)(L)		
		Chlorine, Total Residual (Coldwater Aquatic Habitat)		2	
		Chloride, Total Residual (Warmwater Aquatic Habitat)	19	11	
		Cyanide	22	5.2	
		Gases, Total Dissolved (% saturation)	110	110	
		Hydrogen sulfide		2	
		Oil and Grease (mg/L)		10	
		Oxygen, Dissolved (mg/L) (Coldwater Aquatic Habitat)	6 (minimum)	6 (minimum)	
		Oxygen, Dissolved (mg/L) (Coolwater Aquatic Habitat)	5 (minimum)	5 (minimum)	
		Oxygen, Dissolved (mg/L) (Warmwater Aquatic Habitat)	5 (minimum)	5 (minimum)	
		pH		6.5-9	
		Organic Substances (µg/L)			
		Ethylbenzene		320	
		PCBs		0.014	
		Tributylin (TBT)	0.46	0.072	
		2-Chloronaphthalene		4300	
		Nonylphenol	28	6.6	
		Pentachlorophenol	pH dependent	pH dependent	
		Phenol (Coldwater Aquatic Habitat)	5293	157	
		Phenol (Warmwater Aquatic Habitat)	5293	2560	
		Pesticides (µg/L)			
		4-4;-Dichlorodiphenyltrichloroethane (DDT)	1.1	0.001	
		Acrolein	3	3	
		Aldrin	3		
		Carbaryl	2.1	2.1	
		Chlordane	2.4	0.0043	
		Chlorpyrifos	0.083	0.041	
		Demeton		0.1	
		Diazinon	0.17	0.17	
		Dieldrin	0.24	0.056	
		alpha-Endosulfan (Endosulfan)	0.22	0.056	
		beta-Endosulfan (Endosulfan)	0.22	0.056	
		Endrin	0.086	0.036	
		Guthion		0.01	
		Heptachlor	0.52	0.0038	
		Heptachlor Epoxide	0.52	0.0038	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)	0.95		
		Malathion		0.1	
		Methoxychlor		0.03	
		Mirex		0.001	
		Parathion	0.065	0.013	
		Toxaphene	0.73	0.002	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Fish Consumption for Human Health Protection	Metals (uglL)		Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water.
		Antimony	4300	
		Thallium	6.3	
		Organic Substances (µg/L)		
		Benzene	71	
		Chlorobenzene	21000	
		1,2-Dichlorobenzene (ortho-Dichlorobenzene)	2600	
		1,3-Dichlorobenzene (meta-Dichlorobenzene)	2600	
		1,4-Dichlorobenzene (para-Dichlorobenzene)	2600	
		1,2,4-trichlorobenzene	940	
		1,2,4,5-tetrachlorobenzene	2.9	
		Pentachlorobenzene	4.1	
		Hexachlorobenzene	0.00074	
		Nitrobenzene	1900	
		1,1-dichloroethylene	3.2	
		1,1,2-trichloroethane	42	
		1,1,2,2-tetrachloroethane	11	
		1,2-Dichloroethane	99	
		1,2-dichloropropane	39	
		1,3-Dichloropene	1700	
		Carbon Tetrachloride	5	
		Hexachloroethane	8.7	
		Tetrachloroethylene	8.85	
		trans-1,2-Dichloroethylene	140000	
		Trichloroethylene	80	
		Chlorodibromomethane	34	
		Dichlorobromomethane	46	
		Dichlorodifluoromethane	570000	
		Methyl Bromide	4000	
		Methyl Chloride	470	
		Methylene Chloride	1600	
		tribromomethane	360	
		Trichlorofluoromethane	860000	
		Trichloromethane	470	
		Vinyl chloride	525	
		Bis-2-Chloroethyl Ether	1.4	
		Bis-2-Chloroisopropyl Ether	4360	
		Bis-Chloromethyl Ether	0.00078	
		2,3,7,8-TCDD (dioxin)	1.40E-08	
		Isophorone	2600	
		PCBs	0.000045	
		1,2-diphenylhydrazine	0.54	
		3,3;-Dichlorobenzidine	0.08	
		Acrylonitrile	0.65	
		Benzidine	0.00053	
		n-nitrosodimethylamine	8	
		N-nitrosodi-n-propylamine	1.4	
		N-Nitrosodiphenylamine	16	
		N-Nitrosopyrolidine	91.9	
		Acenaphthene	2700	
		Fluoroanethene	370	
		Fluorene	14000	
		Pyrene	11000	
		Other polynuclear aromatic hydrocarbons	0.049	
		Bis (2-Ethylhexyl) Phthalate	5.9	
		Butylbenzyl phthalate	5200	
		Diethyl phthalate	120000	
		Dimethyl phthalate	2900000	
		Di-n-butyl phthalate	12000	
		2-Chlorophenol	400	
		2-methyl-4,6-dinitrophenol	765	
		2,4-dichlorophenol	790	
		2,4-dimethylphenol	2300	
		2,4-dinitrophenol	14000	
		2,4,5-trichlorophenol	9800	
		2,4,6-trichlorophenol	6.5	
		Pentachlorophenol	8	
		2,4-dinitrotoluene	9	
		Toluene	200000	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Fish Consumption for Human Health Protection (cont.)	Pesticides (µg/L)			Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water. (cont.)
		4-4'-Dichlorodiphenyldichloroethane (DDD)		0.00084	
		4-4'-Dichlorodiphenyltrichloroethylene (DDE)		0.00059	
		4-4'-Dichlorodiphenyltrichloroethane (DDT)		0.00059	
		Acrolein		780	
		Aldrin		0.000079	
		Chlordane		0.00048	
		Dieldrin		0.00076	
		Endrin		0.0023	
		Endrin aldehyde		0.0023	
		Heptachlor		0.0002	
		Heptachlor Epoxide		0.00011	
		Hexachlorobutadiene		50	
		alpha-Hexachlorocyclohexane (alpha-BHC)		0.0074	
		beta-Hexachlorocyclohexane (beta-BHC)		0.0074	
		delta-Hexachlorocyclohexane (delta-BHC)		0.0074	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)		0.062	
		Toxaphene		0.000073	
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Water		Drinking Water Supply	Irrigation / Livestock and Wildlife Protection	Not applicable, but potentially relevant and appropriate for OU-3.
		Metals (ugIL)			
		Antimony	6		
		Arsenic	50	100	
		Barium	2000		
		Beryllium	4	100	
		Boron		2000	
		Cadmium	5		
		Chromium (III)	100	100	
		Cobalt		1000	
		Copper	1300	500	
		Lead	15		
		Mercury	2		
		Nickel	100		
		Selenium	50		
		Silver	50		
		Thallium	2		
		Zinc	5000		
		Other Inorganic Substances (µg/L unless otherwise noted)			
		Asbestos	7×10^6 fibers/L		
		Chloride (mg/L)	250		
		Fluoride (mg/L)	4	4	
		Nitrate	10000		
		Sulfate (mg/L)	250		
		Organic Substances (µg/L)			
		Benzene	5		
		Chlorobenzene	100		
		1,2-Dichlorobenzene (ortho-Dichlorobenzene)	600		
		1,3-Dichlorobenzene (meta-Dichlorobenzene)	600		
		1,4-Dichlorobenzene (para-Dichlorobenzene)	75		
		1,2,4-trichlorobenzene	70		
		1,2,4,5-tetrachlorobenzene	2.3		
		Pentachlorobenzene	3.5		
		Hexachlorobenzene	1		
		Ethylbenzene	700		
		Nitrobenzene	17		
		Styrene (Vinyl Benzene)	100		
		1,1-dichloroethylene	7		
		1,1,1-trichloroethane	200		
		1,1,2-trichloroethane	5		
		1,1,2,2-tetrachloroethane	0.17		
		1,2-Dichloroethane	5		
		1,2-dichloropropane	0.52		
		1,3-Dichloropene	87		
		cis-1,2-Dichloroethylene	5		

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Water (cont.)	Carbon Tetrachloride	70	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Hexachloroethane	1.9	
		Tetrachloroethylene	0.8	
		trans-1,2-Dichloroethylene	100	
		Trichloroethylene	5	
		Chlorodibromomethane	0.41	
		Dichlorobromomethane	0.56	
		Ethylene dibromide	0.05	
		Methyl Bromide	48	
		Methyl Chloride	5	
		Methylene Chloride	4.7	
		Total Trihalomethanes (TTHMs)	80	
		tribromomethane	4.3	
		Trichloromethane	5.7	
		Vinyl chloride	2	
		Bis-2-Chloroethyl Ether	0.03	
		Bis-2-Chloroisopropyl Ether	1400	
		Bis-Chloromethyl Ether	0.00013	
		2,3,7,8-TCDD (dioxin)	1.30E-08	
		di (2-ethylhexyl) adipate	400	
		Isophorone	36	
		1,2-diphenylhydrazine	0.04	
		3,3;-Dichlorobenzidine	0.04	
		Acrylonitrile	0.058	
		Benzidine	0.00012	
		n-nitrosodimethylamine	0.0007	
		N-Nitrosodiphenylamine	5	
		Acenaphthene	1200	
		Fluoroanethene	300	
		Fluorene	1300	
		Pyrene	960	
		Other polynuclear aromatic hydrocarbons	0.0044	
		Bis (2-Ethylhexyl) Phthalate	6	
		Butylbenzyl phthalate	3000	
		Diethyl phthalate	23000	
		Dimethyl phthalate	313000	
		Di-n-butyl phthalate	2700	
		2-Chlorophenol	0.1	
		2-methyl-4,6-dinitrophenol	13	
		2,4-dichlorophenol	93	
		2,4-dimethylphenol	540	
		2,4-dinitrophenol	70	
		2,4,5-trichlorophenol	2600	
		2,4,6-trichlorophenol	2	
		Pentachlorophenol	1	
		Phenol (Coldwater Aquatic Habitat)	100	
		Phenol (Warmwater Aquatic Habitat)	100	
		2,4-dinitrotoluene	0.11	
		Toluene	1000	
		Xylenes (total)	10000	
		<u>Pesticides (µg/L)</u>		
		1,2-Dibromo-3-chloropropane (DBCP)	0.2	
		4-4'-Dichlorodiphenyldichloroethane (DDD)	0.00083	
		4-4'-Dichlorodiphenyldichloroethylene (DDE)	0.00059	
		4-4'-Dichlorodiphenyltrichloroethane (DDT)	0.00059	
		Acrolein	320	
		Alachlor	2	
		Aldrin	0.00013	
		Atrazine	3	
		Carbofuran	40	
		Chlordane	2	
		Chlorophenoxy Herbicide (2,4-D)	70	
		Chlorophenoxy Herbicide (2,4,5-TP)	50	
		Dalapon	200	
		Dieldrin	0.00014	
		Dinoseb	7	
		Diquat	20	
		Endothall	100	
		Endrin	2	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Water (cont.)	Endrin aldehyde	0.75	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Heptachlor	0.4	
		Heptachlor Epoxide	0.2	
		Hexachlorobutadiene	0.45	
		Hexachlorocyclopentadiene	50	
		alpha-Hexachlorocyclohexane (alpha-BHC)	0.0022	
		beta-Hexachlorocyclohexane (beta-BHC)	0.0022	
		delta-Hexachlorocyclohexane (delta-BHC)	0.0022	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)	0.2	
		Methoxychlor	40	
		Oxamyl (vydate)	200	
		Picloram	500	
		Simazine	4	
		Toxaphene	3	
		Health Advisory Levels (µg/L)		
		1,1,1,2-Tetrachloroethane	70	
		1,2,3-trichloropropane	40	
		1,3-dinitrobenzene	1	
		1,4-dithiane	80	
		2,4,5-Trichlorophenoxyacetic acid	70	
		2,4,6-Trinitrotoluene	2	
		Ametryn	60	
		Baygon	3	
		Bentazon	20	
		Bis-2-Chloroisopropyl Ether	300	
		Bromacil	90	
		Bromochloromethane	90	
		Butylate	350	
		Carbaryl	700	
		Carboxin	700	
		Chloramben	100	
		ortho-Chlorotoluene	100	
		para-Chlorotoluene	100	
		Chlorpyrifos	20	
		DCPA (dacthal)	4000	
		Diazinon	0.6	
		Dicamba	200	
		Diisopropyl methylphosphonate	600	
		Dimethyl methylprosphonate	100	
		Diphenamid	200	
		Diphenylamine	200	
		Disulfoton	0.3	
		Diuron	10	
		Fenamiphos	2	
		Fluometron	90	
		Fonofos	10	
		Hexazinone	200	
		Malathion		
		Maleic hydrazide	4000	
		MCPA (2-Methyl-4-Chlorophenoxyacetic acid)	10	
		Methyl Bromide	10	
		Methyl parathion	2	
		Metolachlor	70	
		Metribuzin	100	
		Naphthalene	20	
		Nitroguanidine	700	
		para-Nitrophenol	60	
		Paraquat	30	
		Pronamide	50	
		Propachlor	90	
		Propazine	10	
		Propham	100	
		Tebuthiuron	500	
		Terbacil	90	
		Terbufos	0.9	
		Trichlorofluoromethane	2000	
		Trifluralin	5	
		Trinitroglycerol	5	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Public Drinking Water Program, Contaminant Levels and Monitoring 10 C.S.R. § 60-4	Inorganics, Synthetic Organic Compounds, Radionuclides, Secondary Contaminants, and Volatile Organic Compounds	Maximum contaminant levels for public water systems.		Not applicable, but potentially relevant and appropriate for OU-3.
		Inorganics (mg/L unless otherwise noted)		
		Antimony	0.006	
		Arsenic	0.01	
		Asbestos	7 x 10^6 fibers/L	
		Barium	2	
		Beryllium	0.004	
		Cadmium	0.005	
		Chromium	0.1	
		Cyanide	0.2	
		Fluoride	4	
		Mercury	0.002	
		Nitrate (as N)	10	
		Nitrite (as N)	1	
		Total Nitrate + Nitrite (as N)	10	
		Selenium 0.05	0.05	
		Thallium 0.002	0.002	
		Synthetic Organic Compounds (mg/L)		
		Alachlor	0.002	
		Atrazine	0.002	
		Benzo(a)pyrene	0.0002	
		Carbonfugran	0.04	
		Chlordane	0.002	
		Dalapon	0.2	
		Di(2-ethylhexyl) adipate	0.4	
		Dibromochloropropane (DBCP)	0.0002	
		Di(2-ethylhexyl) phthalate	0.006	
		Dinoseb	0.007	
		Diquat	0.02	
		Endothall	0.1	
		Endrin	0.002	
		2,4-D	0.07	
		Ethylene dibromide (EDB)	0.00005	
		Glyphosoate	0.7	
		Heptachlor	0.0004	
		Heptachlor Epoxide	0.0002	
		Hexachlorobenzene	0.001	
		Hexachlorocyclopentadiene	0.05	
		Lindane	0.0002	
		Methoxychlor	0.04	
		Oxamyl (Vydate)	0.2	
		Picloram	0.5	
		Polychlorinated biphenyls (PCBs)	0.0005	
		Pentachlorophenol	0.001	
		Simazine	0.004	
		Toxaphene	0.003	
		2,3,7,8-TCDD (Dioxin)	0.00000003	
		2,4,5-TP (Silvex)	0.05	
		Radionuclides		
		Combined $Ra^{226 \text{ and }}$ Ra^{228}	5 pCi/L	
		Gross alpha (excluding radon & uranium)	15 pCi/L	
		Uranium	30 µg/L	
		Secondary Contaminants		
		Aluminum	0.05 - 0.2 mg/L	
		Chloride	250 mg/L	
		Color	15 color units	
		Copper	1.0 mg/L	
		Corrosivity	Noncorrosive	
		Fluoride	2.0 mg/L	
		Foaming Agents	0.5 mg/L	
		Iron	0.3 mg/L	
		Manganese	0.05 mg/L	
		Odor	3 Threshold Odor Number	
		pH	6.5-8.5	
		Silver	0.1 mg/L	
		Sulfate	250 mg/L	
		Total Dissolved Solids	500 mg/L	
		Zinc	5 mg/L	
		Volatile Organic Compounds (mg/L)		
		Benzene	0.005	
		Carbon tetrachloride	0.005	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
Missouri Public Drinking Water Program, Contaminant Levels and Monitoring 10 C.S.R. § 60-4 (cont.)	Inorganics, Synthetic Organic Compounds, Radionuclides, Secondary Contaminants, and Volatile Organic Compounds (cont.)	1,2-Dichloroethane		0.005	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		1,1-Dichloroethylene		0.007	
		para-Dichlorobenzene		0.075	
		1,1,1-Trichloroethane		0.2	
		Trichloroethylene		0.005	
		Vinyl chloride		0.002	
		cis-1,2-Dichloroethylene		0.07	
		Dichloromethane		0.005	
		1,2-Dichloropropane		0.005	
		Ethylbenzene		0.7	
		Monodichlorobenzene		0.1	
		o-Dichlorobenzene		0.6	
		Styrene		0.1	
		Tetrachloroethylene		0.005	
		Toluene		1	
		1,2,4-Trichlorobenzene		0.07	
		1,1,2-Trichloroethane		0.005	
		trans-1,2-dischloroethylene		0.1	
		Xylenes (total)		10	
40 C.F.R. Part 141, National Primary Drinking Water Regulations, 40 C.F.R. § 141.50, 40 C.F.R. § 141.51, § 141.52, § 141.53, § 141.54, § 141.55	Various chemicals in water	Establishes standards including maximum contaminant levels (MCLs) and Goals (MCLGs)			Not applicable, but potentially relevant and appropriate for OU-3.
			<u>MCL</u>	<u>MCLG</u>	
		<u>Trace metals (mg/L unless otherwise noted)</u>			
		Antimony	0.006	0.006	
		Asbestos	7 x 10^6 fibers/liter	7 x 106 fibers/liter	
		Barium	2	2	
		Cyanide	0.2	0.2	
		Fluoride	4	4	
		Lead	0.015	zero	
		Mercury (inorganic)	0.002	0.002	
		Nitrate (as N)	10	10	
		Nitrite (as N)	1	1	
		Selenium	0.05	0.05	
		Thallium	0.0005	0.002	
		<u>Organic Chemicals (mg/L)</u>			
		Alachlor zero	zero	0.002	
		Atrazine	0.003	0.003	
		Benzene	zero	0.005	
		Benzo(a)pyrene	zero	0.0002	
		Carbofuran	0.04	0.04	
		Carbon tetrachloride	zero	0.005	
		Chlordane	zero	0.002	
		Chlorobenzene	0.1	0.1	
		2,4-D	0.07	0.07	
		Dalapon	0.2	0.2	
		1,2-Dibromo-3-chloropropane	zero	0.0002	
		o-Dichlorobenzene	0.6	0.6	
		p-Dichlorobenzene	0.075	0.075	
		1,2-Dichloroethane	zero	0.005	
		1,1-Dichloroethylene	0.007	0.007	
		cis-1,2-Dichloroethene	0.07	0.07	
		trans-1,2-Dichloroethene	0.1	0.1	
		Dichloromethane	zero	0.005	
		1,2-Dichloropropane	zero	0.005	
		Di(2-ethylhexyl) adipate	0.4	0.4	
		Di(2-ethylhexyl) phthalate	zero	0.006	
		Dinoseb	0.007	0.007	
		Dioxin (2,3,7,8-TCDD)	zero	0.00000003	
		Diquat	0.02	0.02	
		Endothall	0.1	0.1	
		Endrin	0.002	0.002	
		Ethylbenzene	0.7	0.7	
		Ethylene dibromide	zero	0.00005	
		Glyphosate	0.7	0.7	
		Heptachlor	zero	0.0004	
		Heptachlor epoxide	zero	0.0002	
		Hexachlorobenzene	zero	0.0001	
		Hexachlorocyclopentadiene	0.05	0.05	
		Lindane	0.0002	0.0002	
		Methoxychlor	0.04	0.04	
		Oxamyl (Vydate)	0.2	0.2	
		PCBs	zero	0.0005	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
40 C.F.R. Part 141, National Primary Drinking Water Regulations, 40 C.F.R. § 141.50, 40 C.F.R. § 141.51, § 141.52, § 141.53, § 141.54, § 141.55 (cont.)	Various chemicals in water (cont.)	Pentachlorophenol	zero	0.001	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Picloram	0.5	0.5	
		Simazine	0.004	0.004	
		Styrene	0.1	0.1	
		Tetrachloroethylene	zero	0.005	
		Toluene	1	1	
		Toxaphene	zero	0.003	
		2,4,5-TP (Silvex)	0.05	0.05	
		1,2,4-Trichlorobenzene	0.07	0.07	
		1,1,1-Trichloroethane	0.2	0.2	
		1,1,2-Trichloroethane	0.003	0.005	
		Trichloroethylene	zero	0.005	
		Vinyl chloride	zero	0.002	
		Xylenes (total)	10	10	
		Radionuclides (picocuries per liter [pCi/L])			
		Alpha particles	zero	15 pCi/L	
		Beta particles and photon emitters	zero	4 millirems per year	
		Radium-226 and Radium-228 (combined)	-	5 pCi/L	
		Uranium (μg/L)	zero	30 μg/L	
10 C.S.R. 80-3.010(11)B.4	Water Quality in Water	The owner/operator of a sanitary landfill shall implement a groundwater monitoring program capable of determining the sanitary landfill's impact on the quality of groundwater underlying the sanitary landfill.			May be an ARAR if groundwater discharges to surface water.
TMDL for Missouri Load	Water Quality	Continue to monitor TMDLs			May be an ARAR if groundwater discharges to surface water.
640.100-640.140 RSMo Drinking water regulations	Water pollutants in Water	Safe Drinking Water Law and specified regulatory contaminant limits			May be an ARAR if groundwater discharges to surface water.
EPA Memo "Considering a Noncancer Oral Reference Dose for Uranium for Superfund Human Health Risk Assessments" (Dated December 1, 2016)	Soluble uranium in various matrices	This memorandum provides information and recommendations about an oral reference dose (RfD) for non-radiological toxicity of soluble uranium. This memorandum recommends the use of the ATSDR intermediate MRL for soluble uranium without further adjustment, in lieu of the RfD currently published in IRIS, for assessment of chronic exposures also. Specifically, evaluation of the non- carcinogenic risks posed by uranium should use a toxicity value of 0.0002 mg/kg-day.			May be a TBC
10 C.S.R. 80-3.010 Appendix I	Constituents for detection monitoring	Listed Constituents for Detection Monitoring:			May be an ARAR if Missouri state standard exists
		Indicator Constituents			
		COD (mg/L)			
		Chlorides (mg/L dissolved)			
		pH (units)			
		Specific Conductance (micromhos per centimeter at 25 degrees Celsius)			
		Total Dissolved Solids (mg/L)			
		Inorganic Constituents			
		Ammonia as N, (mg/L)			
		Antimony (μg/L)			
		Arsenic (μg/L)			
		Barium (μg/L)			
		Beryllium (μg/L)			
		Boron (μg/L)			
		Cadmium (μg/L)			
		Calcium (mg/L)			
		Chromium (μg/L)			
		Cobalt (μg/L)			
		Copper (μg/L)			
		Fluoride (mg/L)			
		Hardness (mg/L)			
		Lead (μg/L)			
		Magnesium (mg/L)			
		Manganese (μg/L)			
		Nickel (mg/L)			
		Nitrate/Nitrite (mg/L)			
		Phosphorus, total (mg/L)			
		Selenium (μg/L)			
		Silver (μg/L)			
		Sodium (mg/L)			
		Sulfate (mg/L)			
		Thallium (μg/L)			

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix I (cont.)	Constituents for detection monitoring (cont.)	Total Organic Carbon (TOC) (mg/L) Vanadium (µg/L) Zinc (µg/L) Organic Constituents Acetone Acrylonitrile Benzene Bromochloromethane Bromodichloromethane tribromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroethane Trichloromethane Dibromochloromethane 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethylene cis-1,2-Dichloroethylene trans-1,2-Dichloroetylene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone Methyl bromide Methyl Chloride methyl ethyl ketone Methyl iodide 4-Methyl-2-pentanone Styrene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene Toluene 1,1,1-Trichloroethane 1,1,20Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-trichloropropane Vinyl acetate Vinyl chloride xylenes	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix II	List of Hazardous Inorganic and Organic Constituents	Acenaphthene Acenaphthylene Acetone acetonitrile acetophenone 2-Acetylaminofluorene Acrolein Acrylonitrile Aldrin Allyl chloride 4-Aminobipheny Anthracene Antimony Arsenic Barium Benzene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Benzo(a)pylene Benzyl alcohol Beryllium alpha-BHC beta-BHC	May be an ARAR if Missouri state standard exists

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	delta-BHC gamma-Hexachlorocyclohexane (gamma-BHC; Lindane) Bis(2-chloroethoxy)methane Bis(2-chloroethyl) ether Bis(2-chloro-1-methylethyl) ether Bis(2-ethylhexyl) phthalate Bromochloromethane Bromodichloromethane tribromomethane 4-Bromophenylphenyl ether Butyl benzyl phthalate Cadmium Carbon disulfide Carbon tetrachloride Chlordane p-Chloroaniline Chlorobenzene Chlorobenzilate p-Chloro-m-cresol Chloromethane Trichloromethane 2-Chloronaphthalene 2-Chlorophenol 4-Chlorophenyl phenyl ether Chloroprene Chromium Chrysene Cobalt Copper m-Cresol o-Cresol p-cresol Cyanide 2,4-D 4-4'-DDD 4-4'-DDE 4-4'-DDT Diallate Dibenz(a,h)anthracene Dibenzofuran Dibromochloromethane 1,2-Dibromo3-chloropropane 1,2-Dibromomethane Di-n-butyl phthalate o-Dichlorobenzene m-Dichlorobenzene p-Dichlorobenzene 3,3'-dichlorobenzidine trans-1,4-Dichloro-2-butene Dichlorofluoromethane 1,1-Dichloroethane 1,2-Dichlroroethane 1,1-Dichloroethylene 1,1-Dichloroethene cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene trans-1,2-Dichloroethene 2,4-dichlorophenol 2,6-Dichlorophenol 1,2-Dichloropropane 1,3-Dichloropropane 2,2-Dichloropropane 1,1-Dichloropropene cis-1,3-Dichloropropene trans-1,3-Dichloropropene Dieldrin Diethyl phthalate O,O-Diethyl O-2 pyrazinyl Dimethoate p-(Dimethylamino)azobenzene 7,12-Dimethylbenz(a)nthracene	May be an ARAR if Missouri state standard exists (cont.)

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	3,3'-Dimethylbenzidine 2,4-dimethylphenol Dimethyl phthalate m-Dinitribenzene 4,6-Dinitro-o-cresol 4,6-Dinitro-2-methylphenol 2,4-dinitrophenol 2,4-Dinitrotoluene 2,6-Dinitrotoluene Dinoseb Di-n-octyl phthalate Diphenylamine Disulfoton Endosulfan Endosulfan Endosulfan sulfate Endrin Endrin aldehyde ethylbenzene ethyl methacrylate ethyl methanesulfonate famphur fluoroanthene fluorene heptachlor Heptachlor epoxide Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Hexachloroethane Hexachloropropene 2-Hexanone Indeno(1,2,3-cd)pyrene Isobutyl alcohol Isodrin Isophorone Isosafrole Kepone Lead Mercury Methacrylonitrile Methapyrilene Methoxychlor Methyl bromide Methyl Chloride 3-Methylchloranthrene Methyl ethyl ketone Methyl iodide Methyl methacrylate Methyl methanesulfonate 2-Methylnaphthalene Methyl parathion 4-Methyl-2-pentanone Methyl isobutyl ketone Methylene bromide Methylene Chloride Naphthalene 1,4-Naphthoquinone 1-Naphthylamine 2-Naphthylamine Nickel o-Nitroaniline m-Nitroaniline p-Nitroaniline Nitrobenzene o-Nitrophenol p-nitrophenol N-Nitrosodi-n-butylamine N-Nitrosodiethylamine N-Nitrosodimethylamine N-Nitrosodiphenylamine	May be an ARAR if Missouri state standard exists (cont.)

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	N-Nitrosodipropylamine Di-n-propylnitrosamine N-Nitrosomethylethylamine N-Nitrosopiperidine N-Nitrosopyrrolidine 5-Nitro-o-toluidine Parathion Pentachlorobenzene Pentachlroonitrobenzene Pentachlorophenol Phenacetin Phenol p-Phenylenediamine Phorate PCBs Pronamide Propionitrile Pyrene Safrole Selenium Silver (µg/L) Silvex Styrene Sulfide 2,4-5-Trichlorophenoxyacetic acid 1,2,4,5-tetrachlorobenzene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene 2,3,4,6-Tetrachlorophenol Thallium Tin Toluene o-Toluidine Toxaphene 1,2,4-Trichlorobenzene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethylene Trichlorofluoromethane 2,4,5-trichlorophenol 2,4,6-trichlorophenol 1,2,3-trichloropropane 0,0,0-Triethyl phosphorothioate sym-Trinitrobenzene Vanadium Vinyl acetate Vinyl chloride Xylene (total) Zinc	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix III	Constituents for Detection Monitoring for Demolition Landfills	<u>Indicator Constituents</u> Aluminum Ammonia Antimony Arsenic Barium Beryllium Boron Cadmium Calcium Chemical Oxygen Demand Chloride Chromium Cobalt Copper Fluoride Hardness (mg/L) Iron Lead Magnesium Manganese	May be an ARAR if Missouri state standard exists

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix III (cont.)	Constituents for Detection Monitoring for Demolition Landfills (cont.)	Mercury Nickel pH Potassium Selenium Silver (µg/L) Sodium Specific Conductance (micromhos per centimeter at 25 degrees Celsius) Sulfate Thallium Total Dissolved Solids Total Organic Carbon Total Organic Halogens Zinc	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix IV	Constituents for Assessment Monitoring for Demolition Landfills	Inorganic Constituents Nitrate/Nitrite (mg/L) Phosphorus, total (mg/L) Vanadium Zinc Organic Constituents Acetone Acrylonitrile Benzene Bromochloromethane Bromodichloromethane tribromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroethane Trichloromethane Dibromochloromethane 1,2-Dibromo-3-chloropropane 1,2-Dibromomethane o-Dichlorobenzene p-Dichlorobenzene trans-1,4-Dichloro-2-butene 1,1,-Dichloroethane 1,2-Dichloroethane 1,1,-Dichloroethylene Vinylidene chloride cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone Methyl bromide Methyl Chloride Methylene bromide Methylene Chloride Methyl ethyl ketone Methyl iodide 4-Methyl-2-pentanone Styrene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene Toluene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethylene Trichlorofluoromethane 1,2,3-trichloropropane Vinyl acetate Vinyl chloride Xylenes	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
OSWER 4283.1- 14 ("Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites")	Radionuclides in groundwater	OSWER Directive 9283.1-14 addresses the use of uranium drinking water standards for groundwater remediation at CERCLA sites. This directive specifies that both the uranium MCL (40 CFR 141) and the UMTRCA standards (40 CFR 192) are potentially relevant and appropriate. This directive also provides guidance on the groundwater point of compliance standard in 40 C.F.R. 192.02(c)(4) relative to the CERCLA approach for conducting groundwater responses.	May be TBC

TABLE 3-7. PRELIMINARY ACTION SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
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Citation	Action	Medium	Requirement	Preliminary Determination
Resource Conservation and Recovery Act (RCRA) Subtitle C (40 C.F.R. 240 et seq.)	Hazardous waste management		Establishes standards for identification of and treatment, storage and disposal of hazardous wastes including hazardous wastes disposed in landfills. Standards for Identification of hazardous wastes (40 C.F.R. 261) Standards for Generators of hazardous wastes (40 C.F.R. 262) Standards for Transporters of hazardous wastes (40 C.F.R. 263) Use and Management of Containers (40 C.F.R. 264 Subpart I) Land Disposal Restrictions (40 C.F.R. 264 Subpart N) Staging Piles (40 C.F.R. 264.554) Specifically, must determine if solid waste is a hazardous waste using the following method: ・Should first determine if waste is excluded from regulation under 40 C.F.R. 261.4; and ・Must then determine if waste is listed as a hazardous waste under subpart D 40 C.F.R. part 261 or whether the waste is (characteristic waste) identified in subpart C of 40 C.F.R. part 261 by either: (1)Testing the waste according to the methods set forth in subpart C of 40 C.F.R. part 261, or according to an equivalent method approved by the Administrator under 40 C.F.R. §260.21; or (2)Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used. A generator may accumulate hazardous waste at the facility provided that (accumulation of RCRA hazardous waste on site as defined in 40 C.F.R. §260.10): ・waste is placed in containers that comply with 40 C.F.R. 265.171–173; and ・the date upon which accumulation begins is clearly marked and visible for inspection on each container; ・container is marked with the words “hazardous waste”; or ・container may be marked with other words that identify the contents if accumulation of 55 gal. or less of RCRA hazardous waste or one quart of acutely hazardous waste listed in §261.33(e) at or near any point of generation.	Potentially applicable in the event that hazardous wastes or
CERCLA Offsite Rule 40 C.F.R. 300.440	Off-site disposal		Wastes can only be disposed at offsite facilities operating in compliance with applicable regulations as verified by EPA.	Applicable to off-site disposal
DOT and NRC regulations for shipment of radioactive materials 49 C.F.R. Parts 171-180 and 10 C.F.R. Part 71	Off-site disposal		Specifies requirements for shipment of radioactive materials including hazard communications, labeling, manifests, security, emergency response, and planning.	Applicable to off-site disposal.
CERCLA Offsite Rule 40 C.F.R. 300.440	Off-site disposal		Wastes can only be disposed at offsite facilities operating in compliance with applicable regulations as verified by EPA.	Applicable to off-site disposal

Citation	Action	Medium	Requirement	Preliminary Determination
DOT and NRC regulations for shipment of radioactive materials 49 C.F.R. Parts 171-180 and 10 C.F.R. Part 71	Off-site disposal		Specifies requirements for shipment of radioactive materials including hazard communications, labeling, manifests, security, emergency response, and planning.	Applicable to off-site disposal.
Offsite disposal Waste Acceptance Criteria	Off-site disposal		Lists the types of materials and activity levels of waste materials that can be accepted by off-site disposal facilities.	Applicable to off-site disposal.
40 C.F.R. Part 131 (Water Quality Standards) 40 C.F.R. § 131.36	Sets forth requirements and procedures for developing, reviewing, revising and approving water quality standards by the States as authorized by the Clean Water Act	Groundwater	40 C.F.R. Part 131 describes the requirements and procedures for developing, reviewing, revising, and approving water quality standards by the States as authorized by section 303(c) of the Clean Water Act. 40 C.F.R. Part 131 does not lay out specific standards to be applied, but rather serves as a framework by which States must develop water quality standards for water bodies, including uses that may be made of such bodies, and standards to promote the safety of water as used. It also provides for the process by which EPA reviews, revises and approves of water quality standards developed by States.	Not applicable, but potentially relevant and appropriate for OU-3.
644.051.1	Release of Pollutants to Waters of the State		1 It is unlawful for any person to cause pollution of any waters of the state or to place or cause or permit to be placed any water contaminant in a location where it is reasonably certain to cause pollution of any waters of the state. Unlawful to pollute waters of the state, reduce quality below water quality standards, violate pretreatment and toxic material control regulations, discharge radiological, chemical or biological gen or high-level radioactive wastes into waters of the state.	Substantive elements of these chapters may be applicable if implementing a remedial action to include a groundwater treatment remedy.
10 C.S.R. 80-3.010(12)(C)	Corrective Measures		Requirement related to the establishment and implementation of a corrective action groundwater monitoring program.	Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in groundwater or any water discharge.
10 C.S.R. 23-4 Monitoring Well Construction Code	Installation of observation or monitoring wells		Regulates drilling, construction, registration, and abandonment of monitoring wells in Missouri	Substantive portions of Division 23 may be relevant and appropriate if wells are constructed and/or abandoned as part of the remedy, but will mostly be administrative.
4 C.S.R. 145-1.010 Board of Geologist Registration	Practice of geology		Regulates practice	Substantive portions of 4 C.S.R. 145-1.010 may be relevant and appropriate if a PG stamp and seal on drawings are necessary as part of the remedy. Otherwise mostly administrative.
10 C.S.R. 23-3.110 Plugging of Wells	Abandonment of unused domestic supply wells		Regulates activity	Although abandonment of unused domestic supply wells are not envisioned; could be relevant and appropriate if monitoring wells are required to be abandoned.

TABLE 3-7. PRELIMINARY ACTION SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Citation	Action	Medium	Requirement	Preliminary Determination
L.1991 S.B.221, an Act RSMo 256.621	Groundwater tracing		All persons engaged in groundwater or surface water tracing, for any purpose, shall register with the division. The registrant shall report in writing all proposed injections of tracers to the division prior to actual injection. Written and graphical documentation of traces shall be provided to the division within thirty days of completion of each trace. The division shall maintain records of all injections and traces reported and will provide this information to interested parties upon request.	If groundwater tracing is required, this might be considered an ARAR, but note that this activity is not part of the proposed RI activities.
Hazardous Waste Management Law 260.350- 260.1039 Hazardous Waste Regulations 10 C.S.R. 25-1 through 19.	Hazardous Waste Generation, storage, treatment, transportation and disposal		Follow all applicable state and federal hazardous waste laws and regulations	Substantive portions of Division 25 may be Relevant and Appropriate if hazardous waste is required to be managed under the selected remedial options.

TABLE 3-8. PRELIMINARY IDENTIFICATION OF POTENTIAL LOCATION-SPECIFIC ARARS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Location Subject to Requirement	Requirement	Reason Why Requirement May Be an ARAR	Regulatory Citation
Fee Fee Creek Watershed	Effluent Limitations for Metropolitan No-Discharge Streams. Discharge is prohibited except as specifically permitted under the Water Quality Standards 10 C.S.R 20-7031(7).	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.015(5) (A) Discharge to metropolitan no-discharge streams is prohibited, except as specifically permitted under the Water Quality Standards 10 C.S.R 20-7.031 and noncontaminated storm water flows.
Waters of the State of Missouri	Protection of designated uses.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(2)(A)-(C) (2) Designation of Uses. (A) Rebuttable presumption. (B) Presumed Uses. All waters described in subsection (2)(A) shall also be assigned Livestock and wildlife protection and Irrigation designated uses, as defined in this rule. (C) Other Uses
Waters of the State of Missouri	Waters of the state are subject to applicable Anti- Degradation Tiers 1 & 2.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(3) The antidegradation policy shall provide three (3) levels of protection.
Waters of the State of Missouri	General criteria are applicable to all waters of the state at all times, including mixing zones.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(4) The following water quality criteria shall be applicable to all waters of the state at all times including mixing zones.
Mixing Zones	Where mixing zones are applicable, they will be based on 7Q10 low flow.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(5)(A) Specific Criteria. The specific criteria shall apply to waters contained in Tables G and H of this rule and the Missouri Use Designation Dataset. Protection of drinking water supply is limited to surface waters designated for raw drinking water supply and aquifers. Protection of whole body contact recreation is limited to waters designated for that use. (A) The maximum chronic toxicity criteria in Tables A and B shall apply to waters designated for the indicated uses given in the Missouri Use Designation Dataset and Tables G and H.

TABLE 5-1. PRELIMINARY MONITORING WELL INVENTORY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Well ID	DTW (ft bmp)	TD Measured (ft bmp)	Construction	Comments
D-13	40.19	135.57	2" SCH 80 PVC	SILTY, WATERRA
I-66	11.61	38.48	2" SCH 40 PVC	WATERRA
I-65	11.68	41.14	2" SCH 40 PVC	SOFT, WATERRA
I-67	11.53	40.56	2" SCH 40 PVC	NONE NOTED
D-12	49.63	148.55	2" SCH 80 PVC	WATERRA
S-10	49.98	56.63	2" SCH 40 PVC	WATERRA
I-11	49.95	94.48	2" SCH 80 PVC	WATERRA
D-6	17.35	108.09	2" SCH 80 PVC	WATERRA
I-9	20.5	56.8	2" SCH 40 PVC	STICK UP MISLABELED, WATERRA
S-82	19.73	26.42	2" SCH 40 PVC	WATERRA
D-93	19.6	114.52	2" SCH 40 PVC	STICK UP MISLABELED, WATERRA
MW-103	8.42	14.35	2" SCH 40 PVC	WATERRA
I-62	16.1	44.78	2" SCH 40 PVC	WATERRA
D-83	18.4	98.09	2" SCH 40 PVC	WATERRA
D-3	37.57	107.7	2" SCH 80 PVC	WATERRA
I-4	34.91	35.9	2" SCH 40 PVC	PINCHED CASING, WATERRA
S-5	34.19	43.43	2" SCH 40 PVC	WATERRA
D-89	26.25	50.46	2" SCH 40 PVC	NO SURVEY DATA
D-81	20.05	62.56	2" SCH 40 PVC	NO SURVEY DATA
D-87	34.2	115.25	2" SCH 40 PVC	NONE NOTED
MW-1201	NM	NM	NM	NOT LOCATED
I-7	NM	NM	NM	NOT LOCATED
PZ-305-AI	NM	NM	NM	ABANDONED 4/2016
LR-103	NM	NM	NM	COVERED BY ASPHALT PLANT
LR-104	NM	NM	NM	ABANDONED 4/2016
LR-105	NM	NM	NM	ABANDONED 4/2017
PZ-110-SS	NM	NM	NM	ABANDONED 2017-2018

Abbreviations:
DTW: depth to water
ft bmp: feet below measuring point
TD: total depth
SCH: schedule
PVC: polyvinyl chloride
WATERRA: contains Waterra check valve and tubing
NM: not measured

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Phase	Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Borehole Diameter (inches)	Proposed Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
Phase I	MW	213	AS	MW-213-AS	23	448	425	11	2-inch double nested Sch. 40 PVC	I-67	2, 3, 5, 6, 7, 9	No shallow alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	213	AD	MW-213-AD	111	451	340	11	2-inch double nested Sch. 80 PVC	I-67	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	302	AD	MW-302-AD	111	451	340	7	2-inch Sch. 80 PVC	PZ-302-AS, PZ-302-AI	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	303	AI	MW-303-AI	53	448	395	11	2-inch double nested Sch. 40 PVC	MW-104, PZ-303-AS, LR-105	2, 3, 5, 6, 7, 9	No intermediate alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	303	AD	MW-303-AD	111	451	340	11	2-inch double nested Sch. 80 PVC	MW-104, PZ-303-AS, LR-105	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	304	AD	MW-304-AD	111	451	340	7	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	304	SS	MW-304-SS	151	451	300	12/7	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	304	SD	MW-304-SD	211	451	240	12/7	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	306	AI	MW-306-AI	53	448	395	11	2-inch double nested Sch. 40 PVC	MW-103	2, 3, 5, 6, 7, 9	No intermediate alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	306	AD	MW-306-AD	109	451	342	11	2-inch double nested Sch. 80 PVC	MW-103	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	400	AS	MW-400-AS	26	446	420	11	2-inch double nested Sch. 40 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
	MW	400	AI	MW-400-AI	51	446	395	11	2-inch double nested Sch. 40 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
	MW	400	AD	MW-400-AD	106	446	340	7	2-inch Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
	MW	400	SS*	MW-400-SS*	146	446	300	12/7	2-inch Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
	MW	400	SD	MW-400-SD	206	446	240	12/7	2-inch Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
	MW	401	AS	MW-401-AS	25	445	420	11	2-inch double nested Sch. 40 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
	MW	401	AI	MW-401-AI	50	445	395	11	2-inch double nested Sch. 40 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
	MW	401	AD	MW-401-AD	105	445	340	7	2-inch Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
	MW	401	SS*	MW-401-SS*	145	445	300	12/7	2-inch Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	No bedrock wells exist at this location	Sonic/Continuous Core	AAA Trailers
	MW	401	SD	MW-401-SD	205	445	240	12/7	2-inch Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	No bedrock wells exist at this location	Sonic/Continuous Core	AAA Trailers
	MW	402	AS	MW-402-AS	34	454	420	11	2-inch double nested Sch. 40 PVC	I-66, D-13	2, 3, 5, 6, 7, 9, 10	No shallow alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	402	AI	MW-402-AI	59	454	395	11	2-inch double nested Sch. 40 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	Supplemental intermediate alluvial well to I-66	Sonic/Continuous Core	Bridgeton Landfill, LLC

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Phase	Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Borehole Diameter (inches)	Proposed Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
Phase I	MW	402	AD	MW-402-AD	114	454	340	7	2-inch Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	Supplemental deep alluvial well to D-13	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	402	SS*	MW-402-SS*	154	454	300	12/7	2-inch Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	402	SD	MW-402-SD	214	454	240	12/7	2-inch Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	403	AS	MW-403-AS	21	440	419	11	2-inch double nested Sch. 40 PVC	I-65	2, 3, 5, 6, 7, 9	No shallow alluvial well exists at this location	Sonic/Continuous Core	City of Bridgeton Right of Way
	MW	403	AI	MW-403-AI	53	448	395	11	2-inch double nested Sch. 40 PVC	I-65	2, 3, 5, 6, 7, 9	Supplemental intermediate alluvial well to I-65	Sonic/Continuous Core	City of Bridgeton Right of Way
	MW	403	AD	MW-403-AD	109	448	339	7	2-inch Sch. 80 PVC	I-65	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	City of Bridgeton Right of Way
	MW	404	SS	MW-404-SS	160	460	300	12/7	2-inch Sch. 80 PVC	S-82, I-9, D-93	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	404	SD	MW-404-SD	220	460	240	12/7	2-inch Sch. 80 PVC	S-82, I-9, D-93	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	500	AS	MW-500-AS	19	439	420	11	2-inch double nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	500	AI	MW-500-AI	44	439	395	11	2-inch double nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	500	AD	MW-500-AD	99	439	340	7	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	501	AS	MW-501-AS	18	438	420	11	2-inch double nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	501	AI	MW-501-AI	43	438	395	11	2-inch double nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	501	AD	MW-501-AD	98	438	340	7	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	502	AS	MW-502-AS	25	445	420	11	2-inch double nested Sch. 40 PVC	USGS St. Charles Missouri River Gauge, SG-502*, SG-503*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T Group II LLC
	MW	502	AI	MW-502-AI	50	445	395	11	2-inch double nested Sch. 40 PVC	USGS St. Charles Missouri River Gauge, SG-502*, SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T Group II LLC
	MW	502	AD	MW-502-AD	105	445	340	7	2-inch Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*, SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T Group II LLC
	MW	503	AS	MW-503-AS	21	440	419	11	2-inch double nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	503	AI	MW-503-AI	46	441	395	11	2-inch double nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	503	AD	MW-503-AD	101	441	340	7	2-inch Sch. 80 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	504	AS	MW-504-AS	21	440	419	11	2-inch double nested Sch. 40 PVC	SG-501*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems Inc
	MW	504	AI	MW-504-AI	46	441	395	11	2-inch double nested Sch. 40 PVC	SG-501*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems Inc

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Phase	Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Borehole Diameter (inches)	Proposed Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
Phase I	MW	504	AD	MW-504-AD	101	441	340	7	2-inch Sch. 80 PVC	SG-501*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems Inc
	MW	505	AS	MW-505-AS	22	447	425	11	2-inch double nested Sch. 40 PVC	S-53	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	505	AI	MW-505-AI	52	447	395	11	2-inch double nested Sch. 40 PVC	S-53	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	505	AD	MW-505-AD	107	447	340	7	2-inch Sch. 80 PVC	S-53	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	600	AS	MW-600-AS	25	445	420	11	2-inch double nested Sch. 40 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	State Highway
	MW	600	AI	MW-600-AI	50	445	395	11	2-inch double nested Sch. 40 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
	MW	600	AD*	MW-600-AD*	105	445	340	7	2-inch Sch. 80 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
	MW	601	AS	MW-601-AS	20	440	420	11	2-inch double nested Sch. 40 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Unknown
	MW	601	AI	MW-601-AI	45	440	395	11	2-inch double nested Sch. 40 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Unknown
	MW	601	AD	MW-601-AD	100	440	340	7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Unknown
	MW	602	AS	MW-602-AS	14	434	420	11	2-inch double nested Sch. 40 PVC	N/A	2, 3, 5, 6, 8, 9,10	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	602	AI	MW-602-AI	39	434	395	11	2-inch double nested Sch. 40 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	602	AD*	MW-602-AD*	94	434	340	7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	602	SS*	MW-602-SS*	134	434	300	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	602	SD	MW-602-SD	194	434	240	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	Sensory Effects Flavor Co
	MW	603	SS	MW-603-SS	232	532	300	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
	MW	603	SD	MW-603-SD	292	532	240	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
	MW	604	SS	MW-604-SS	214	514	300	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
	MW	604	SD	MW-604-SD	274	514	240	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
	MW	605	SS	MW-605-SS	170	470	300	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 10	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	Rolling Frito Lay Sales LP
	MW	605	SD	MW-605-SD	230	470	240	12/7	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 11	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	Rolling Frito Lay Sales LP

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Phase	Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Borehole Diameter (inches)	Proposed Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
Phase II	MW	111	AS	MW-111-AS	43	463	420	11	2-inch double nested Sch. 40 PVC	PZ-111-SS, PZ-111-SD, PZ-111-KS	2, 3, 5, 6, 9,10	No alluvial wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	111	AI	MW-111-AI	68	463	395	11	2-inch double nested Sch. 40 PVC	PZ-111-SS, PZ-111-SD, PZ-111-KS	2, 3, 5, 6, 9,10	No alluvial wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	111	AD	MW-111-AD	123	463	340	7	2-inch Sch. 80 PVC	PZ-111-SS, PZ-111-SD, PZ-111-KS	2, 3, 5, 6, 9,10	No alluvial wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	113	SD	MW-113-SD	220	460	240	12/7	2-inch Sch. 80 PVC	PZ-113-AS, PZ-113-AD, PZ-113-SS	2, 3, 5, 6, 9,10	No Salem Formation well exists at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	205	SD	MW-205-SD	220	460	240	12/7	2-inch Sch. 80 PVC	PZ-205-AS, PZ-205-SS	2, 3, 5, 6, 9,10	No Salem Formation well exists at this on-site location	Sonic/Continuous Core	Earth City Right of Way
	MW	500	SS*	MW-500-SS*	139	439	300	12/7	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	500	SD	MW-500-SD	199	439	240	12/7	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	501	SS*	MW-501-SS*	138	438	300	12/7	2-inch Sch. 80 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right of Way
	MW	501	SD	MW-501-SD	198	438	240	12/7	2-inch Sch. 80 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Seventy Seventy LLC
	MW	502	SS*	MW-502-SS*	145	445	300	12/7	2-inch Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*, SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
	MW	502	SD	MW-502-SD	205	445	240	12/7	2-inch Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*, SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
	MW	505	SS	MW-505-SS	147	447	300	12/7	2-inch Sch. 80 PVC	S-53	2, 3, 5, 6, 9,11	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Bridgeton Landfill, LLC
	MW	505	SD	MW-505-SD	207	447	240	12/7	2-inch Sch. 80 PVC	S-53	2, 3, 5, 6, 9,12	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Bridgeton Landfill, LLC

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Phase	Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Borehole Diameter (inches)	Proposed Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
Phase II Piezometers	PZ	700	AS	PZ-700-AS	21	441	420	7	2-inch Sch. 40 PVC	North of 500 Series	9, 10	Model calibration	Sonic/Continuous Core	St. Louis County
	PZ	701	AS	PZ-701-AS	21	441	420	7	2-inch Sch. 40 PVC	North of 500 Series	9, 10	Model calibration	Sonic/Continuous Core	St. Louis County
	PZ	702	AS	PZ-702-AS	25	445	420	7	2-inch Sch. 40 PVC	South of 600 Series	9, 10	Model calibration	Sonic/Continuous Core	City of Maryland Heights
	PZ	703	AS	PZ-703-AS	25	445	420	7	2-inch Sch. 40 PVC	South of 600 Series	9, 10	Model calibration	Sonic/Continuous Core	City of Maryland Heights

Notes:

Data Gaps

1: Adequacy, usability, and status of existing and abandoned on-site and perimeter monitoring wells and associated data

2: Aquifer properties, including recharge/discharge rates and hydraulic conductivities

3: Regional and localized hydraulic gradients and flow directions within and between the alluvial aquifer and shallow and deep units (upper and lower intervals) of the bedrock aquifer system (Mississippian age)

4: Background groundwater quality of aquifers located at and near the Site

5: Occurrence and extent of groundwater impacts

6: Groundwater geochemistry parameters, redox couples, and organic content

7: Effects of the Bridgeton Landfill related infrastructure (leachate extraction system, EVOH cover, etc.) and hydraulic characteristics of landfill material on the groundwater system, and leachate chemistry/occurrence

8: Vapor intrusion

9: Temporal variability in groundwater levels and flow direction

10: Temporal and spatial water elevation effects from nearby surface water features (Missouri River) and storm events

Phase I: Proposed Phase I wells will be installed at the beginning of the drilling program based on the locations shown in Work Plan Figure 5-5a.

Phase II: Proposed Phase II wells will be installed at the end of the drilling program; locations may be shifted based on initial data from the Phase I wells;

Phase II piezometers will be installed in the locations shown in Work Plan Figure 5-5g if no shallow alluvial wells are identified during the Well Inventory.

* - To be installed in formation if encountered in this location.

All boreholes drilled using sonic drilling techniques and monitoring wells constructed using 0.010-inch factory slotted PVC screen

Alluvial samples will be collected from deepest alluvial hole at each location and submitted for laboratory analysis

Total depth is approximate

New wells subject to access agreement with property owner

Abbreviations:

PVC: polyvinyl chloride

Sch.: Schedule

N/A: not applicable

TBD: to be determined if deep alluvium present at this location

USGS: United States Geological Survey

Notes:

Zone Explanation

AS: Shallow Alluvial

AI: Intermediate Alluvial

AD: Deep Alluvial

SS: Deep St. Louis/Shallow Salem Formation

SD: Salem Formation

KS: Keokuk Formation

Series Explanation

100: Immediately adjacent to the perimeter of the active sanitary landfill

200: Within 500 feet of the active sanitary landfill

300: Adjacent to inactive landfill areas in western portion of site

400: Within 500 feet of Area 2

500: Offsite

600: Background

TABLE 5-3. SURROUNDING MDNR SITES
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Address[1]	Facility Type	Status
12999 Saint Charles Rock Rd, Bridgeton, MO 63044	Hazardous Substance Investigation and Cleanup Site	Active
13001 Saint Charles Rock Rd, Bridgeton, MO 63044	Hazardous Substance Investigation and Cleanup Site	
13810 Missouri Bottom Road, Bridgeton, MO 63044	Hazardous Substance Investigation and Cleanup Site	
5665 St. Louis Mills Boulevard, Bridgeton, MO 63044	Hazardous Substance Investigation and Cleanup Site	Long-Term Stewardship[2]
12257 Natural Bridge, Bridgeton, MO 63044	Hazardous Substance Investigation and Cleanup Site	
12921 Enterprise Way, Bridgeton, MO 63044	Former UST Facility	Ongoing Investigation/Corrective Action
2264 Creve Coeur Mill Road, Maryland Heights, MO 63043	Former UST Facility	
12235 McKelvey Rd, Maryland Heights, MO 63043	Operating UST Facility	
11747 St Charles Rock Rd, Bridgeton, MO 63044	Operating UST Facility	
13945 Missouri Bottom Road, Bridgeton, MO 63044	Operating UST Facility	Operating Facility with No Known Release
13860 Corporate Wood Dr, Bridgeton, 63045	Operating UST Facility	
85 Corporate Wood Dr, Bridgeton, MO 63044	Operating UST Facility	
13880 Saint Charles Rock Rd, Bridgeton, 63045	Operating UST Facility	
13690 Lake Front Drive, Earth City, 63045	Operating UST Facility	
3298 Rider Trail South, Earth City, 63045	Operating UST Facility	
3402 Rider Trail South, Earth City, 63045	Operating UST Facility	
13736 Riverport Dr, Maryland Heights, MO 63043	Operating UST Facility	
13553 Riverport Dr, Maryland Heights, MO 63043	Operating UST Facility	
3180 S Rider Trail, Bridgeton, 63045	Operating UST Facility	
12901 Saint Charles Rock Rd, Bridgeton, MO 63044	Operating UST Facility	
12843 Pennridge Dr, Bridgeton, MO 63044	Operating UST Facility	
12755 Saint Charles Rock Rd, Bridgeton, MO 63044	Operating UST Facility	
12700 Saint Charles Rock Rd, Bridgeton, MO 63044	Operating UST Facility	
12665 Pennridge Dr, Bridgeton, MO 63044	Operating UST Facility	

Notes:
1 : Sites identified using the MDNR database (downloaded 3/11/2020) that are located within close proximity to West Lake Landfill, and may potentially have associated monitoring wells.
MDNR sites listed are shown on Figure 5-4b within a 2 mile radius of West Lake Landfill.
2: Property is under a restricted use environmental land covenant

Abbreviations:
MDNR: Missouri Department of Natural Resources
UST: Underground Storage Tank

TABLE 5-4. PROPOSED MONITORING WELL NETWORK
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

78 Proposed Monitoring Wells and 4 Piezometers

Location	Prefix	Series	Zone	Well ID	Phase
On-site	MW	111	AS	MW-111-AS	Phase II
	MW	111	AI	MW-111-AI	Phase II
	MW	111	AD	MW-111-AD	Phase II
	MW	113	SD	MW-113-SD	Phase II
	MW	205	SD	MW-205-SD	Phase II
	MW	213	AS	MW-213-AS	Phase I
	MW	213	AD	MW-213-AD	Phase I
	MW	302	AD	MW-302-AD	Phase I
	MW	303	AI	MW-303-AI	Phase I
	MW	303	AD	MW-303-AD	Phase I
	MW	304	AD	MW-304-AD	Phase I
	MW	304	SS	MW-304-SS	Phase I
	MW	304	SD	MW-304-SD	Phase I
	MW	306	AI	MW-306-AI	Phase I
	MW	306	AD	MW-306-AD	Phase I
On-site / Near-site	MW	400	AS	MW-400-AS	Phase I
	MW	400	AI	MW-400-AI	Phase I
	MW	400	AD	MW-400-AD	Phase I
	MW	400	SS*	MW-400-SS*	Phase I
	MW	400	SD	MW-400-SD	Phase I
	MW	401	AS	MW-401-AS	Phase I
	MW	401	AI	MW-401-AI	Phase I
	MW	401	AD	MW-401-AD	Phase I
	MW	401	SS*	MW-401-SS*	Phase I
	MW	401	SD	MW-401-SD	Phase I
	MW	402	AS	MW-402-AS	Phase I
	MW	402	AI	MW-402-AI	Phase I
	MW	402	AD	MW-402-AD	Phase I
	MW	402	SS*	MW-402-SS*	Phase I
	MW	402	SD	MW-402-SD	Phase I
	MW	403	AS	MW-403-AS	Phase I
	MW	403	AI	MW-403-AI	Phase I
	MW	403	AD	MW-403-AD	Phase I
	MW	404	SS	MW-404-SS	Phase I
	MW	404	SD	MW-404-SD	Phase I
Off-site	MW	500	AS	MW-500-AS	Phase I
	MW	500	AI	MW-500-AI	Phase I
	MW	500	AD	MW-500-AD	Phase I
	MW	500	SS*	MW-500-SS*	Phase II
	MW	500	SD	MW-500-SD	Phase II
	MW	501	AS	MW-501-AS	Phase I
	MW	501	AI	MW-501-AI	Phase I
	MW	501	AD	MW-501-AD	Phase I
	MW	501	SS*	MW-501-SS*	Phase II
	MW	501	SD	MW-501-SD	Phase II
	MW	502	AS	MW-502-AS	Phase I
	MW	502	AI	MW-502-AI	Phase I
	MW	502	AD	MW-502-AD	Phase I
	MW	502	SS*	MW-502-SS*	Phase II
	MW	502	SD	MW-502-SD	Phase II
	MW	503	AS	MW-503-AS	Phase I
	MW	503	AI	MW-503-AI	Phase I
	MW	503	AD	MW-503-AD	Phase I
	MW	504	AS	MW-504-AS	Phase I
	MW	504	AI	MW-504-AI	Phase I
	MW	504	AD	MW-504-AD	Phase I
	MW	505	AS	MW-505-AS	Phase I
	MW	505	AI	MW-505-AI	Phase I
	MW	505	AD	MW-505-AD	Phase I
	MW	505	SS	MW-505-SS	Phase II
	MW	505	SD	MW-505-SD	Phase II

80 Existing Monitoring Wells

Prefix	Series	Zone	Well ID	Current Monitoring Status
PZ	112	AS	PZ-112-AS	A
PZ	113	AS	PZ-113-AS	A
PZ	114	AS	PZ-114-AS	A
PZ	205	AS	PZ-205-AS	A
PZ	207	AS	PZ-207-AS	A
S	84	AS	S-84	A
MW	103	AS	MW-103	I
MW	104	AS	MW-104	I
PZ	302	AS	PZ-302-AS	I
PZ	303	AS	PZ-303-AS	I
PZ	304	AS	PZ-304-AS	I
S	5	AS	S-5**	I
S	8	AS	S-8	I
S	10	AS	S-10**	I
S	53	AS	S-53	I
S	82	AS	S-82	I
I	68	AI	I-68	A
I	73	AI	I-73	A
D	89	AI	D-89	I
I	9	AI	I-9	I
I	11	AI	I-11**	I
I	62	AI	I-62**	I
I	65	AI	I-65	I
I	66	AI	I-66	I
I	67	AI	I-67	I
PZ	302	AI	PZ-302-AI	I
PZ	304	AI	PZ-304-AI	I
D	85	AD	D-85	A
PZ	113	AD	PZ-113-AD	A
D	3	AD	D-3**	I
D	6	AD	D-6**	I
D	12	AD	D-12**	I
D	13	AD	D-13**	I
D	81	AD	D-81	I
D	83	AD	D-83**	I
D	87	AD	D-87	I
D	93	AD	D-93	I
LR	100	LR	LR-100	I
PZ	100	SS	PZ-100-SS	A
PZ	101	SS	PZ-101-SS	A
PZ	102	SS	PZ-102R-SS	A
PZ	102	SS	PZ-102-SS	A
PZ	103	SS	PZ-103-SS	A
PZ	104	SS	PZ-104-SS	A
PZ	105	SS	PZ-105-SS	A
PZ	106	SS	PZ-106-SS	A
PZ	107	SS	PZ-107-SS	A
PZ	109	SS	PZ-109-SS	A
PZ	111	SS	PZ-111-SS	A
PZ	113	SS	PZ-113-SS	A
PZ	115	SS	PZ-115-SS	A
PZ	116	SS	PZ-116-SS	A
PZ	200	SS	PZ-200-SS	A
PZ	201	SS	PZ-201A-SS	A
PZ	202	SS	PZ-202-SS	A
PZ	203	SS	PZ-203-SS	A
PZ	204A	SS	PZ-204A-SS	A
PZ	204	SS	PZ-204-SS	A
PZ	205	SS	PZ-205-SS	A
PZ	206	SS	PZ-206-SS	A
PZ	208	SS	PZ-208-SS	A

TABLE 5-4. PROPOSED MONITORING WELL NETWORK
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

78 Proposed Monitoring Wells and 4 Piezometers					
Location	**Prefix**	**Series**	**Zone**	**Well ID**	**Phase**
Background	MW	600	AS	MW-600-AS	Phase I
	MW	600	AI	MW-600-AI	Phase I
	MW	600	AD	MW-600-AD	Phase I
	MW	601	AS	MW-601-AS	Phase I
	MW	601	AI	MW-601-AI	Phase I
	MW	601	AD	MW-601-AD	Phase I
	MW	602	AS	MW-602-AS	Phase I
	MW	602	AI	MW-602-AI	Phase I
	MW	602	AD	MW-602-AD	Phase I
	MW	602	SS*	MW-602-SS*	Phase I
	MW	602	SD	MW-602-SD	Phase I
	MW	603	SS	MW-603-SS	Phase I
	MW	603	SD	MW-603-SD	Phase I
	MW	604	SS	MW-604-SS	Phase I
	MW	604	SD	MW-604-SD	Phase I
	MW	605	SS	MW-605-SS	Phase I
	MW	605	SD	MW-605-SD	Phase I
Piezometers	PZ	700	AS	PZ-700-AS	Phase II
	PZ	701	AS	PZ-701-AS	Phase II
	PZ	702	AS	PZ-702-AS	Phase II
	PZ	703	AS	PZ-703-AS	Phase II

80 Existing Monitoring Wells				
Prefix	**Series**	**Zone**	**Well ID**	**Current Monitoring Status**
PZ	209	SS	PZ-209-SS	A
PZ	210	SS	PZ-210-SS	A
PZ	211	SS	PZ-211-SS	A
PZ	212	SS	PZ-212-SS	A
MO	3	SS	MO-3-SS	I
MW	1204	SD	MW-1204	A
PZ	100	SD	PZ-100-SD	A
PZ	104	SD	PZ-104-SD	A
PZ	106	SD	PZ-106-SD	A
PZ	111	SD	PZ-111-SD	A
PZ	209	SD	PZ-209-SD	A
PZ	210	SD	PZ-210-SD	A
PZ	211	SD	PZ-211-SD	A
PZ	212	SD	PZ-212-SD	A
MO	3	SD	MO-3-SD	I
PZ	100	KS	PZ-100-KS	A
PZ	104	KS	PZ-104-KS	A
PZ	106	KS	PZ-106-KS	A
PZ	111	KS	PZ-111-KS	A

Notes:
* Installed if zone encountered at proposed location
** Monitoring well may be in the footprint of OU-1 removal activities
Samples will not be collected from well I-4 due to compromised casing
Phase I - Proposed Phase I wells will be installed at the beginning of the drilling program based on the locations shown in Work Plan Figure 5-5a.
Phase II - Proposed Phase II wells will be installed at the end of the drilling program; locations may be shifted based on initial data from the Phase I wells. Phase II piezometers will be installed in the locations shown in Work Plan Figure 5-5g if no shallow alluvial wells are identified during the Well Inventory.

Abbreviations:
S: Shallow
I: Intermediate
D: Deep
LR: Leachate Riser
MW: Monitoring Well
PZ: Piezometer
MO: Missouri
I: Inactive
U: Unknown
A: Abandoned

Hydrological Zone
AS: Shallow Alluvial
AI: Intermediate Alluvial
AD: Deep Alluvial
LR: Leachate Riser
SS: Upper Salem/St. Louis Formation
SD: Salem Formation
KS: Keokuk Formation

TABLE 5-5. WELLS PROPOSED FOR SLUG TESTING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

40 Proposed Wells					32 Existing Wells				
Location	Prefix	Series	Zone	Well ID	Prefix	Series	Zone	Well ID	Current Monitoring Status
On-site/Near-site	MW	205	SD	MW-205-SD	S	84	AS	S-84	A
	MW	302	AD	MW-302-AD	I	73	AI	I-73	A
	MW	303	AI	MW-303-AI	PZ	102	SS	PZ-102-SS	A
	MW	303	AD	MW-303-AD	PZ	111	SS	PZ-111-SS	A
	MW	304	AD	MW-304-AD	PZ	203	SS	PZ-203-SS	A
	MW	304	SS	MW-304-SS	PZ	209	SS	PZ-209-SS	A
	MW	304	SD	MW-304-SD	PZ	210	SS	PZ-210-SS	A
	MW	400	SS	MW-400-SS	PZ	211	SS	PZ-211-SS	A
	MW	400	SD	MW-400-SD	PZ	212	SS	PZ-212-SS	A
	MW	401	SS	MW-401-SS	MW	1204	SD	MW-1204	A
	MW	401	SD	MW-401-SD	PZ	209	SD	PZ-209-SD	A
Off-site	MW	500	AS	MW-500-AS	PZ	210	SD	PZ-210-SD	A
	MW	500	AI	MW-500-AI	PZ	211	SD	PZ-211-SD	A
	MW	500	AD	MW-500-AD	PZ	212	SD	PZ-212-SD	A
	MW	501	AS	MW-501-AS	MO	3	SS	MO-3-SS	I
	MW	501	AI	MW-501-AI	MO	3	SDR	MO-3-SDR	I
	MW	501	AD	MW-501-AD	MW	103	AS	MW-103	I
	MW	502	AS	MW-502-AS	MW	104	AS	MW-104	I
	MW	502	AI	MW-502-AI	S	5	AS	S-5	I
	MW	502	AD	MW-502-AD	S	8	AS	S-8	I
	MW	503	AS	MW-503-AS	S	10	AS	S-10	I
	MW	503	AI	MW-503-AI	S	53	AS	S-53	I
	MW	503	AD	MW-503-AD	S	82	AS	S-82	I
Background	MW	600	AS	MW-600-AS	D	89	AI	D-89	I
	MW	600	AI	MW-600-AI	I	62	AI	I-62	I
	MW	600	AD	MW-600-AD	I	65	AI	I-65	I
	MW	601	AS	MW-601-AS	I	66	AI	I-66	I
	MW	601	AI	MW-601-AI	I	67	AI	I-67	I
	MW	601	AD	MW-601-AD	D	81	AD	D-81	I
	MW	602	AS	MW-602-AS	D	83	AD	D-83	I
	MW	602	AI	MW-602-AI	D	87	AD	D-87	I
	MW	602	AD	MW-602-AD	LR	100	LR	LR-100	I
	MW	602	SS*	MW-602-SS*					
	MW	602	SD	MW-602-SD					
	MW	604	SS	MW-604-SS					
	MW	604	SD	MW-604-SD					
Piezometers	PZ	700	AS	PZ-700-AS					
	PZ	701	AS	PZ-701-AS					
	PZ	702	AS	PZ-702-AS					
	PZ	703	AS	PZ-703-AS					

Note:
* slug tested if monitoring zone encountered during well installation

Abbreviations:
S: Shallow
I: Intermediate
D: Deep
LR: Leachate Riser
MW: Monitoring Well
PZ: Piezometer
MO: Missouri

Hydrological Zone
AS: Shallow Alluvial
AI: Intermediate Alluvial
AD: Deep Alluvial
LR: Leachate Riser
SS: Upper Salem/St. Louis Formation
SD: Salem Formation

TABLE 5-6. LANDFILL LEACHATE AND REDOX INDICATOR CONSTITUENTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Parameter Type	Constituent
Analytical Parameters	Alkalinity
	Boron
	Bromide
	Calcium
	Dissolved Carbon Dioxide
	Carbonate
	Cation+Anions
	Chemical Oxygen Demand
	Chloride
	Chromium (Cr^{+3})
	Chromium (Cr^{+6})
	Copper
	Dissolved Organic Carbon
	Iodide
	Iron
	Lead
	Manganese
	Magnesium
	Dissolved Methane
	Nickel
	Nitrate, as Nitrogen (NO^{3-})
	Nitrite, as Nitrogen (NO^{2-})
	Phosphate
	Potassium
	Sodium
	Strontium
	Sulfate (SO_4^{2-})
	Sulfide (S^{2-})
	Total Dissolved Solids
	Total Hardness
	Total Organic Carbon
	Total Suspended Solids
	Tritium
	Volatile Organic Compounds (benzene, chlorobenzene, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, ethylbenzene, methylene chloride, PCE, toluene, 1,1-trichloroethane, TCE, and VC)
	Zinc

TABLE 5-6. LANDFILL LEACHATE AND REDOX INDICATOR CONSTITUENTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Parameter Type	Constituent
Field Parameters	Ammonium
	Dissolved Oxygen
	Ferrous Iron (Fe^{2+})
	Ferric Iron (Fe^{3+})
	Oxidation Reduction Potential
	pH
	Specific Conductance

Notes:
USEPA RI/FS Guidance: Conducting Remedial Investigations/Feasibility Studies for CERLCA Municipal Landfill Sites,
Leachate Constituents from Table 3-2, EPA/540/P-91/001, February 1991
- Assumes metals are total and dissolved
- Background concentrations of inorganic constituents may also be naturally-occurring
- Methane and carbon dioxide are representative of dissolved landfill gasses

Redox parameters are highlighted gray
Chemical speciation shown in parentheses for redox parameters evaluated as a redox couples
United States Geological Survey (USGS) Workbook for Identifying Redox Processes in Ground Water (McMahon & Chapelle, 2008), or comparable tool, will be used to evaluate redox conditions as part of the remedial investigation (RI)

Abbreviations:
1,1-DCA: 1,1-dichloroethane
1,1-DCE: 1,1 dichloroethene
cis-1,2-DCE: cis-1,2-dichloroethene
trans-1,2-DCE: trans-1,2-dichloroethene
PCE: tetrachloroethene
Redox: oxidation reduction
TCE: trichloroethene
VC: vinyl chloride

TABLE 5-7. WELL LOCATIONS FOR DATALOGGERS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

NEW ONSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-111	X	X	X			
MW-113					X	
MW-205					X	
MW-304			X	X	X	
MW-306		X	X			

NEW ONSITE / NEAR-SITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-400	X	X	X	X	X	
MW-401	X	X	X	X	X	
MW-402	X	X	X	X	X	

NEW OFFSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-500	X	X	X	X*	X	
MW-501	X	X	X	X*	X	
MW-502	X	X	X	X*	X	
MW-503	X	X	X			
MW-504	X	X	X			
MW-505	X	X	X	X*	X	
MW-602	X	X	X	X	X	
MW-603				X	X	
MW-604				X	X	

TABLE 5-7. WELL LOCATIONS FOR DATALOGGERS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

NEW OFFSITE PIEZOMETER LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-700	X					
MW-701	X					
MW-702	X					
MW-703	X					

EXISTING ONSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
S-8	X					
I-62		X				
D-83			X			
S-82	X					
I-9		X				
D-93			X			
PZ-202				X		
PZ-209				X	X	
PZ-211				X	X	
PZ-113	X		X	X		
PZ-100				X	X	X
PZ-111				X	X	
PZ-205	X			X		
PZ-304	X	X				
MW-103	X					

Note:
* deployed if proposed zone encountered during well installation

Abbreviations:
AS: Shallow Alluvium
AI: Intermediate Alluvium
AD: Deep Alluvium
SS: St. Louis and Upper Salem Formations
SD: The base of the Salem Formation
KS: Keokuk Formation

TABLE 5-8. SOURCE AREA INDICATOR WELLS AND LEACHATE POINTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Well / Leachate Point ID	Area 1	Area 2	Former Inactive Sanitary Landfill	Former C&D Landfill	Bridgeton Landfill - North Quarry	Bridgeton Landfill - South Quarry and SSR	Former Leachate Lagoon
S-84	X						
D-85	X						
I-68	X						
PZ-114-AS	X						
PZ-115-SS	X						
MW-113-SD	X						
PZ-113-AS, AD, SS	X						
D-3	X						
S-5	X						
PZ-112-AS	X						
MW-111-AS, AI, AD	X						
PZ-111-SS, SD, KS	X						
S-8		X					
I-62		X					
D-83		X					
MW-401-AS, AI, AD, SS, SD		X					
D-6		X					
MW-400-AS, AI, AD, SS, SD		X					
I-65		X					
D-13		X					
D-12		X					
I-11		X					
S-10		X					
I-66		X		X			
MW-402-AS, AI, AD, SS, SD		X		X			

TABLE 5-8. SOURCE AREA INDICATOR WELLS AND LEACHATE POINTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Well / Leachate Point ID	Area 1	Area 2	Former Inactive Sanitary Landfill	Former C&D Landfill	Bridgeton Landfill - North Quarry	Bridgeton Landfill - South Quarry and SSR	Former Leachate Lagoon
MW-404-SS, SD		X					
I-9		X					
S-82		X					
D-93		X					
D-89			X				
LR-100			X				
PZ-302-AS, AI			X				
MW-302-AD			X				
D-81			X				
MW-104			X				
PZ-303-AS			X				
MW-303-AI, AD			X				
PZ-304-AS, AI			X				
MW-304-AD, SS, SD			X				
MW-103			X				
MW-306-AI, AD			X				
I-67				X			
MW-213-AS, AD				X			
PZ-207-AS				X			
D-87				X			
LCS-5A					X		
LCS-5B					X		
LCS-6					X		
PZ-208-SS					X		
PZ-100-SS, SD, KS					X		

TABLE 5-8. SOURCE AREA INDICATOR WELLS AND LEACHATE POINTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Well / Leachate Point ID	Area 1	Area 2	Former Inactive Sanitary Landfill	Former C&D Landfill	Bridgeton Landfill - North Quarry	Bridgeton Landfill - South Quarry and SSR	Former Leachate Lagoon
PZ-101-SS					X		
PZ-200-SS					X		
PZ-102-SS					X		
PZ-102R-SS					X		
PZ-109-SS					X		
PZ-201A-SS					X		
PZ-103-SS					X		
PZ-206-SS					X		
PZ-209-SS,SD						X	
PZ-211-SS, SD						X	
PZ-202-SS						X	
PZ-104-SS, SD, KS						X	
PZ-210-SS, SD						X	
PZ-203-SS						X	
PZ-105-SS						X	
PZ-116-SS						X	
MW-1204						X	
PZ-204-SS						X	
PZ-204A-SS						X	
MO-3-SS, SDR						X	
PZ-106-SS, SD, KS						X	
PZ-107-SS						X	
PZ-205-AS, SS						X	
MW-205-SD						X	
I-73						X	

TABLE 5-8. SOURCE AREA INDICATOR WELLS AND LEACHATE POINTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Well / Leachate Point ID	Area 1	Area 2	Former Inactive Sanitary Landfill	Former C&D Landfill	Bridgeton Landfill - North Quarry	Bridgeton Landfill - South Quarry and SSR	Former Leachate Lagoon
LCS-1D						X	
LCS-3D						X	
LCS-4						X	
MW-505-AS, AI, AD, SS, SD							X
S-53							X

Note:
Excludes PZ-212-SS, SD which are isolated from source areas by over 500 ft

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m^3)	Residential RSL for Indoor Air[3] (µg/m^3)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m^3/mol)	Notes
Acetone	VOC	17000	24325	140000	0.17	**2.3E+02**	**3.5E-05**	
Acrolein	VOC	--	--	0.088	**--**	**2.7E+02**	**1.2E-04**	
Acrylonitrile	VOC	--	--	0.18	**--**	**1.1E+02**	**1.4E-04**	
Benzene	VOC	4510	1023324	1.6	**639577**	**9.5E+01**	**5.6E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Bromobenzene	VOC	--	--	260	**--**	**4.2E+00**	**2.5E-03**	
Bromodichloromethane	VOC	--	--	0.33	**--**	**5.0E+01**	**2.1E-03**	
Bromoform	VOC	--	--	11	**--**	**5.4E+00**	**5.4E-04**	
Bromomethane (Methyl Bromide)	VOC	1.0	300	22	**14**	**1.6E+03**	**7.3E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Bromochloromethane	VOC	--	--	180	**--**	**1.4E+02**	**1.5E-03**	
2-Butanone (MEK)	VOC	8400	19540	22000	0.89	**9.1E+01**	**5.7E-05**	
n-Butylbenzene	VOC	--	--	--	**--**	**1.1E+00**	**1.6E-02**	
sec-Butylbenzene	VOC	--	--	--	**--**	**1.8E+00**	**1.8E-02**	
tert-Butylbenzene	VOC	--	--	--	**--**	**2.2E+00**	**1.3E-02**	
Carbon disulfide	VOC	5.3	3120	3100	**1.0**	**3.6E+02**	**1.4E-02**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Carbon tetrachloride	VOC	--	--	2.0	**--**	**1.2E+02**	**2.8E-02**	
Chlorobenzene	VOC	3500	445012	220	**2023**	**1.2E+01**	**3.1E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Chloroethane (Ethyl Chloride)	VOC	183	83046	44000	**1.9**	**1.0E+03**	**1.1E-02**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Chloroform	VOC	0.94	141	0.53	**266**	**2.0E+02**	**3.7E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m³)	Residential RSL for Indoor Air[3] (µg/m³)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m³/mol)	Notes
Chloromethane (Methyl Chloride)	VOC	1.6	577	390	**1.5**	**4.3E+03**	**8.8E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
2-Chlorotoluene	VOC	--	--	--	**--**	**3.4E+00**	**3.6E-03**	
4-Chlorotoluene	VOC	--	--	--	**--**	**2.7E+00**	**4.4E-03**	
Cyclohexane	VOC	22	134914	26000	**5.2**	**9.7E+01**	**1.5E-01**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Dibromochloromethane	VOC	--	--	--	**--**	**5.5E+00**	**7.8E-04**	
1,2-Dibromoethane (EDB)	VOC	--	--	0.02	**--**	**1.1E+01**	**6.5E-04**	
1,2-Dibromo-3-chloropropane (DBCP)	VOC	--	--	0.002	**--**	5.8E-01	**1.5E-04**	
Dibromomethane (Methylene Bromide)	VOC	--	--	18	**--**	**4.4E+01**	**8.2E-04**	
trans-1,4-Dichloro-2-butene	VOC	--	--	0.0029	**--**	**3.4E+00**	**6.6E-04**	
1,2-Dichlorobenzene	VOC	19	1491	880	**1.7**	**1.4E+00**	**1.9E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,3-Dichlorobenzene	VOC	13	--	--	**--**	**--**	**--**	
1,4-Dichlorobenzene	VOC	33	3251	1.1	**2956**	**1.7E+00**	**2.4E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Dichlorodifluoromethane	VOC	25	347768	440	**790**	**4.8E+03**	**3.4E-01**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,1-Dichloroethane (DCA)	VOC	3.8	873	7.7	**113**	**2.3E+02**	**5.6E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,2-Dichloroethane (EDC)	VOC	43	2074	0.47	**4414**	**7.9E+01**	**1.2E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,1-Dichloroethene	VOC	--	--	880	**--**	**6.0E+02**	**2.6E-02**	
1,2-Dichloroethene	VOC	0.60	--	--	**--**	**--**	**--**	
cis-1,2-Dichloroethene	VOC	53	8841	--	**--**	**2.0E+02**	**4.1E-03**	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m³)	Residential RSL for Indoor Air[3] (µg/m³)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m³/mol)	Notes
trans-1,2-Dichloroethene	VOC	0.91	349	--	--	**3.3E+02**	**9.4E-03**	
1,2-Dichloropropane	VOC	0.55	63	3.3	**19**	**5.3E+01**	**2.8E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,3-Dichloropropane	VOC	--	--	--	--	**1.8E+01**	**9.8E-04**	
2,2-Dichloropropane	VOC	--	--	--	--	--	--	
1,1-Dichloropropene	VOC	--	--	--	--	--	--	
cis-1,3-Dichloropropene	VOC	--	--	--	--	--	--	
trans-1,3-Dichloropropene	VOC	--	--	--	--	--	--	
1,4-Dioxane (p-Dioxane)	VOC	--	--	2.5	--	**3.8E+01**	4.8E-06	
Diethyl ether	VOC	38	1911	--	--	**5.4E+02**	**1.2E-03**	
Ethylbenzene	VOC	140	45102	4.9	**9205**	**9.6E+00**	**7.9E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Ethyl methacrylate	VOC	--	--	1300	--	**2.1E+01**	**5.7E-04**	
Hexachloro-1,3-butadiene	VOC	--	--	0.56	--	2.2E-01	**1.0E-02**	
n-Hexane	VOC	--	--	3100	--	**1.5E+02**	**1.8E+00**	
2-Hexanone	VOC	87	331	130	**2.5**	**1.2E+01**	**9.3E-05**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Iodomethane	VOC	7.4	--	--	--	--	--	
Isopropylbenzene (Cumene)	VOC	40	18806	1800	**10**	**4.5E+00**	**1.2E-02**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
p-Isopropyltoluene	VOC	17	--	--	--	--	--	
Methyl Acetate	VOC	--	--	--	--	**2.2E+02**	**1.2E-04**	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m^3)	Residential RSL for Indoor Air[3] (µg/m^3)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m^3/mol)	Notes
Methylcyclohexane	VOC	64	--	--	**--**	**--**	**--**	
Methylene Chloride (Dichloromethane)	VOC	8.7	1156	1200	1.0	**4.4E+02**	**3.3E-03**	
4-Methyl-2-pentanone (MIBK)	VOC	250	1410	13000	0.11	**2.0E+01**	**1.4E-04**	
Methyl-tert-butyl-Ether (MTBE)	VOC	15	360	47	**7.7**	**2.5E+02**	**5.9E-04**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
n-Propylbenzene	VOC	1.4	601	4400	0.14	**3.4E+00**	**1.1E-02**	
Styrene	VOC	2.4	270	4400	0.06	**6.4E+00**	**2.8E-03**	
1,1,1,2-Tetrachloroethane	VOC	--	--	1.7	**--**	**1.2E+01**	**2.5E-03**	
1,1,2,2-Tetrachloroethane	VOC	--	--	0.21	**--**	**4.6E+00**	**3.7E-04**	
Tetrachloroethene (PCE)	VOC	1.2	868	47	**18**	**1.9E+01**	**1.8E-02**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Toluene	VOC	2400	651513	22000	**30**	**2.8E+01**	**6.6E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,2,3-Trichlorobenzene	VOC	--	--	--	**--**	2.1E-01	**1.3E-03**	
1,2,4-Trichlorobenzene	VOC	7.9	459	8.8	**52**	4.6E-01	**1.4E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,1,1-Trichloroethane (TCA)	VOC	--	--	22000	**--**	**1.2E+02**	**1.7E-02**	
1,1,2-Trichloroethane	VOC	37	1246	0.77	**1619**	**2.3E+01**	**8.2E-04**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,1,2-Trichlorotrifluoroethane	VOC	--	--	22000	**--**	**3.6E+02**	**5.3E-01**	
Trichloroethene (TCE)	VOC	1.0	403	3	**134**	**6.9E+01**	**9.9E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Trichlorofluoromethane	VOC	--	--	--	**--**	**8.0E+02**	**9.7E-02**	
1,2,3-Trichloropropane	VOC	--	--	1.3	**--**	**3.7E+00**	**3.4E-04**	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m^3)	Residential RSL for Indoor Air[3] (µg/m^3)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m^3/mol)	Notes
1,2,4-Trimethylbenzene	VOC	18.8	4735	260	**18**	**2.1E+00**	**6.2E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
1,3,5-Trimethylbenzene	VOC	5.0	1793	260	**6.9**	**2.5E+00**	**8.8E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Vinyl Acetate	VOC	--	--	880	**--**	**9.0E+01**	**5.1E-04**	
Vinyl Chloride (Chloroethene)	VOC	31	35233	2.8	**12583**	**3.0E+03**	**2.8E-02**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
m,p-Xylenes	VOC	480	140899	440	**320**	**8.3E+00**	**7.2E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
o-Xylenes	VOC	190	40237	440	**91**	**6.6E+00**	**5.2E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Xylenes, Total	VOC	460	124685	440	**283**	**8.0E+00**	**6.6E-03**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
Acenaphthene	SVOC	--	--	--	**--**	2.2E-03	**1.8E-04**	
Acenaphthylene	SVOC	--	--	--	**--**	**--**	**--**	
Acetophenone	SVOC	--	--	--	**--**	4.0E-01	**1.0E-05**	
Anthracene	SVOC	--	--	--	**--**	6.5E-06	**5.6E-05**	
Atrazine	SVOC	--	--	--	**--**	2.9E-07	2.4E-09	
Benzaldehyde	SVOC	--	--	--	**--**	**1.3E+00**	**2.7E-05**	
Benz[a]anthracene	SVOC	--	--	0.20	**--**	2.1E-07	**1.2E-05**	
Benzo[a]pyrene	SVOC	--	--	0.0088	**--**	5.5E-09	4.6E-07	
Benzo[b]fluoranthene	SVOC	1.3	0.035	0.20	0.17	5.0E-07	6.6E-07	
Benzo[g,h,i]perylene	SVOC	--	--	--	**--**	**--**	**--**	
Benzo[k]fluoranthene	SVOC	--	--	2	**--**	9.7E-10	5.8E-07	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m^3)	Residential RSL for Indoor Air[3] (µg/m^3)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m^3/mol)	Notes
Benzyl alcohol	SVOC	--	--	--	--	9.4E-02	3.4E-07	
Biphenyl (1,1 - biphenyl or Diphenyl)	SVOC	--	--	1.8	--	8.9E-03	**3.1E-04**	
bis(2-chloroethoxy) methane	SVOC	--	--	--	--	1.3E-01	3.9E-06	
bis(2-chloroethyl) ether	SVOC	--	--	0.037	--	**1.6E+00**	**1.7E-05**	
bis(2-chloro-1-methylethyl) ether*	SVOC	--	--	--	--	5.6E-01	**7.4E-05**	
bis(2-ethylhexyl) phthalate	SVOC	120	1.3	5.1	0.26	1.4E-07	2.7E-07	
4-Bromophenyl phenyl ether	SVOC	--	--	--	--	--	--	
Butyl benzyl phthalate	SVOC	1.4	0.072	--	--	8.3E-06	1.3E-06	
4-Chloroaniline	SVOC	--	--	--	--	2.7E-02	1.2E-06	
4-Chloro-3-methylphenol (p-chloro-m-Cresol)	SVOC	4020	403	--	--	5.0E-02	2.5E-06	
2-Chloronaphthalene	SVOC	--	--	--	--	1.2E-02	**3.2E-04**	
2-Chlorophenol	SVOC	9.8	4.5	--	--	**2.5E+00**	**1.1E-05**	
4-Chlorophenyl phenyl ether	SVOC	--	--	--	--	--	--	
Caprolactam	SVOC	--	--	9.6	--	1.6E-03	2.5E-08	
Carbazole	SVOC	--	--	--	--	--	--	
Chrysene	SVOC	--	--	20	--	6.2E-09	5.2E-06	
Dibenz[a,h]anthracene	SVOC	--	--	0.020	--	9.6E-10	1.4E-07	
Dibenzofuran	SVOC	--	--	--	--	2.5E-03	**2.1E-04**	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m^3)	Residential RSL for Indoor Air[3] (µg/m^3)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m^3/mol)	Notes
Di-n-butyl phthalate	SVOC	15	1.1	--	--	2.0E-05	1.8E-06	
3,3'-Dichlorobenzidine	SVOC	--	--	0.036	--	2.6E-07	2.8E-11	
2,4-Dichlorophenol	SVOC	--	--	--	--	9.0E-02	4.3E-06	
Diethyl phthalate	SVOC	--	--	--	--	2.1E-03	6.1E-07	
2,4-Dimethylphenol	SVOC	120	4.7	--	--	1.0E-01	9.5E-07	
7,12-Dimethylbenz(a)anthracene	SVOC	--	--	0.00017	--	6.8E-07	3.8E-06	
Dimethylphthalate	SVOC	4.9	--	--	--	--	--	
4,6-Dinitro-2-methylphenol	SVOC	--	--	--	--	1.2E-04	1.4E-06	
2,4-Dinitrophenol	SVOC	--	--	--	--	3.9E-04	8.6E-08	
2,4-Dinitrotoluene	SVOC	--	--	0.14	--	1.5E-04	5.4E-08	
2,6-Dinitrotoluene	SVOC	--	--	--	--	5.7E-04	7.5E-07	
Di-n-octyl phthalate	SVOC	5.3	0.56	--	--	1.0E-07	2.6E-06	
Fluoranthene	SVOC	1.3	0.47	--	--	9.2E-06	8.9E-06	
Fluorene	SVOC	--	--	--	--	6.0E-04	**9.6E-05**	
Hexachlorobenzene	SVOC	--	--	0.027	--	1.8E-05	**1.7E-03**	
Hexachloro-1,3-butadiene	SVOC	--	--	0.56	--	2.2E-01	**1.0E-02**	
Hexachlorocyclopentadiene	SVOC	--	--	0.88	--	6.0E-02	**2.7E-02**	
Hexachloroethane	SVOC	--	--	1.1	--	2.1E-01	**3.9E-03**	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m³)	Residential RSL for Indoor Air[3] (µg/m³)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m³/mol)	Notes
Indeno[1,2,3-cd]pyrene	SVOC	3.6	0.051	0.20	0.26	1.3E-10	3.5E-07	
Isophorone	SVOC	--	--	8800	--	4.4E-01	6.6E-06	
2-Methylphenol (o-Cresol)	SVOC	31	1.5	2600	0.00058	3.0E-01	1.2E-06	
3 & 4-Methylphenol (m & p Cresols)1	SVOC	--	--	2600	--	1.1E-01	8.6E-07	
1-Methylnaphthalene	SVOC	--	--	--	--	6.7E-02	**5.1E-04**	
2-Methylnaphthalene	SVOC	55	1165	--	--	5.5E-02	**5.2E-04**	
N-Nitroso-di-n-propylamine	SVOC	--	--	0.0061	--	8.6E-02	5.4E-06	
N-Nitrosodiphenylamine	SVOC	2.5	0.12	4.7	0.026	1.0E-01	1.2E-06	
Naphthalene	SVOC	220	3957	0.36	**10993**	8.5E-02	**4.4E-04**	**"Potentially toxic" and "volatile" per OSWER VI Technical Guide criteria.**
2-Nitroaniline	SVOC	--	--	0.22	--	2.8E-03	5.9E-08	
3-Nitroaniline	SVOC	--	--	--	--	--	--	
4-Nitroaniline	SVOC	--	--	26	--	3.2E-06	1.3E-09	
Nitrobenzene	SVOC	--	--	0.31	--	2.5E-01	**2.4E-05**	
2-Nitrophenol	SVOC	--	--	--	--	--	--	
4-Nitrophenol	SVOC	--	--	--	--	--	--	
Pentachlorophenol	SVOC	--	--	2.4	--	1.1E-04	2.5E-08	

TABLE 5-9. VAPOR COPC EVALUATION OF ANALYTES DETECTED IN GROUNDWATER
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
WORK PLAN

Target Analytes[1]	Method Category	Max Concentration in Groundwater[2] (µg/L)	Saturated Vapor Concentration (µg/m³)	Residential RSL for Indoor Air[3] (µg/m³)	Ratio of Max Soil Gas Concentration to Residential RSL	Vapor Pressure (mm-Hg)	Henry's Law Constant (atm-m³/mol)	Notes
Phenanthrene	SVOC	107	--	--	--	--	--	
Phenol	SVOC	2500	34	880	0.039	3.5E-01	3.3E-07	
Pyrene	SVOC	1.1	0.54	--	--	4.5E-06	**1.2E-05**	
1,2,4,5-Tetrachlorobenzene	SVOC	--	--	--	--	5.4E-03	**1.0E-03**	
2,3,4,6-Tetrachlorophenol	SVOC	--	--	--	--	6.7E-04	8.8E-06	
2,4,5-Trichlorophenol	SVOC	--	--	--	--	7.5E-03	1.6E-06	
2,4,6-Trichlorophenol	SVOC	--	--	4.0	--	8.0E-03	2.6E-06	

Notes:

1: Constituents selected from historical groundwater data set.

2: Maximum detected concentration in groundwater since 2000, maximum value not included if target analyte was not detected since 2000.

3: RSLs are documented from the United States Environmental Protection Agency website (last updated in 11/2019)

Ratio of Max Soil Gas Concentration to Residential RSL > 1, vapor pressure > 1 mm-Hg, and Henry's Law Constant > 0.0001 atm-m³/mol shown in bold and used to evaluate potential volatility and toxicity

Abbreviations:

RSL: Regional Screening Level

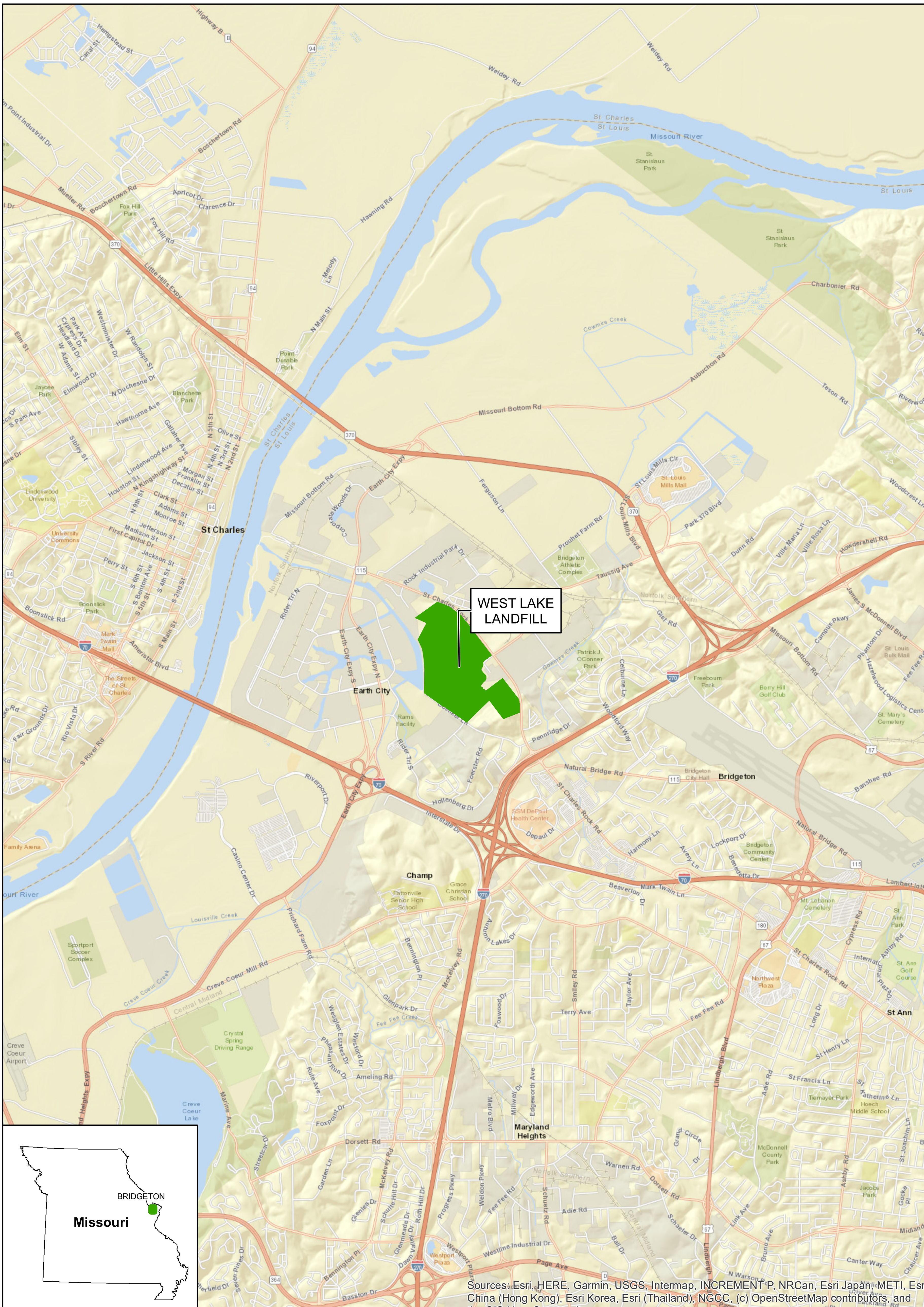
µg/m³: micrograms per cubic meter

µg/L: micrograms per liter

mm-Hg: millimeters of mercury

atm-m³/mol: atmospheres of air to moles per cubic meter for water

FIGURES



EXPLANATION

LANDFILL PROPERTY EXTENT

LATITUDE: 38.768106
LONGITUDE: -90.444574
LATITUDE AND LONGITUDE ARE IN NAD83

N

0 4,000 '

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FIGURE 1-1

SITE LOCATION MAP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 4,000 '	Date: 4/11/20	File: 1-1_SiteLocation_Fig1-1.mxd

M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\1-1_SITELOCATION_FIG1-1.MXD

EXPLANATION

- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY
- OPERABLE UNIT 1

N

0 1,000 '

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FIGURE 1-2

SITE LAYOUT MAP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 1,000 '	Date: 4/21/20	File: 1-2_SiteLayout_Fig1-2.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\1-2_SITELAYOUT_FIG1-2.MXD

EXPLANATION

- SUPERFUND SITE BOUNDARY
- LANDFILL PROPERTY BOUNDARY
- FORMER LEACHATE LAGOON
- OPERABLE UNIT 1

N

0 500 '

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FIGURE 2-1

AREAS OF LANDFILL OPERATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 4/21/20	File: 2-1_LandfillOperations_Fig2-1.mxd

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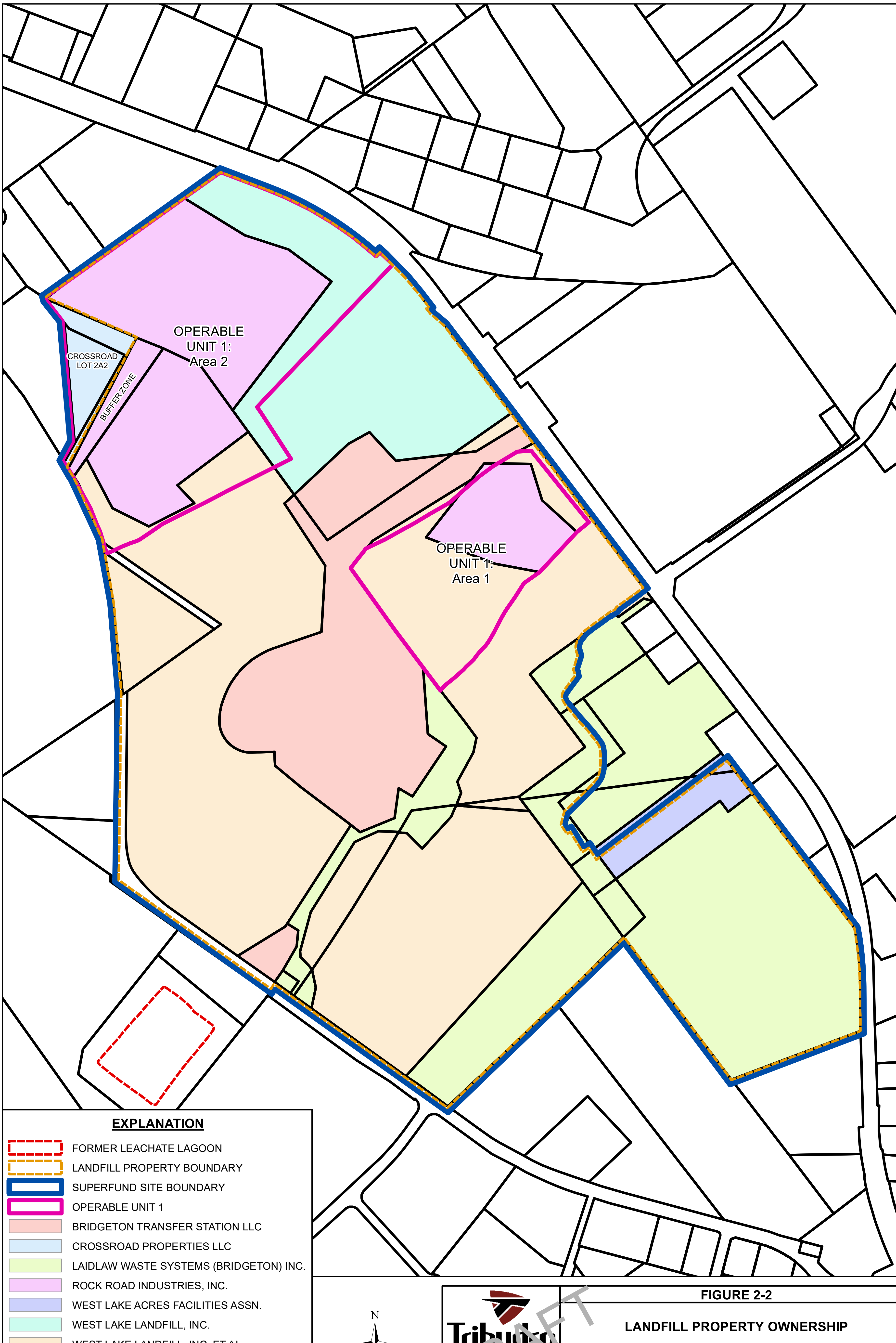

NOTE:

LANDOWNER PARCEL DATA DOWNLOADED FROM SAINT LOUIS COUNTY GIS SERVICE CENTER

FIGURE 2-2

LANDFILL PROPERTY OWNERSHIP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

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Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 4/15/20	File: 2-2_LandfillPropertyOwnership_Fig2-2.mxd

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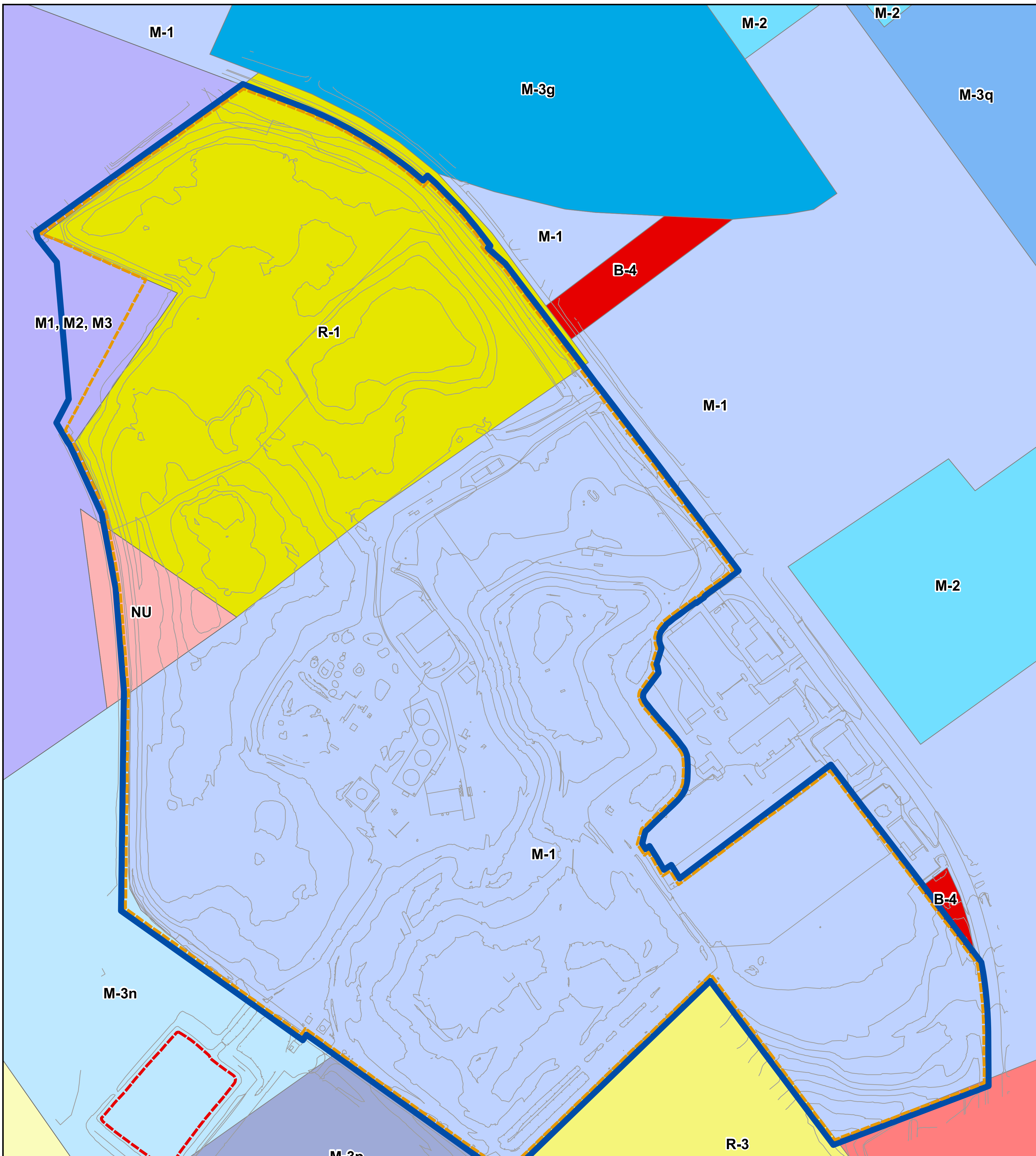

EXPLANATION

- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY
- B-3 = TRAVEL / ENTERTAINMENT SERVICES DISTRICT
- B-4 = GENERAL COMMERCIAL DISTRICT
- C1, C2, C3, C4, C8 = COMMERCIAL DISTRICT VAROUS (UNINCORPORATED)
- M-1 = MANUFACTURING DISTRICT, LIMITED
- M-2 = MANUFACTURING DISTRICT
- M-3A = PLANNED MANUFACTURING DISTRICT (HOLLENBERG BUSINESS PARK)
- M-3G = PLANNED MANUFACTURING DISTRICT (NORTHWEST INDUSTRIAL SUBDIVISION)
- M-3N = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3O = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3P = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3Q = PLANNED MANUFACTURING DISTRICT (NORTHWEST INDUSTRIAL PARK)
- M1, M2, M3 = INDUSTRIAL DISTRICT VAROUS (UNINCORPORATED)
- NU = NON-URBAN DISTRICT (UNINCORPORATED)
- R-1 = SINGLE FAMILY DWELLING DISTRICT
- R-3 = SINGLE FAMILY DWELLING DISTRICT

NOTES:

1. LANDOWNER PARCEL DATA DOWNLOADED FROM SAINT LOUIS COUNTY GIS SERVICE CENTER
2. ZONING DATA FROM CITY OF BRIDGETON ZONING MAP AMENDED 9/20/2017 AND ZONING IN UNINCORPORATED AREA ST. LOUIS COUNTY, MISSOURI PREPARED JULY 2018

N

0 500 '

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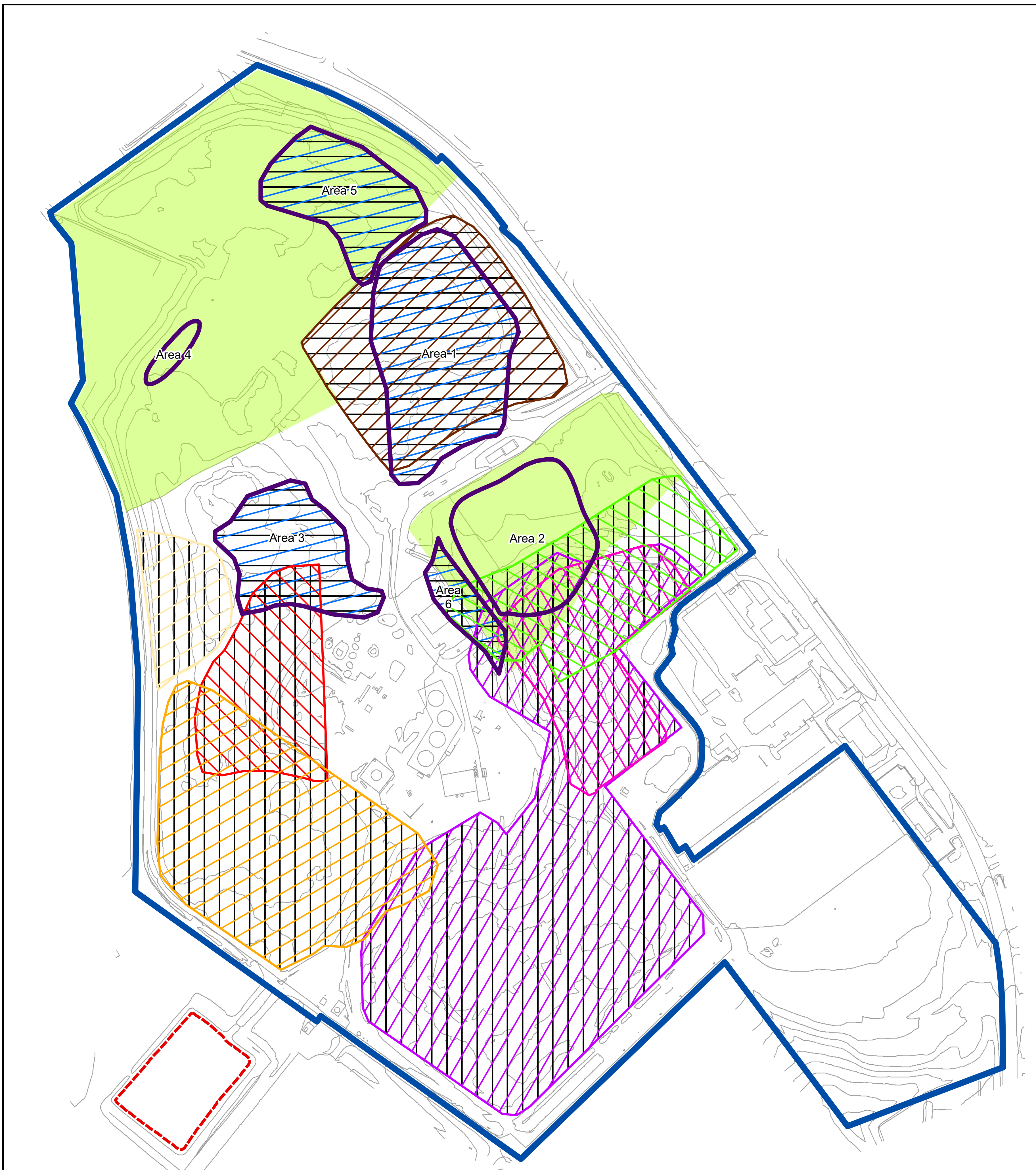
FIGURE 2-3

LANDFILL AND SURROUNDING AREA ZONING

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 4/15/20	File: 2-3_Zoning_Fig2-3.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\2-3_ZONING_FIG2-3.MXD



EXPLANATION

	FORMER LEACHATE LAGOON	
	SUPERFUND SITE BOUNDARY	
	MDNR AREA	
	DEMOLITION	
	SANITARY	
	PERMIT 118903, 1/27/1976	ACTUAL AUTHORIZATION GRANTED ON 8/27/1974
	PERMIT 218903, 1/27/1976	USED FOR SANITARY WASTE DISPOSAL PRIOR TO ISSUANCE OF DEMOLITION FILL PERMIT
	PERMIT 118903, 5/23/1978	EXPANSION OF ORIGINAL 25 ACRE TRACT
	PERMIT 118906, 1/22/1979	
	PERMIT 118908, 8/27/1980	
	PERMIT 118909, 8/20/1981	
	PERMIT 218912, 9/18/1984	
	PERMIT 118912, 11/18/1985	SUPERSEDES PERMIT 118909 AND 118906, PLUS 33 ACRES, PER EXPANSION
	OPERABLE UNIT 1	

N

0 500 '

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FIGURE 2-4

MDNR PERMITTED AREAS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 4/15/20	File: 2-4_PermittedAreas_Fig2-4.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\2-4_PERMITTEDAREAS_FIG2-4.MXD

EXPLANATION

- APPROXIMATE LOCATION OF DRAINAGE SWALE (1981-1984)
- SUPERFUND SITE BOUNDARY
- OPERABLE UNIT 1

N

0 200'

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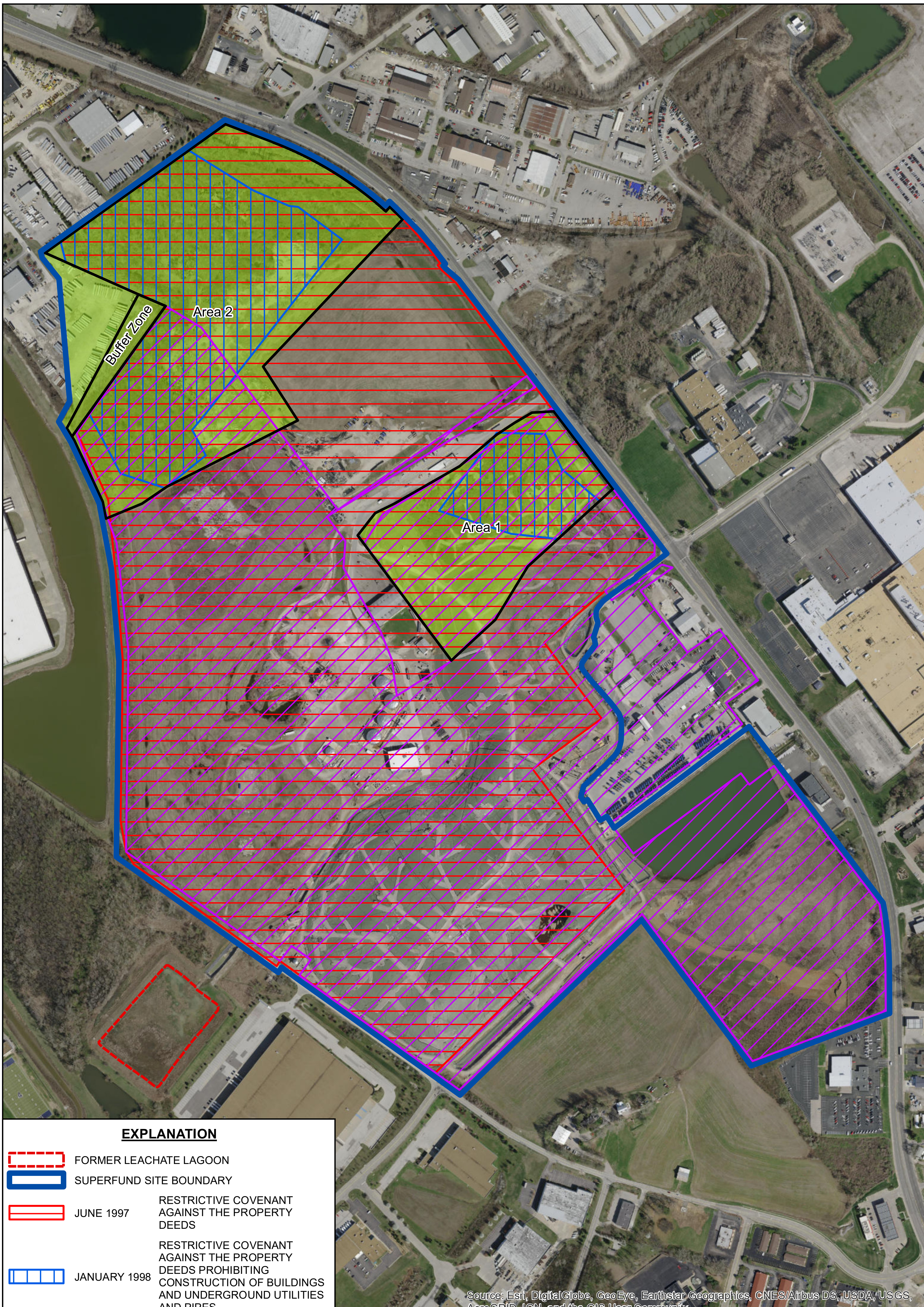
FIGURE 2-5

APPROXIMATE LOCATION OF DRAINAGE SWALES

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1" = 200'	Date: 4/21/20	File: 2-5_DrainageSwales_Fig2-5.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\2-5_DRAINAGESWALES_FIG2-5.MXD



EXPLANATION

	FORMER LEACHATE LAGOON	
	SUPERFUND SITE BOUNDARY	
	JUNE 1997	RESTRICTIVE COVENANT AGAINST THE PROPERTY DEEDS
	JANUARY 1998	RESTRICTIVE COVENANT AGAINST THE PROPERTY DEEDS PROHIBITING CONSTRUCTION OF BUILDINGS AND UNDERGROUND UTILITIES AND PIPES
	AUGUST 2005	NEGATIVE EASEMENT AND RESTRICTIVE COVENANTS PROHIBITING ADDITIONAL DEPOSITING OR DUMPING
	OCTOBER 2016	SUPPLEMENTAL AND PARTIALLY RESTATED COVENANTS AND RESTRICTIONS
	OPERABLE UNIT 1	

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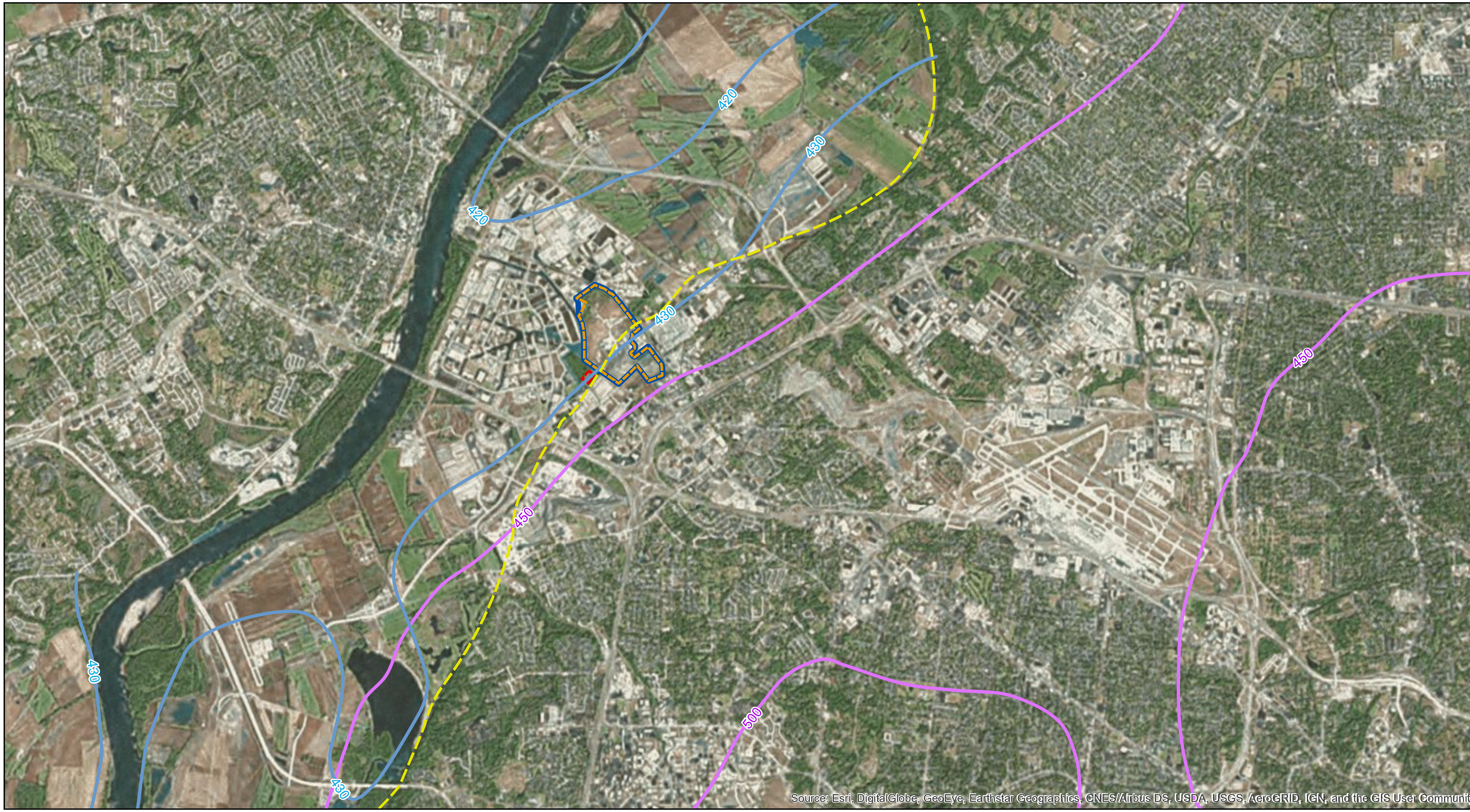
FIGURE 2-6

LAND USE RESTRICTIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 3/19/20	File: 2-6_LandRestrictions_Fig2-6.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\2-6_LANDRESTRICTIONS_FIG2-6.MXD



EXPLANATION

- 1966 ALLUVIAL WATER TABLE CONTOUR
- MISSISSIPPIAN-AGE ROCKS POTENTIOMETRIC SURFACE CONTOUR
- EDGE OF ALLUVIAL VALLEY
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

NOTES:

1. 1966 WATER TABLE CONTOURS DIGITIZED FROM EMMETT & JEFFERY, USGS 1968.
2. MISSISSIPPIAN-AGE ROCKS POTENTIOMETRIC SURFACE DIGITIZED FROM IMES 1990
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
4. USGS = U.S. GEOLOGICAL SURVEY

N

0 5,000 '

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FIGURE 3-1

REGIONAL POTENTIOMETRIC SURFACE MAPS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 5,000 '	Date: 4/22/20	File: 3-1_RegionalPS_Fig3-1.mxd

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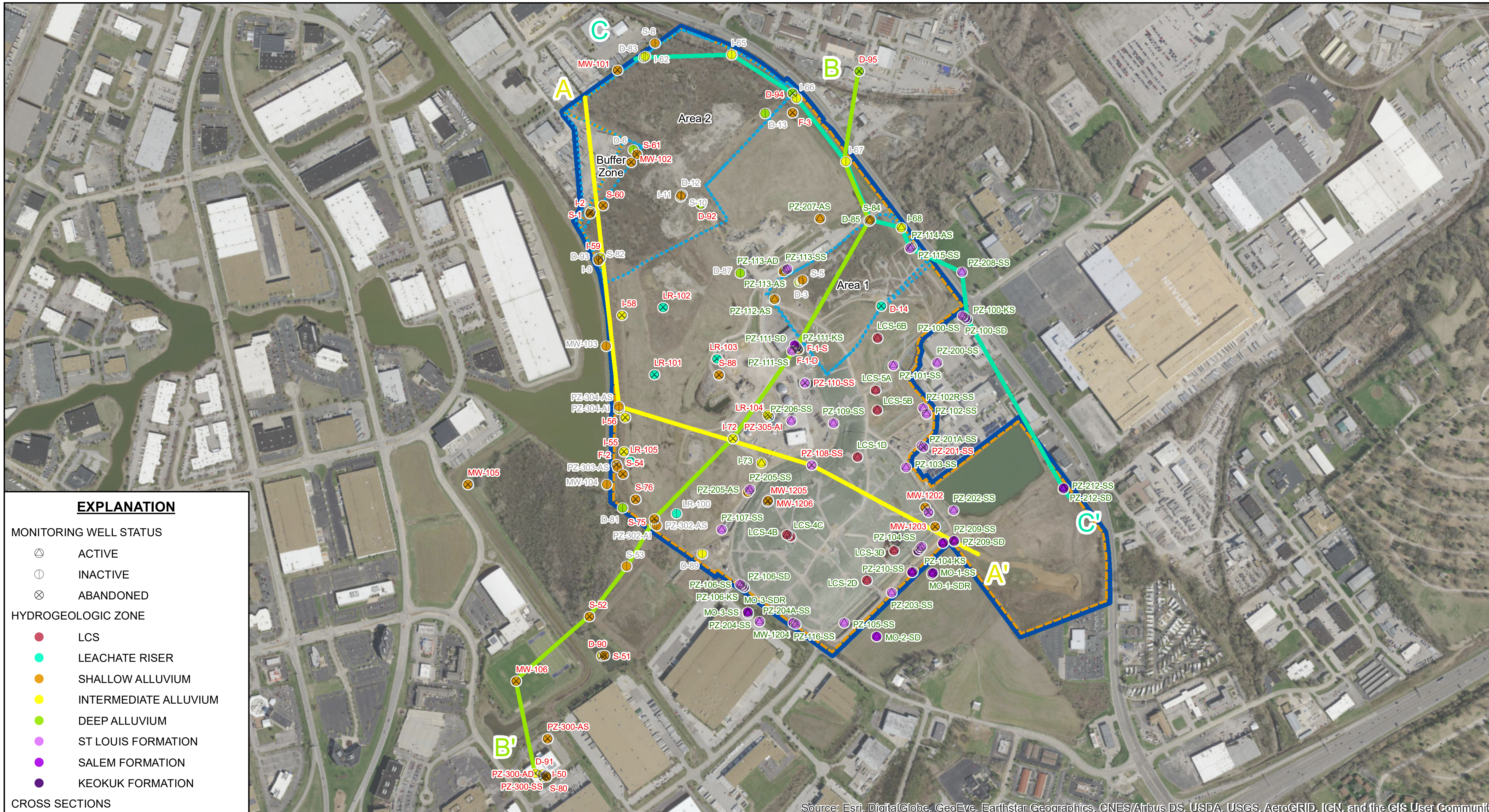

EXPLANATION

MONITORING WELL STATUS
- ACTIVE
- INACTIVE
- ABANDONED

HYDROGEOLOGIC ZONE
- LCS
- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION

CROSS SECTIONS
- CROSS SECTION A
- CROSS SECTION B
- CROSS SECTION C

SITE FEATURES
- OU-1
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 800 '

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FIGURE 3-2

LINES OF SECTION

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 800 '	Date: 4/21/20	File: 3-2_X-S_Fig3-2.mxd

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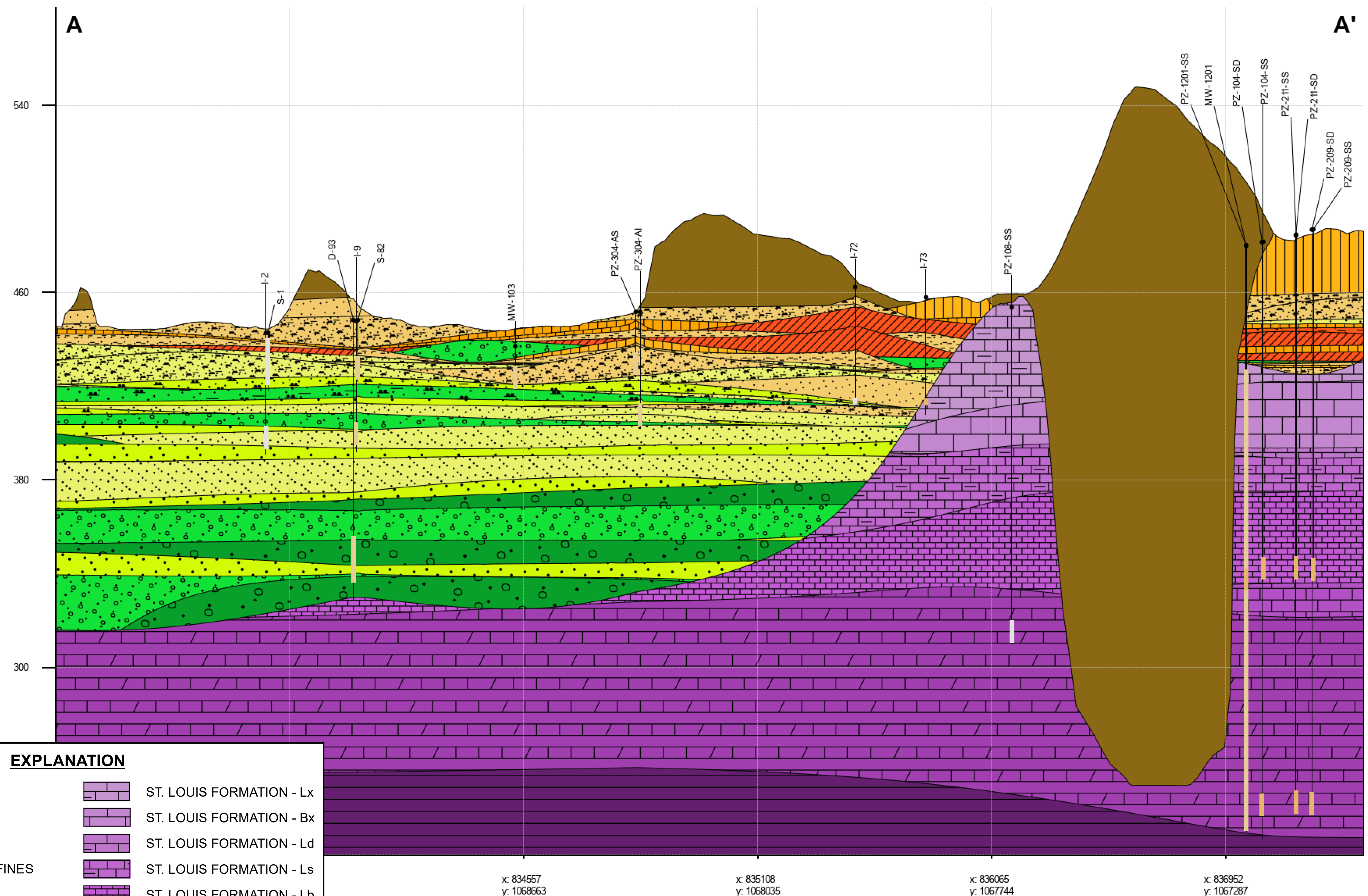

EXPLANATION

- REFUSE
- CLAY
- SILT
- FINE SAND WITH FINES
- FINE SAND
- MEDIUM SAND WITH FINES
- MEDIUM SAND
- COARSE SAND WITH FINES
- COARSE SAND
- FINES WITH FINE GRAVEL
- FINE GRAVEL
- COARSE GRAVEL
- ST. LOUIS FORMATION - Lx
- ST. LOUIS FORMATION - Bx
- ST. LOUIS FORMATION - Ld
- ST. LOUIS FORMATION - Ls
- ST. LOUIS FORMATION - Lb
- ST. LOUIS FORMATION - Lc
- SALEM FORMATION
- WARSAW FORMATION
- KEOKUK FORMATION

NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY
4. PRELIMINARY CROSS SECTION GENERATED USING DIGITIZED DATA IN LEAPFROG VISUALIZATION SOFTWARE AND WILL BE REFINED
5. NORTHING AND EASTING UNITS ARE IN FEET
6. ELEVATION SHOWN IN FEET ABOVE MEAN SEA LEVEL

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L[illegible]ramie, WY 82070
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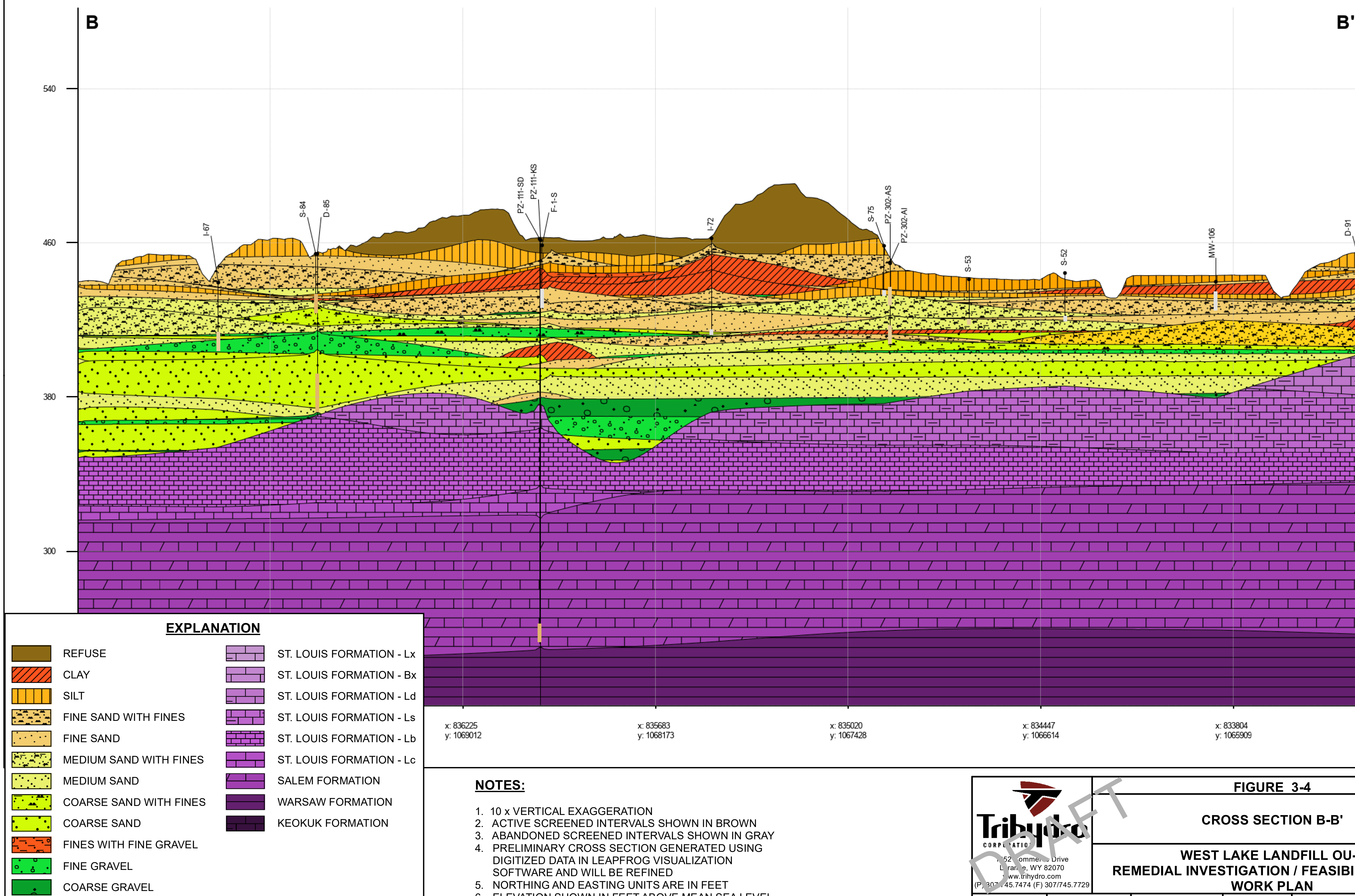
FIGURE 3-3

CROSS SECTION A-A'

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 4/21/20	File: 3-3_X-SA_Fig3-3.mxd



NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY
4. PRELIMINARY CROSS SECTION GENERATED USING DIGITIZED DATA IN LEAPFROG VISUALIZATION SOFTWARE AND WILL BE REFINED
5. NORTHING AND EASTING UNITS ARE IN FEET
6. ELEVATION SHOWN IN FEET ABOVE MEAN SEA LEVEL

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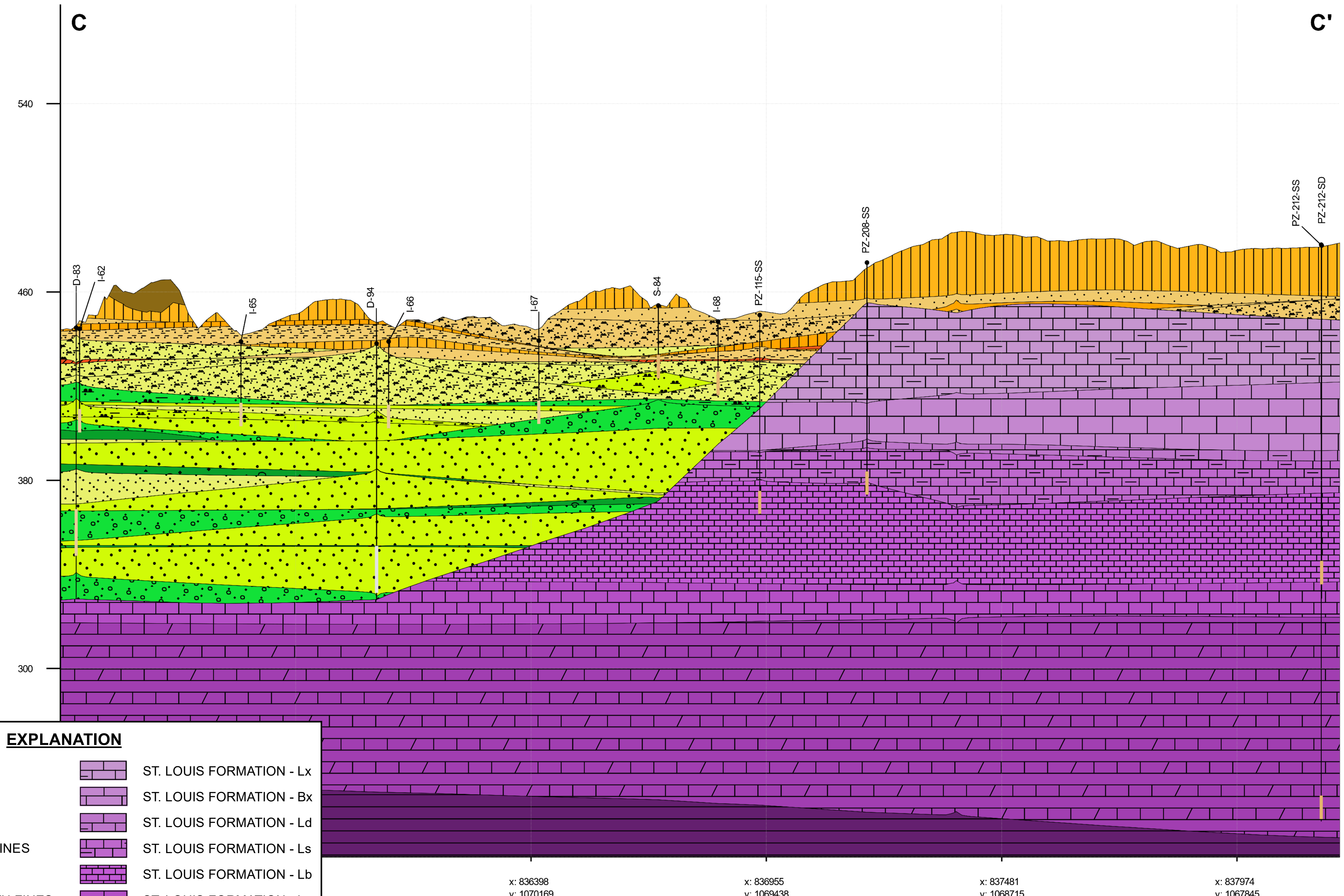
FIGURE 3-4

CROSS SECTION B-B'

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 4/21/20	File: 3-4_X-SB_Fig3-4.mxd



EXPLANATION

- REFUSE
- CLAY
- SILT
- FINE SAND WITH FINES
- FINE SAND
- MEDIUM SAND WITH FINES
- MEDIUM SAND
- COARSE SAND WITH FINES
- COARSE SAND
- FINES WITH FINE GRAVEL
- FINE GRAVEL
- COARSE GRAVEL
- ST. LOUIS FORMATION - Lx
- ST. LOUIS FORMATION - Bx
- ST. LOUIS FORMATION - Ld
- ST. LOUIS FORMATION - Ls
- ST. LOUIS FORMATION - Lb
- ST. LOUIS FORMATION - Lc
- SALEM FORMATION
- WARSAW FORMATION
- KEOKUK FORMATION

NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY
4. PRELIMINARY CROSS SECTION GENERATED USING DIGITIZED DATA IN LEAPFROG VISUALIZATION SOFTWARE AND WILL BE REFINED
5. NORTHING AND EASTING UNITS ARE IN FEET
6. ELEVATION SHOWN IN FEET ABOVE MEAN SEA LEVEL

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FIGURE 3-5

CROSS SECTION C-C'

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 4/21/20	File: 3-5_X-SC_Fig3-5.mxd

EXPLANATION

- EDGE OF ALLUVIAL VALLEY
- OU-1
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 3,000 '

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FIGURE 3-6

EDGE OF THE ALLUVIAL VALLEY

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 3,000 '	Date: 4/22/20	File: 3-6_EdgeAV_Fig3-6.mxd

M:\WYO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-6_EDGEAV_FIG3-6.MXD

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FIGURE 3-7

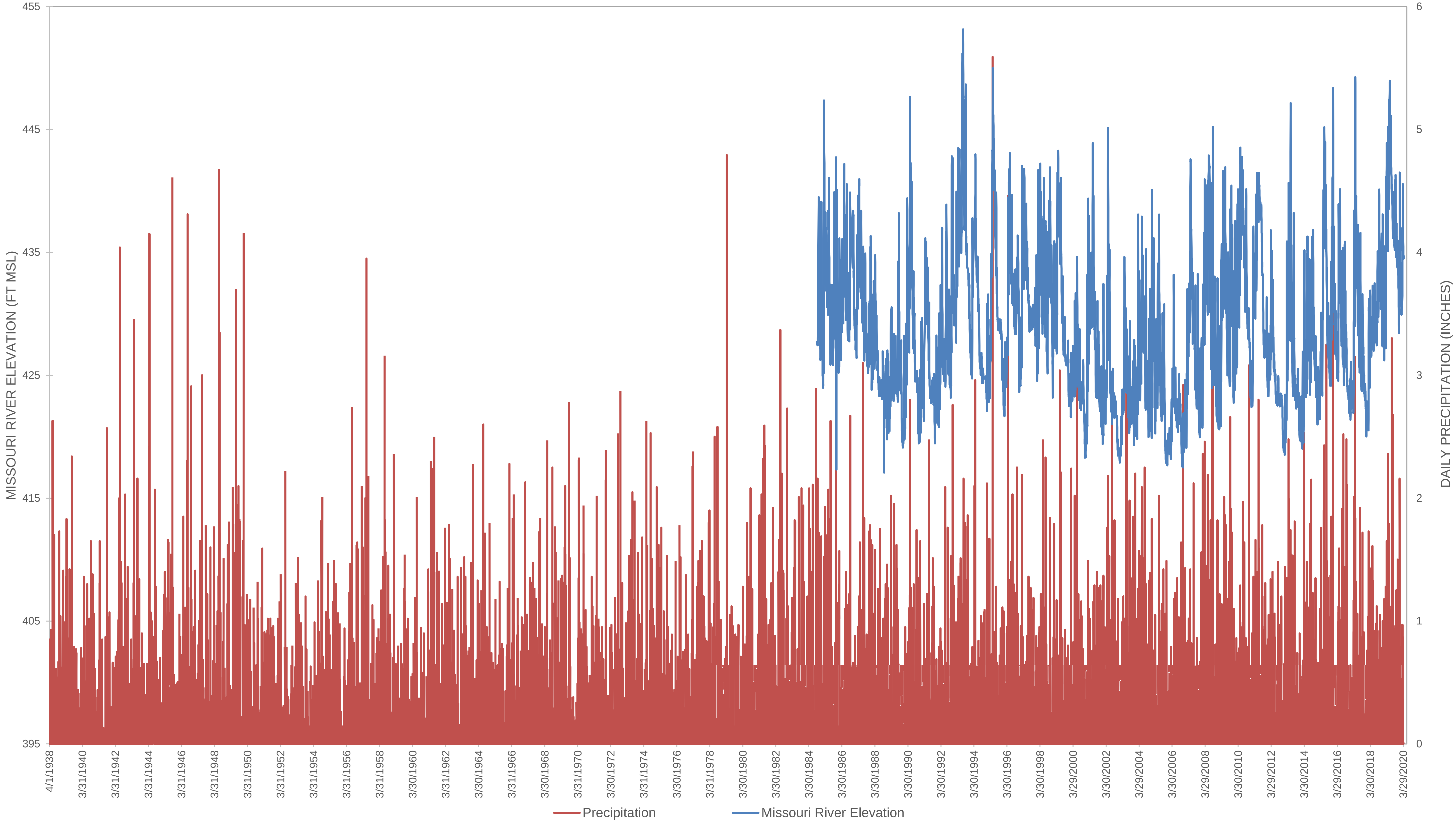
SURFACE WATER AND PRECIPITATION GAUGES

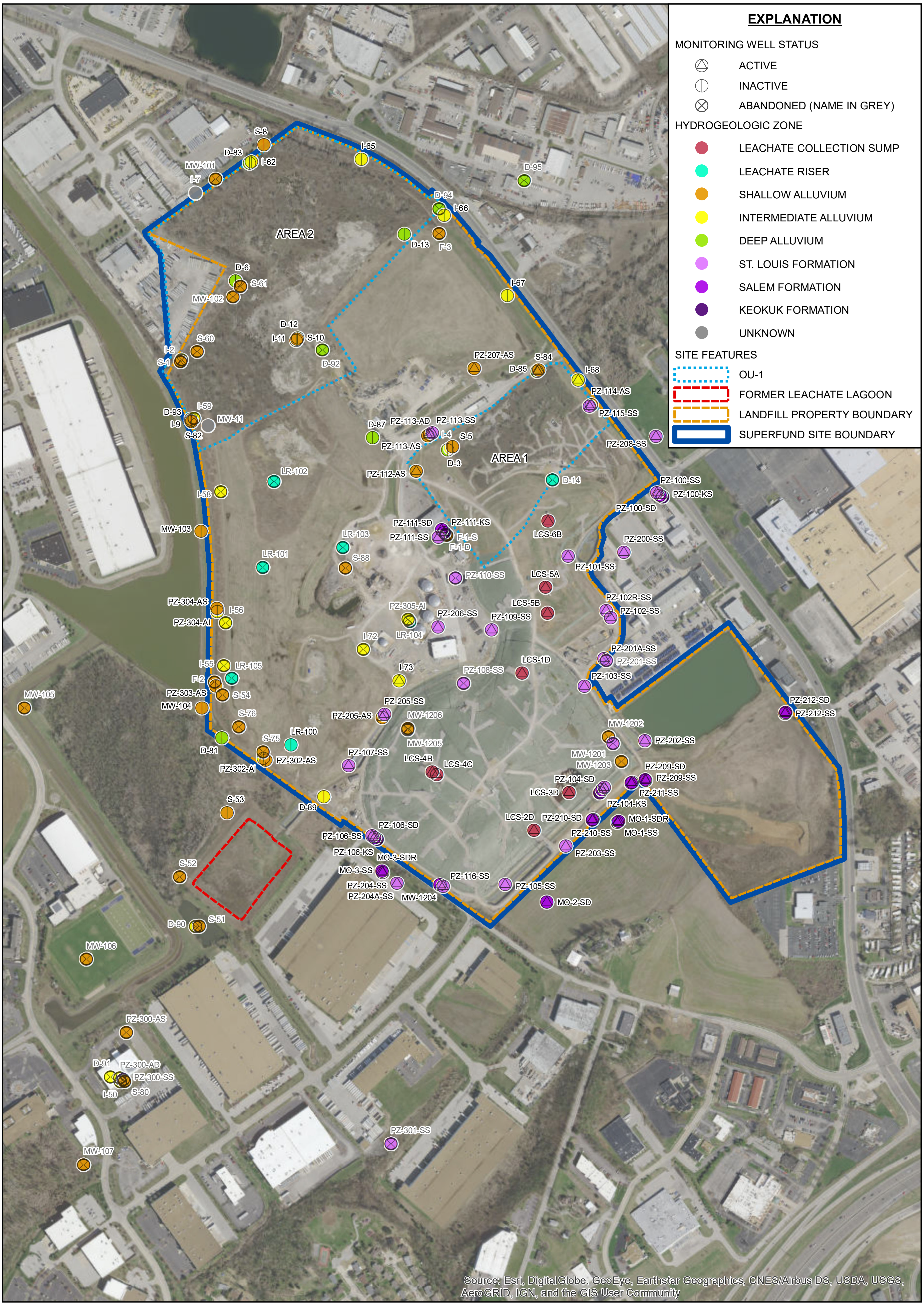
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 2,000 '	Date: 4/9/20	File: 3-7_SW_Precip_Fig3-7.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-7_SW_PRECIP_FIG3-7.MXD

FIGURE 3-8. MISSOURI RIVER ELEVATIONS AT ST. CHARLES USGS GAUGE AND DAILY PRECIPITATION AT LAMBERT ST. LOUIS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN





N

0 600 '

FIGURE 3-9

MONITORING WELL STATUS AND HYDROGEOLOGIC ZONE

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

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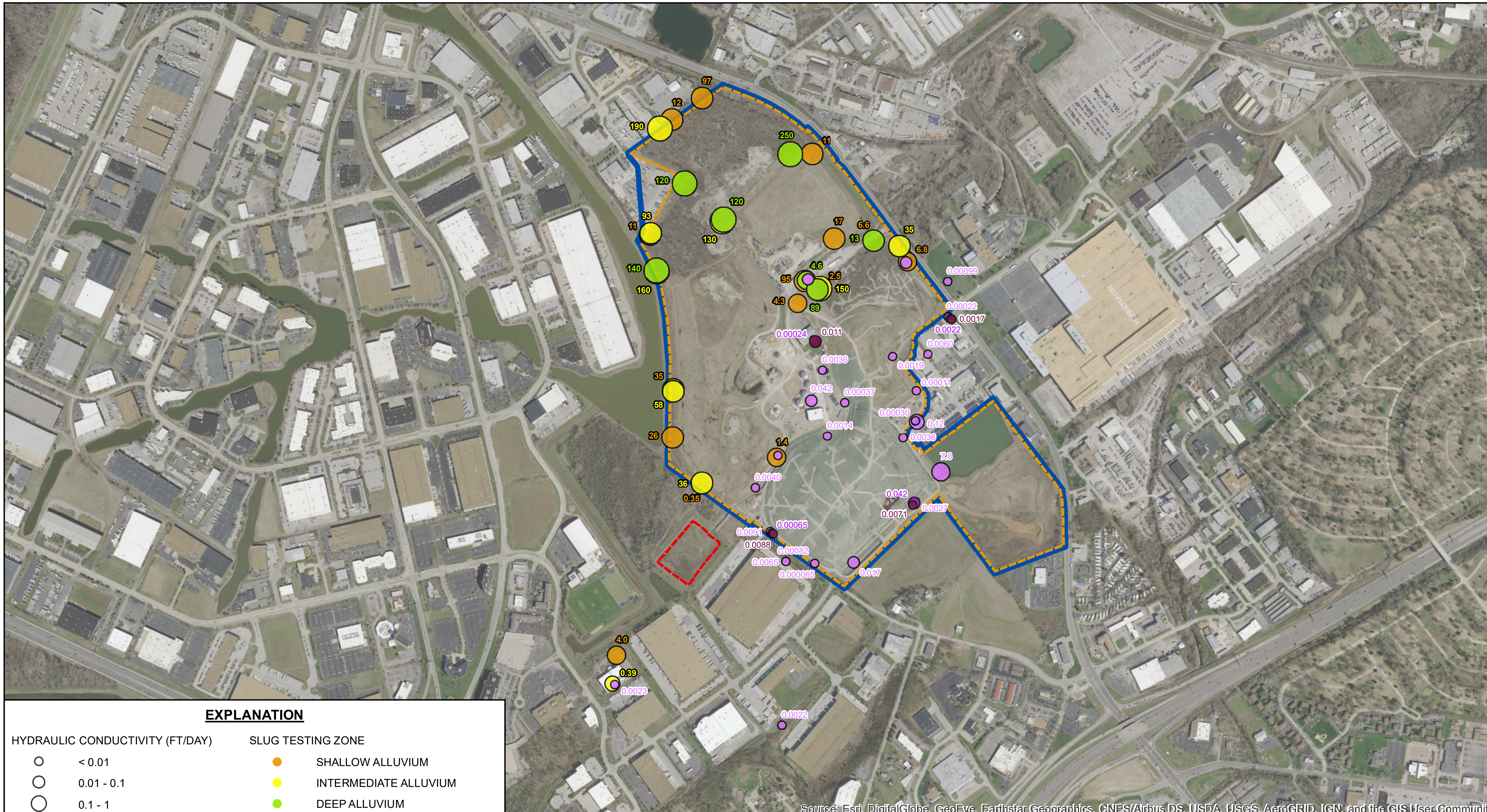
Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/9/20	File: 3-9_MWStatus_Fig3-9.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP3-9_MWSTATUS_FIG3-9.MXD



EXPLANATION

HYDRAULIC CONDUCTIVITY (FT/DAY)

- < 0.01
- 0.01 - 0.1
- 0.1 - 1
- 1 - 10
- 10 - 100
- > 100

SLUG TESTING ZONE

- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST. LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION

SITE FEATURES

- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

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FIGURE 3-10

EXISTING SLUG TESTING RESULTS SUMMARY

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 1,000 '	Date: 4/15/20	File: 3-10_K_Fig3-10.mxd

M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-10_K_FIG3-10.MXD

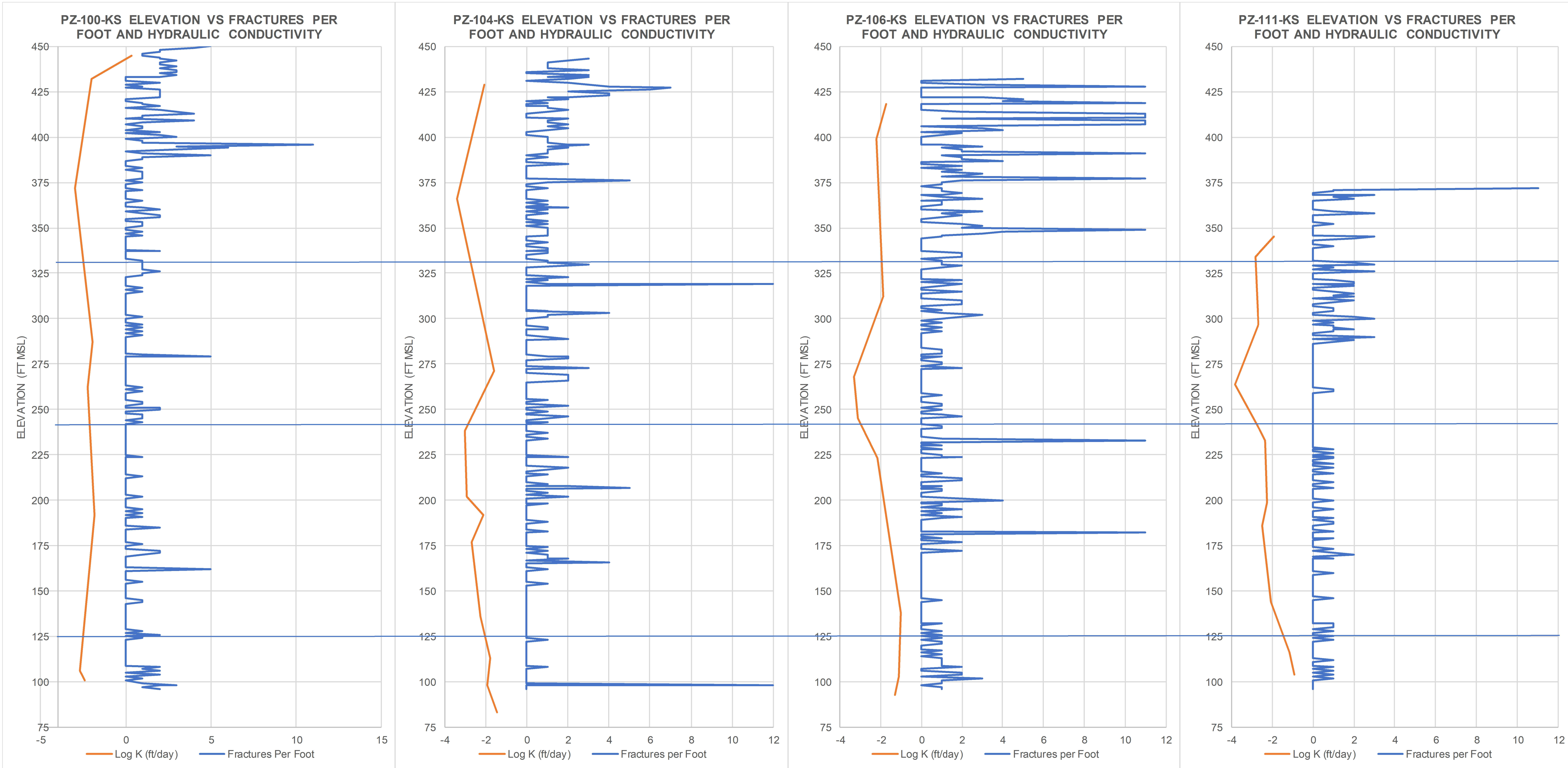

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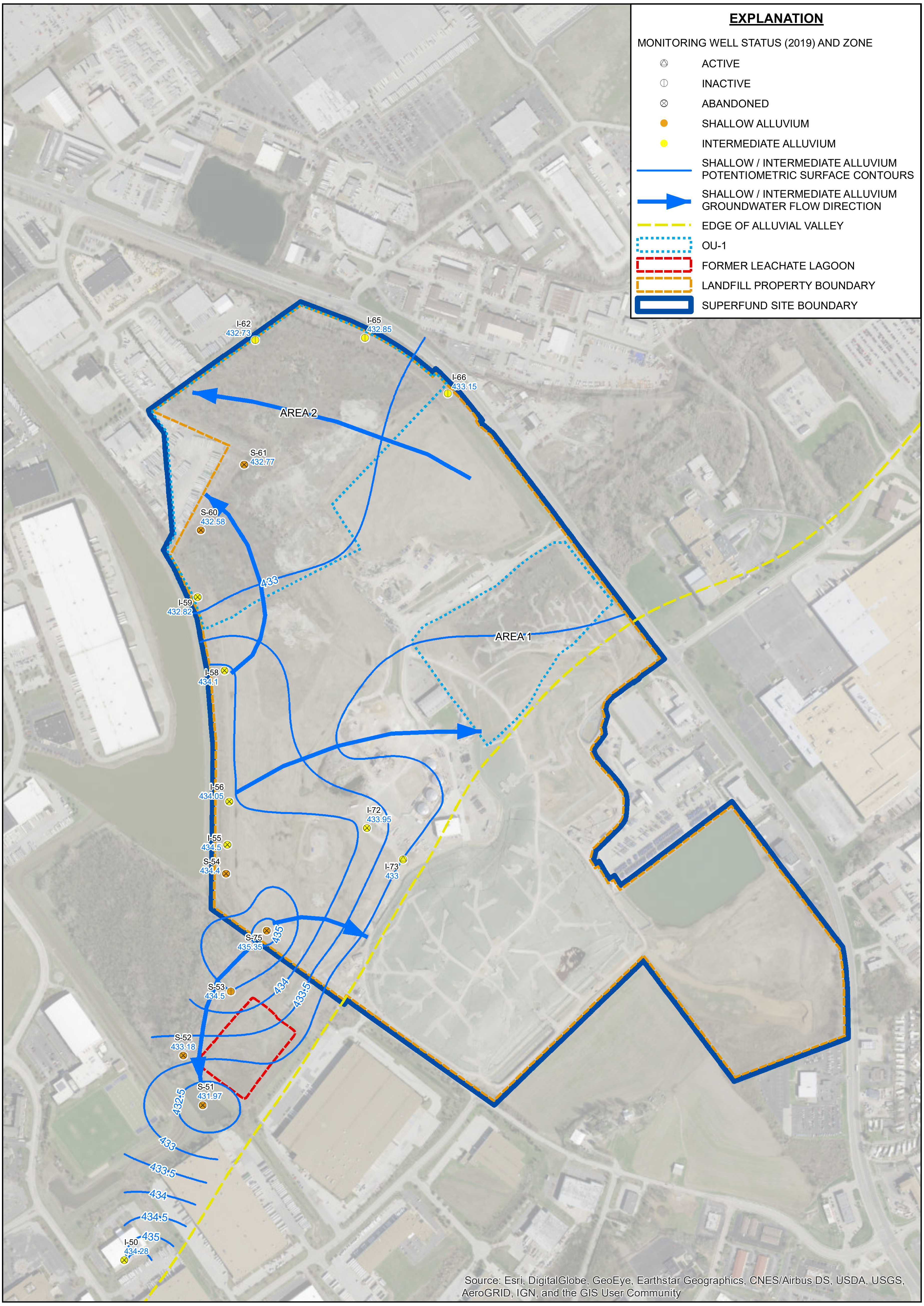
FIGURE 3-11

EXISTING PACKER TESTING RESULTS SUMMARY

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: REP	Checked By: MH	Scale: NONE	Date: 5/9/19	File: 63N-RIFSWP_PACKERRESULTS_20190509



NOTE:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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FIGURE 3-12a
MISSOURI RIVER SHALLOW/INTERMEDIATE ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP
OCTOBER 26, 1984

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-12a_19841026PS_S_Fig3-12a.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-12A_19841026PS_S_FIG3-12A.MXD

NOTE:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

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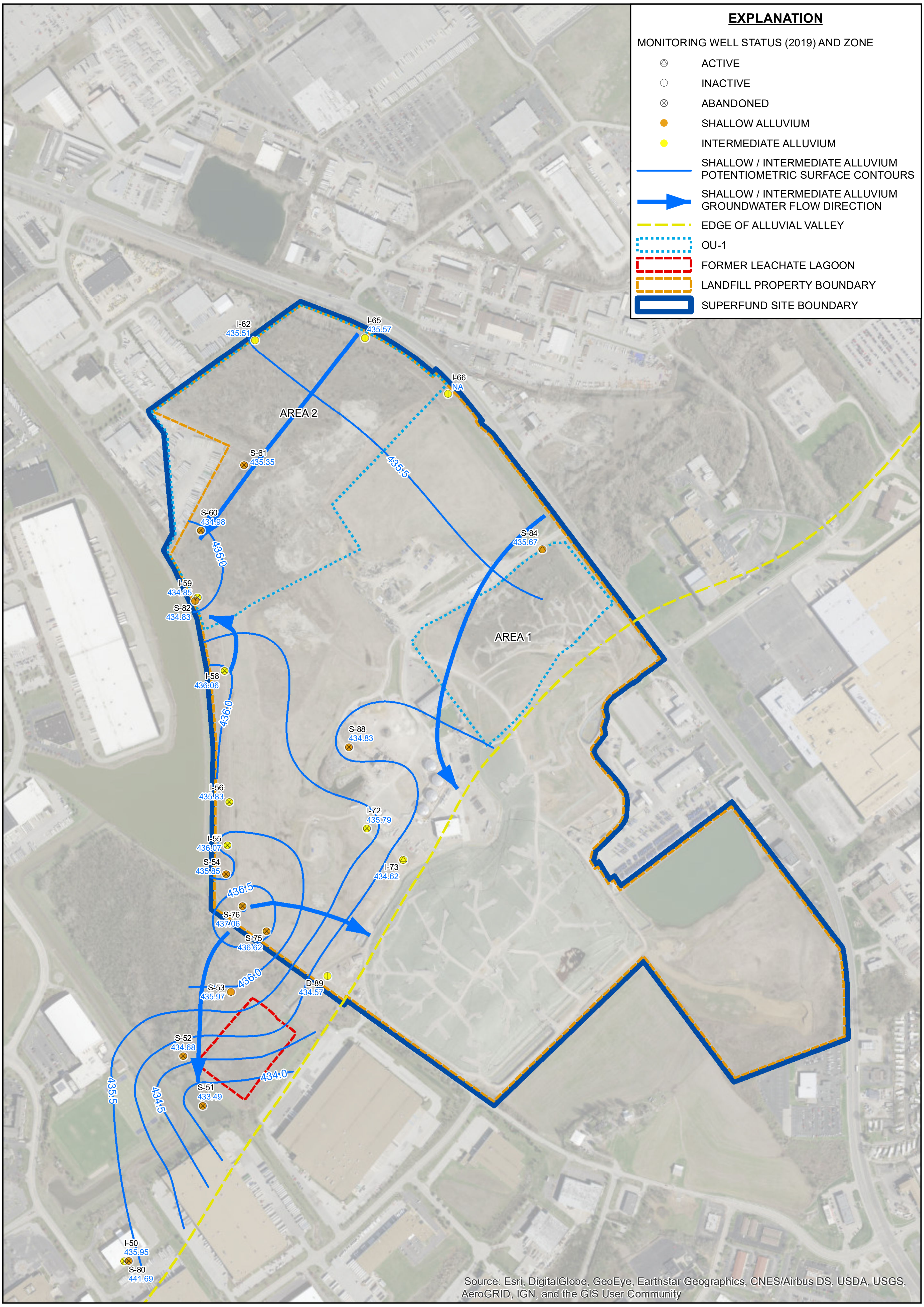
FIGURE 3-12b

MISSOURI RIVER DEEP ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP OCTOBER 26, 1984

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-12b_19841026PS_D_Fig3-12b.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-12B_19841026PS_D_FIG3-12B.MXD



NOTE:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600'

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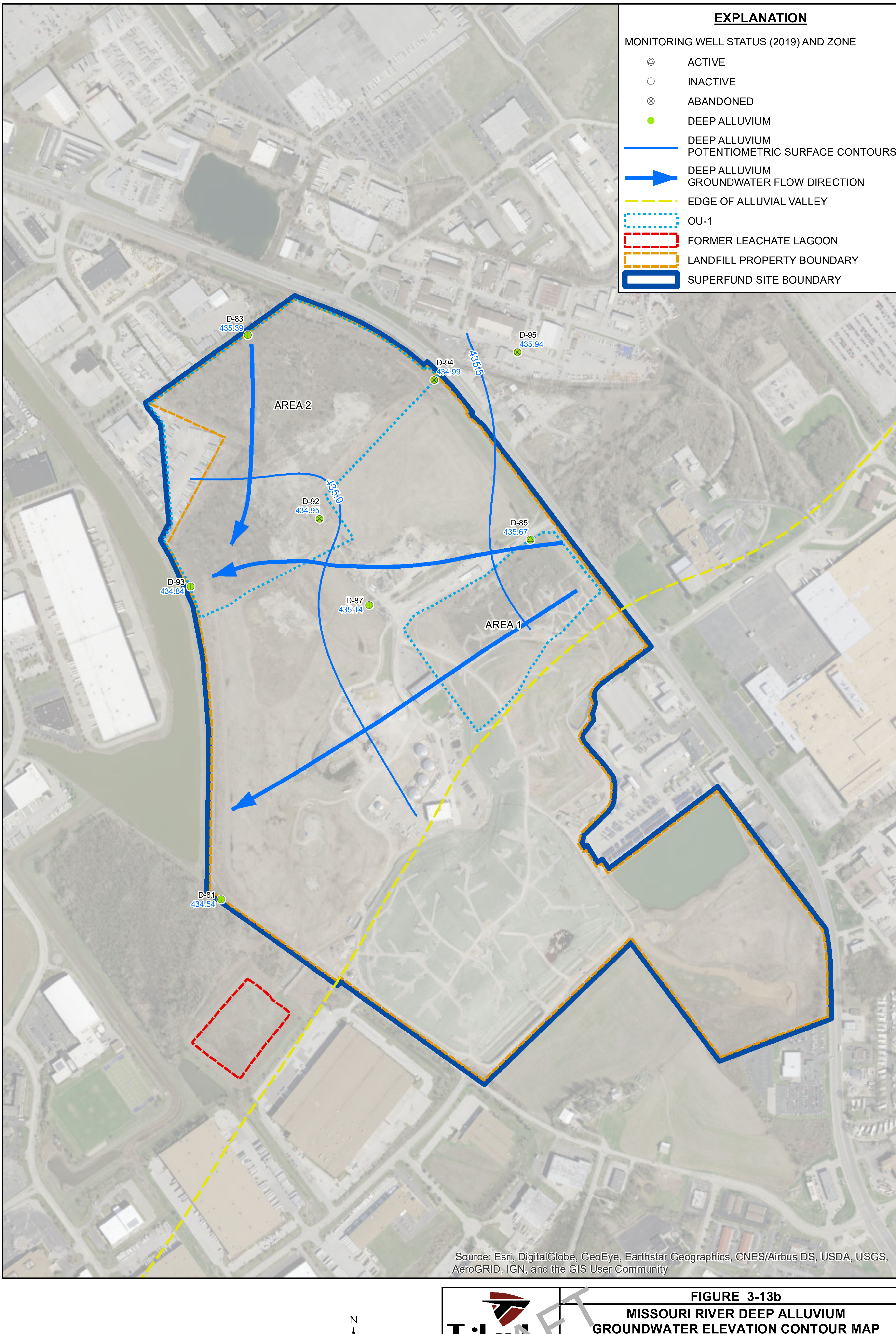
FIGURE 3-13a
MISSOURI RIVER SHALLOW/INTERMEDIATE ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP
APRIL 25, 1985

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-13a_19850425PS_S_Fig3-13a.mxd

M:\WTDZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-13A_19850425PS_S_FIG3-13A.MXD



NOTE:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600'

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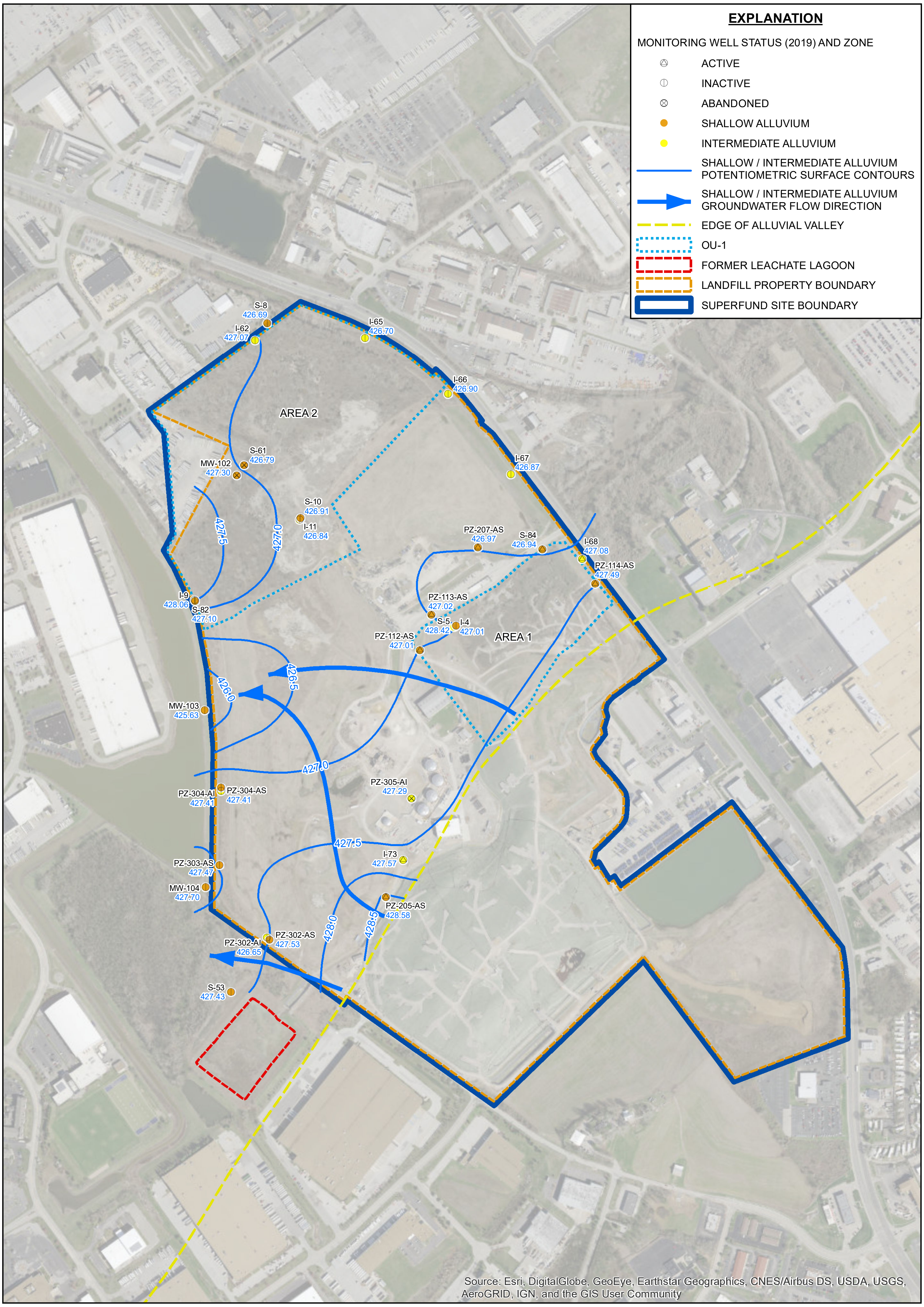
FIGURE 3-13b

MISSOURI RIVER DEEP ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP APRIL 25, 1985

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-13b_19850425PS_D_Fig3-13b.mxd

M:\WTDZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-13B_19850425PS_D_Fig3-13B.MXD



NOTES:

1. MONITORING WELLS S-5 AND PZ-302-AI NOT CONTOURED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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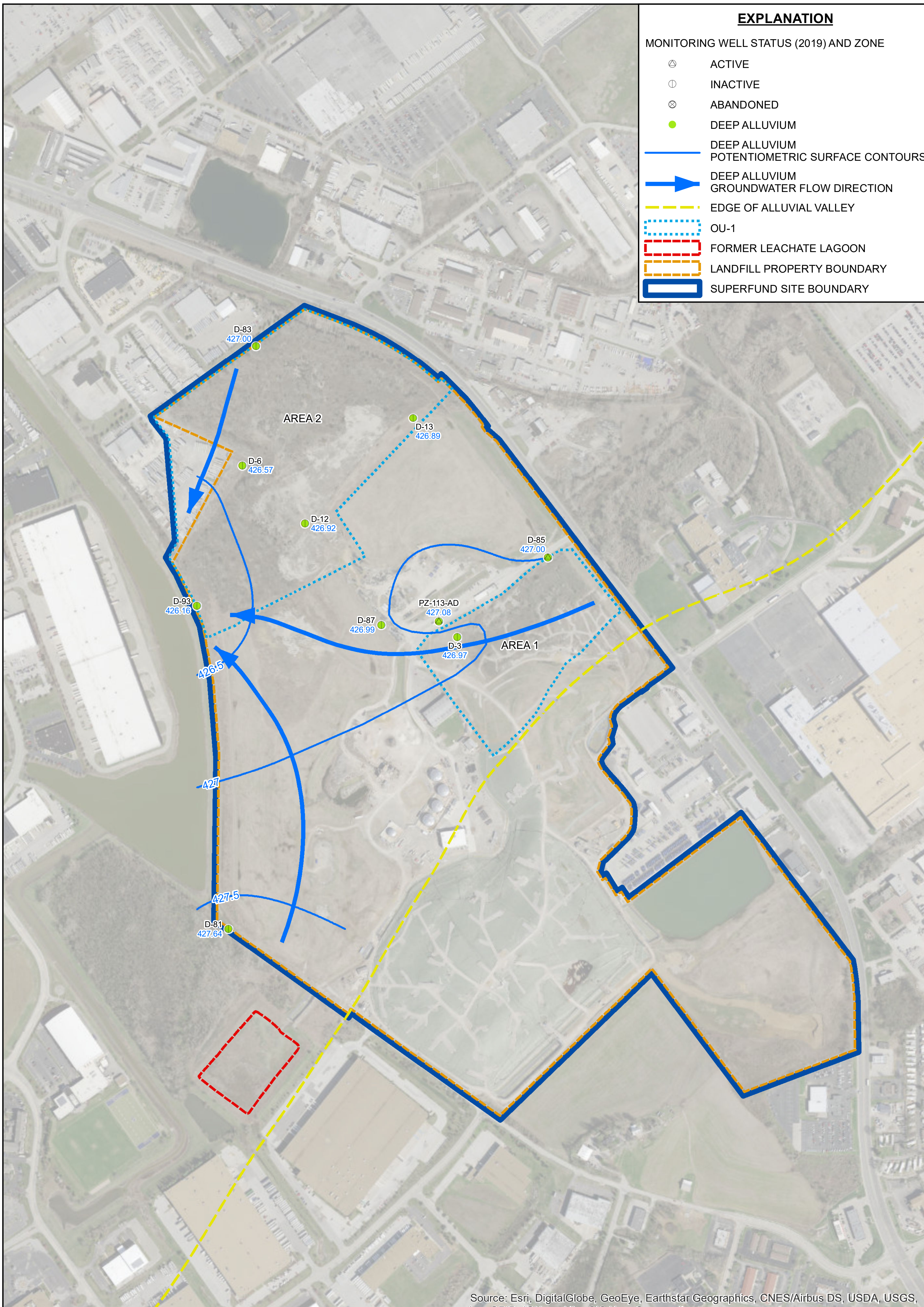
FIGURE 3-14a

MISSOURI RIVER SHALLOW/INTERMEDIATE ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-14a_201304MA_S_Fig3-14a.mxd

M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\2020\03_RIFS_WP\3-14A_201304MA_S_FIG3-14A.MXD



M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-14B_201304MA_D_FIG3-14B.MXD

N

0 600 '

NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

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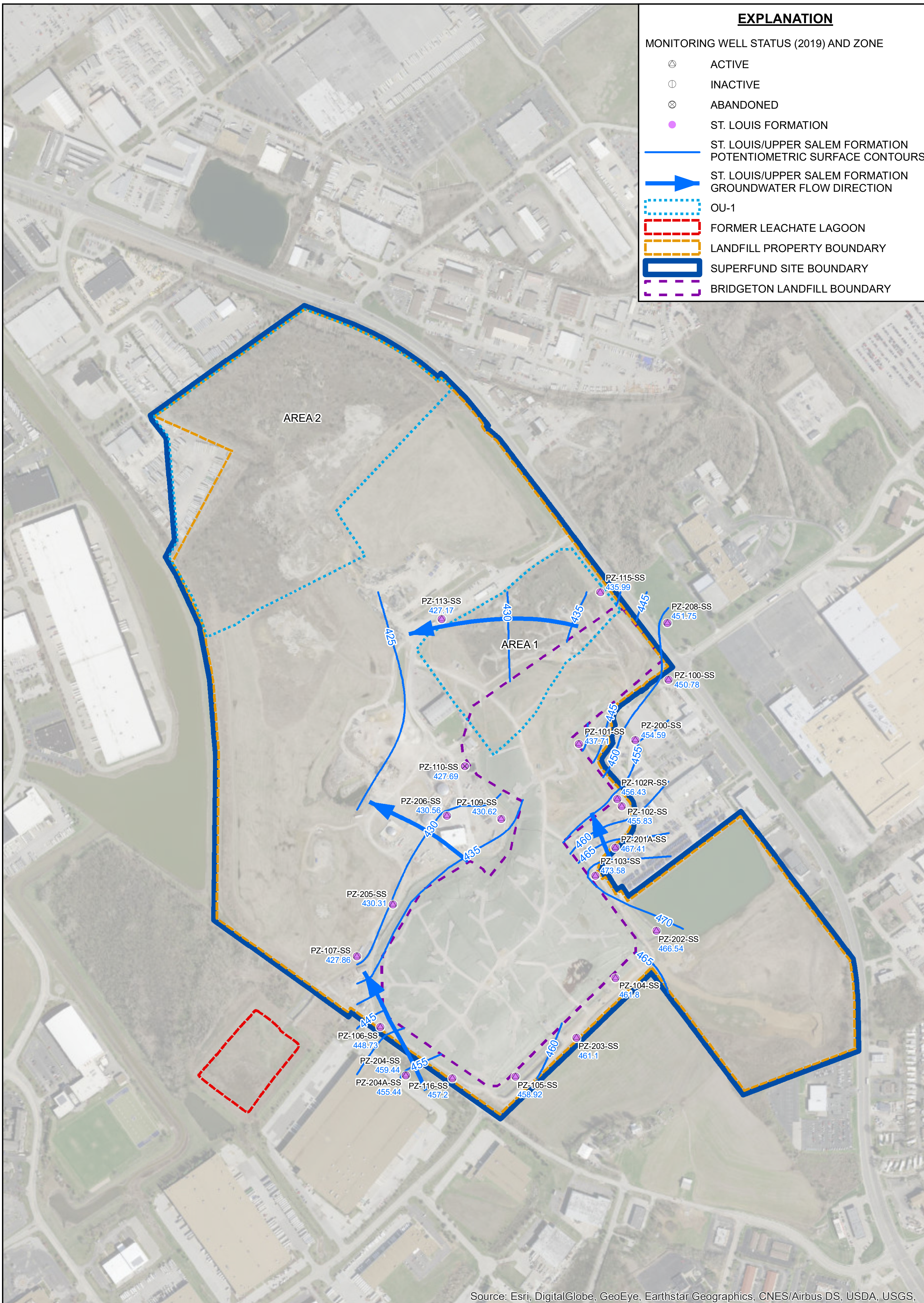
FIGURE 3-14b

MISSOURI RIVER DEEP ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-14b_201304MA_D_Fig3-14b.mxd



NOTES:

1. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
3. ELEVATIONS AT LCS POINTS WERE NOT INCLUDED ON MAP

N

0 600 '

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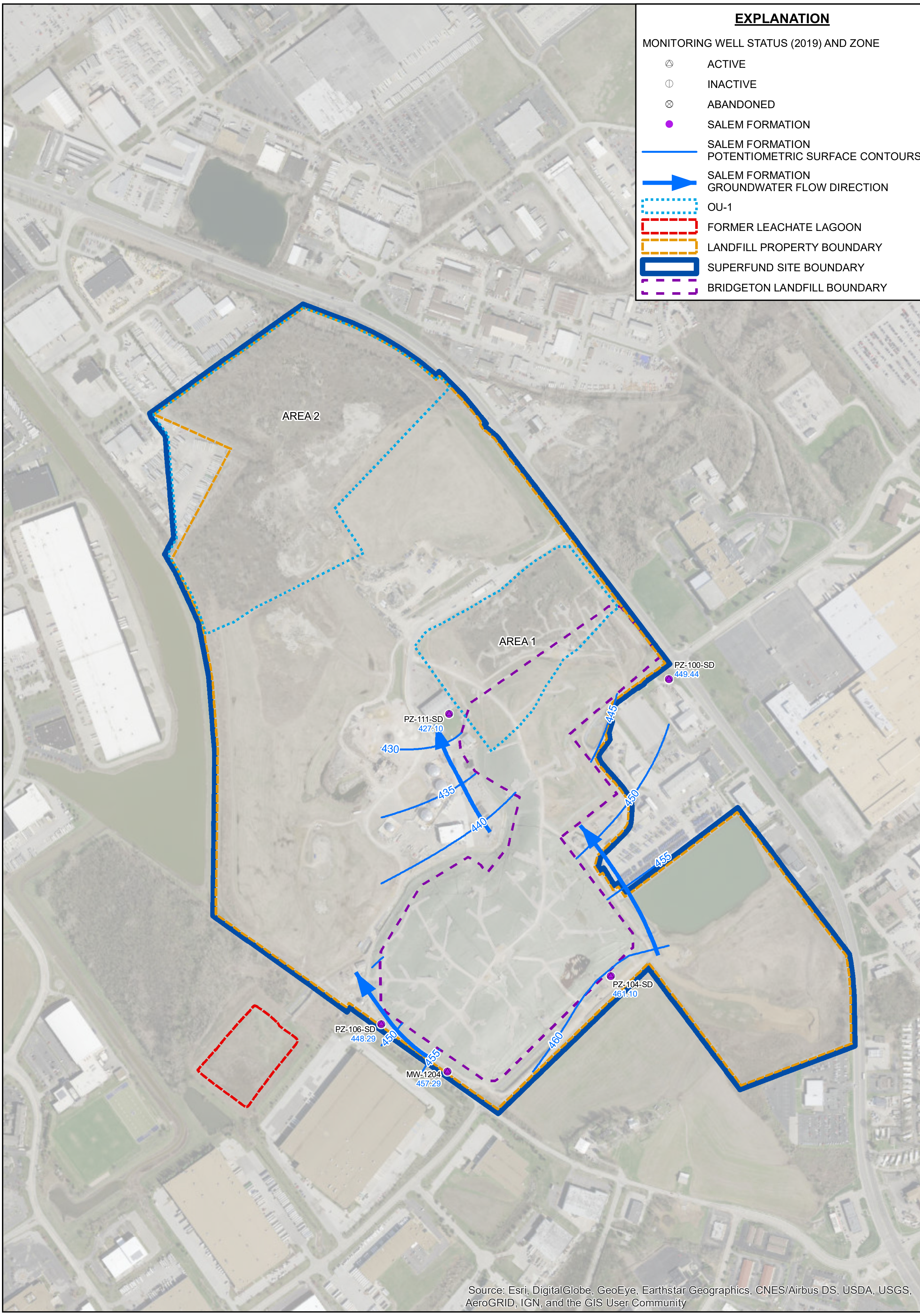
FIGURE 3-14c

ST. LOUIS/UPPER SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-14c_201304SS_Fig3-14c.mxd

M:\WTO2\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-14C_201304SS_Fig3-14C.MXD



NOTES:

1. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
3. ELEVATIONS AT LCS POINTS WERE NOT INCLUDED ON MAP

N

0 600 '

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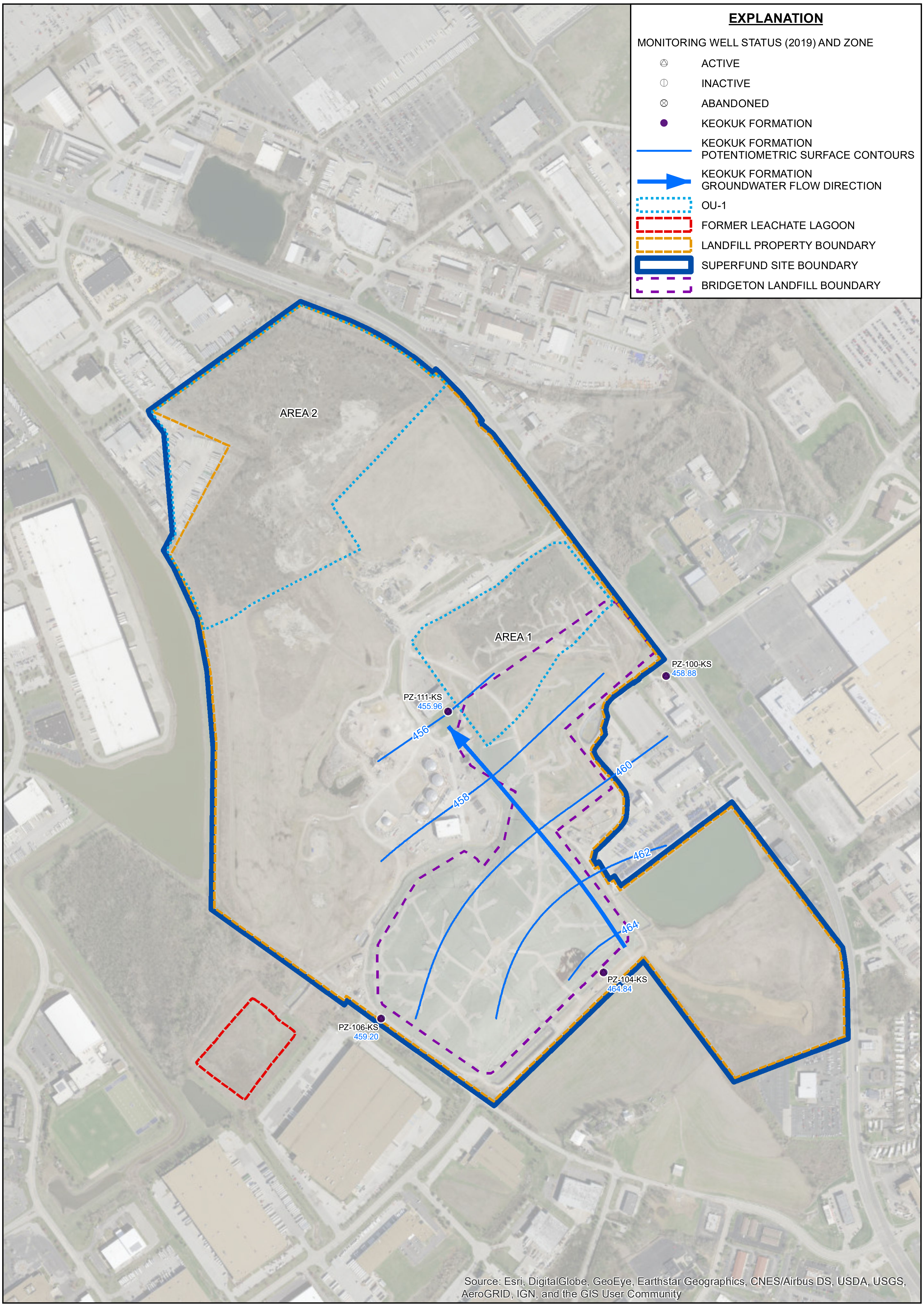
FIGURE 3-14d

SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-14d_201304SD_Fig3-14d.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-14D_201304SD_FIG3-14D.MXD



NOTE:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600'

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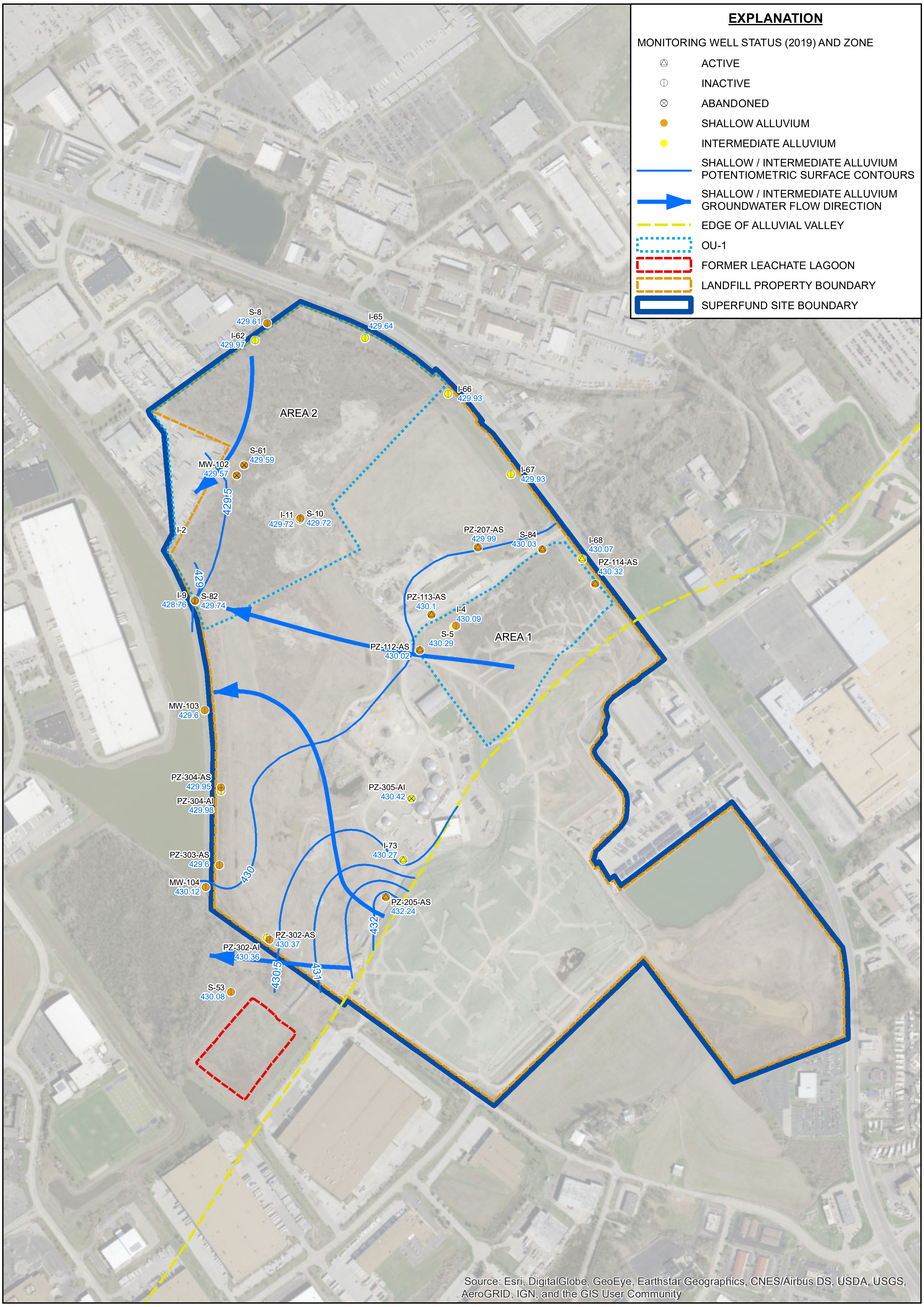
FIGURE 3-14e

KEOKUK FORMATION GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-14e_201304KS_Fig3-14e.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-14E_201304KS_FIG3-14E.MXD



M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-15A_201309MA_S_FIG3-15A.MXD

NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

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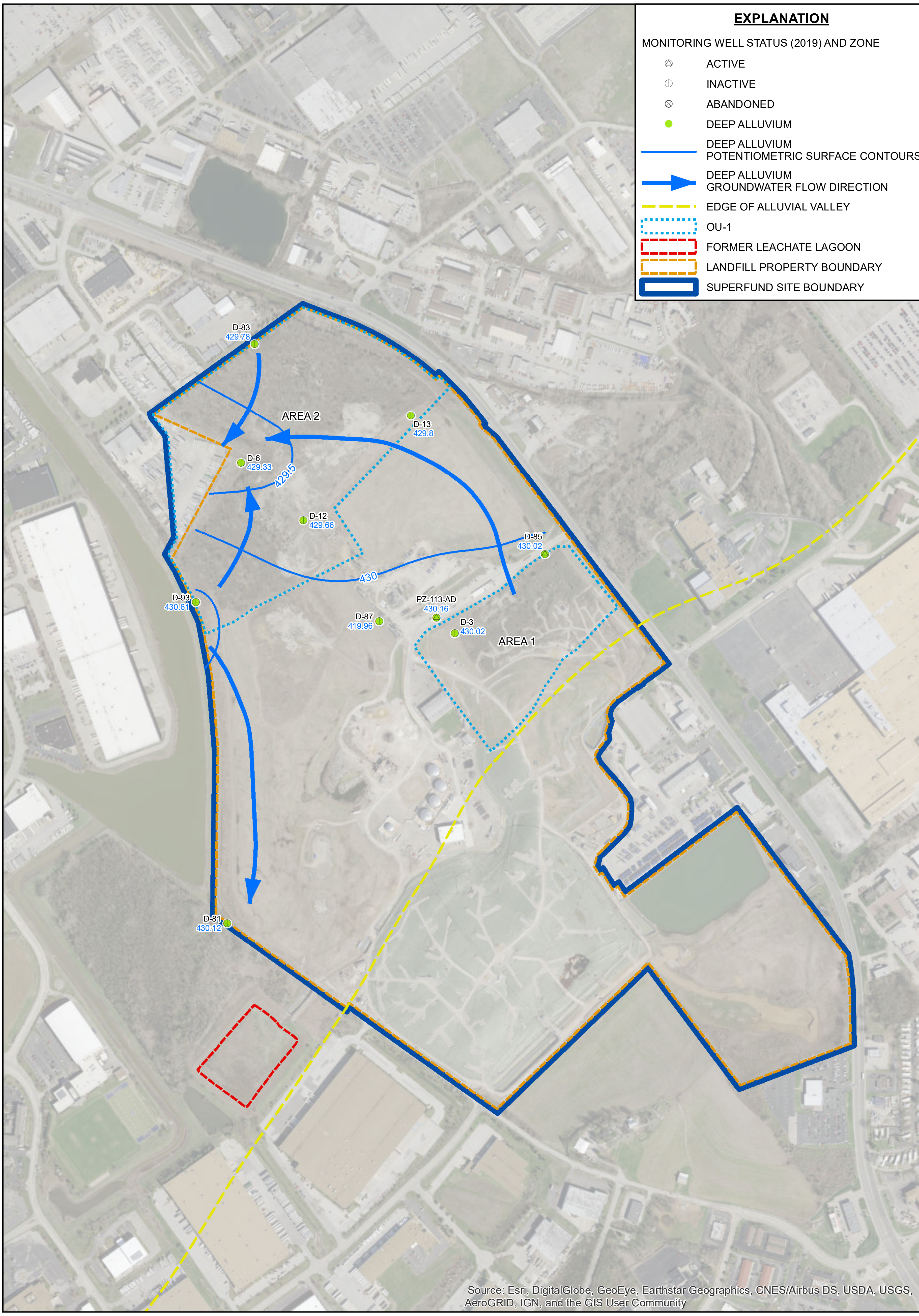
FIGURE 3-15a
MISSOURI RIVER SHALLOW/INTERMEDIATE ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-15a_201309MA_S_Fig3-15a.mxd



NOTES:

1. MONITORING WELL D-87 NOT CONTOURED DUE TO POSSIBLE GAUGING ERROR
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600'

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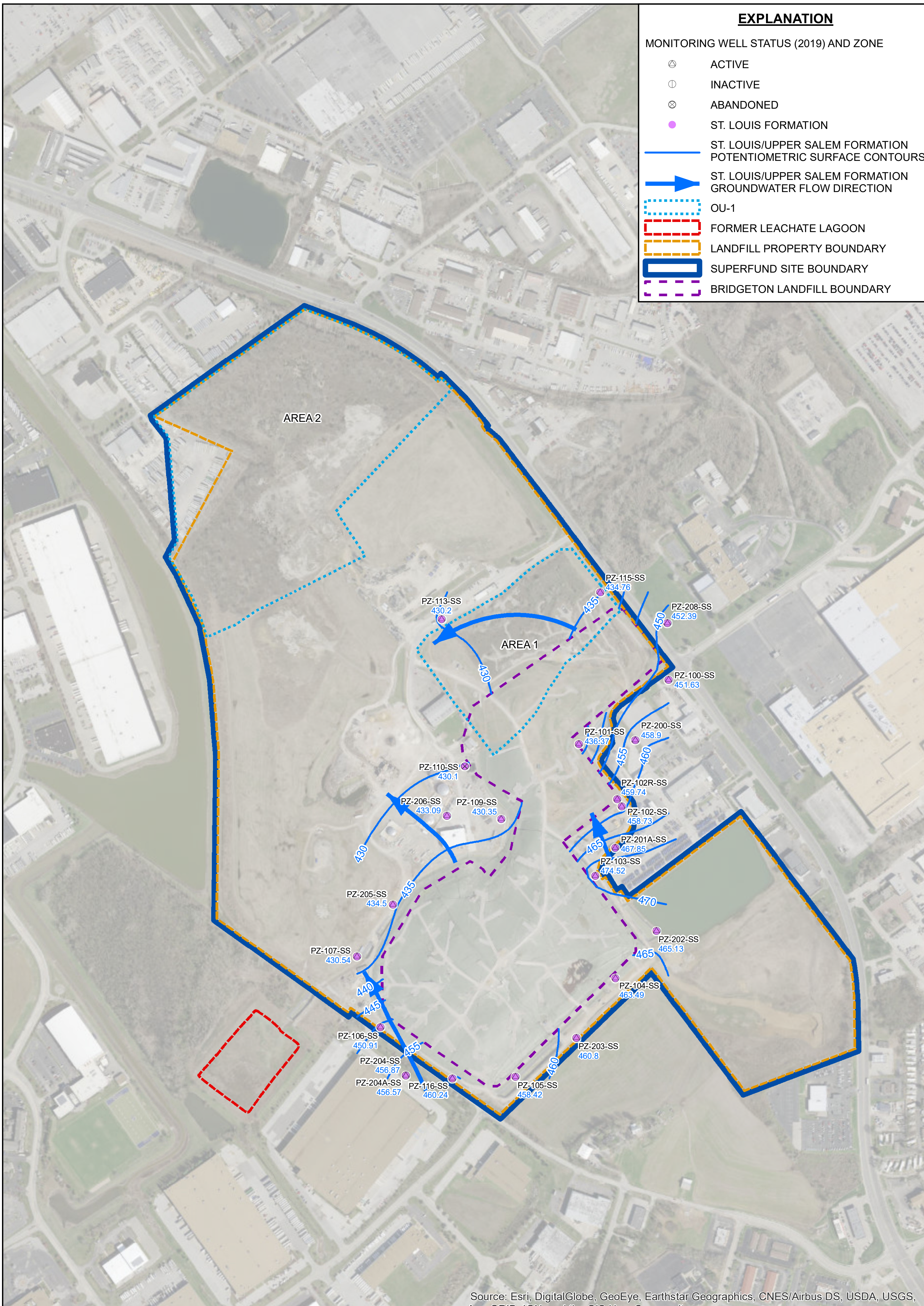
FIGURE 3-15b

MISSOURI RIVER DEEP ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-15b_201309MA_D_Fig3-15b.mxd

M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-15B_201309MA_D_FIG3-15B.MXD



NOTES:

1. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
3. ELEVATIONS AT LCS POINTS WERE NOT INCLUDED ON MAP

N

0 600 '

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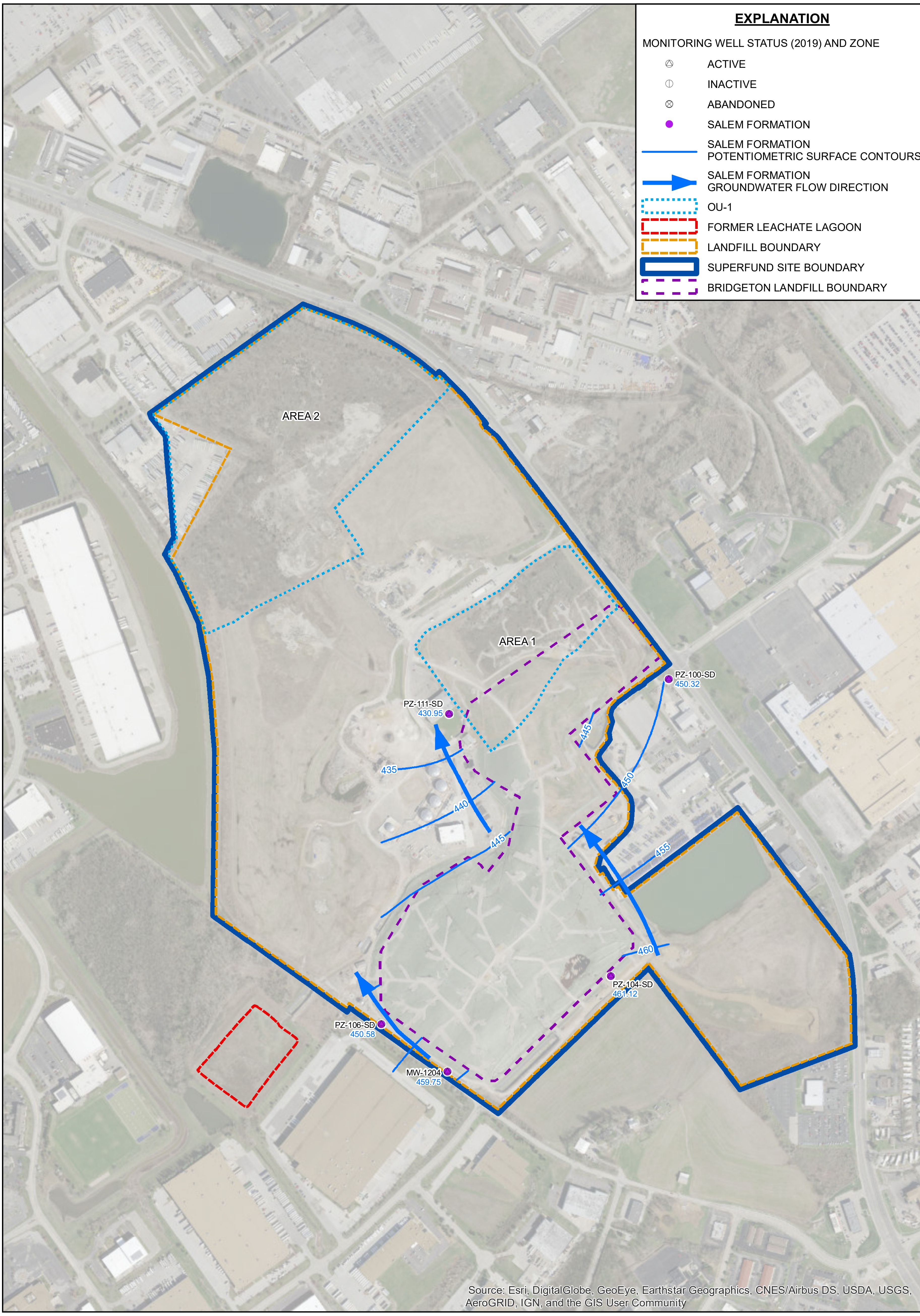
FIGURE 3-15c

ST. LOUIS/UPPER SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-15c_201309SS_Fig3-15c.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-15C_201309SS_FIG3-15C.MXD



NOTES:

1. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
3. ELEVATIONS AT LCS POINTS WERE NOT INCLUDED ON MAP

N

0 600 '

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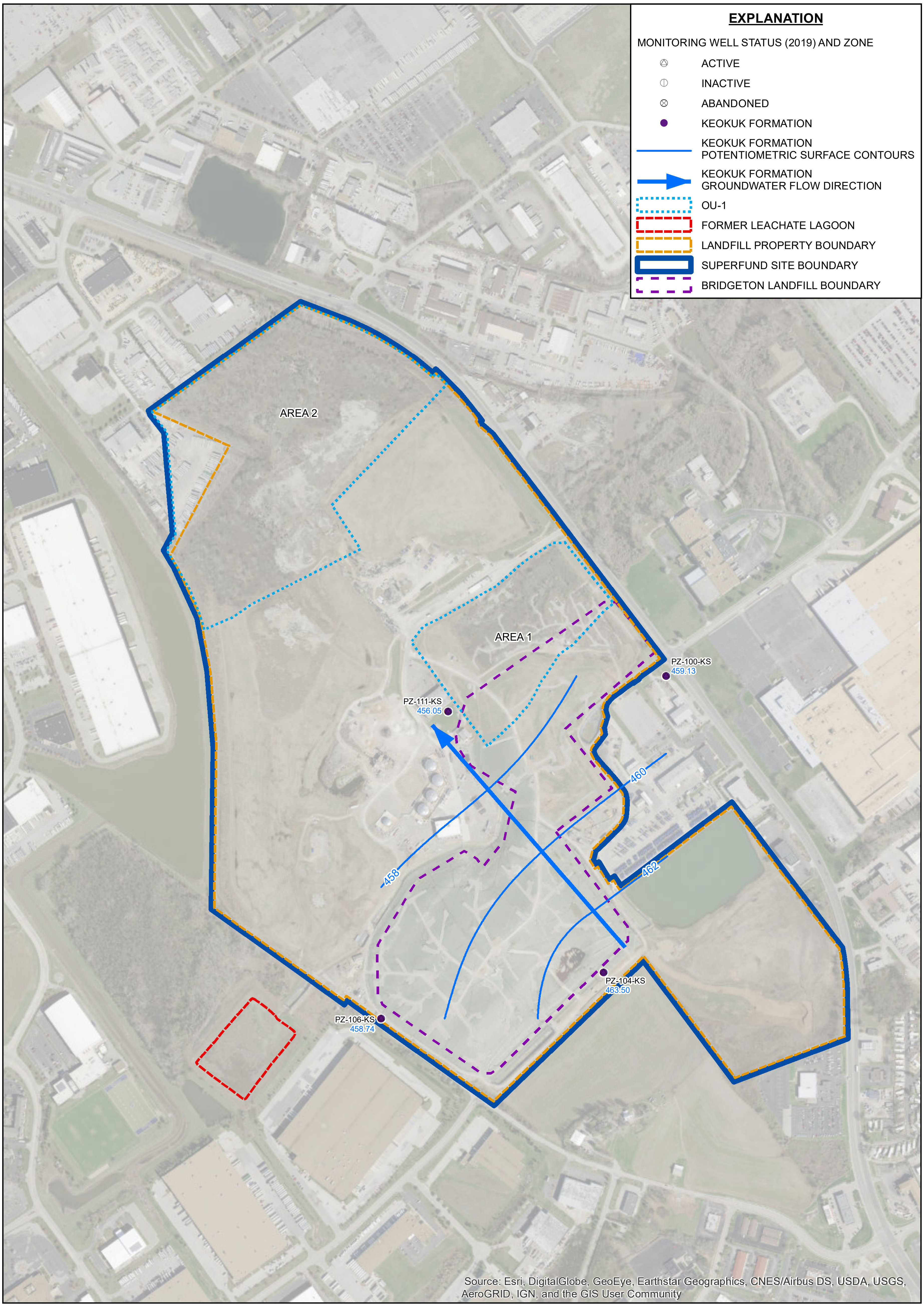
FIGURE 3-15d

SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-15d_201309SD_Fig3-15d.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP3-15D_201309SD_FIG3-15D.MXD



NOTE:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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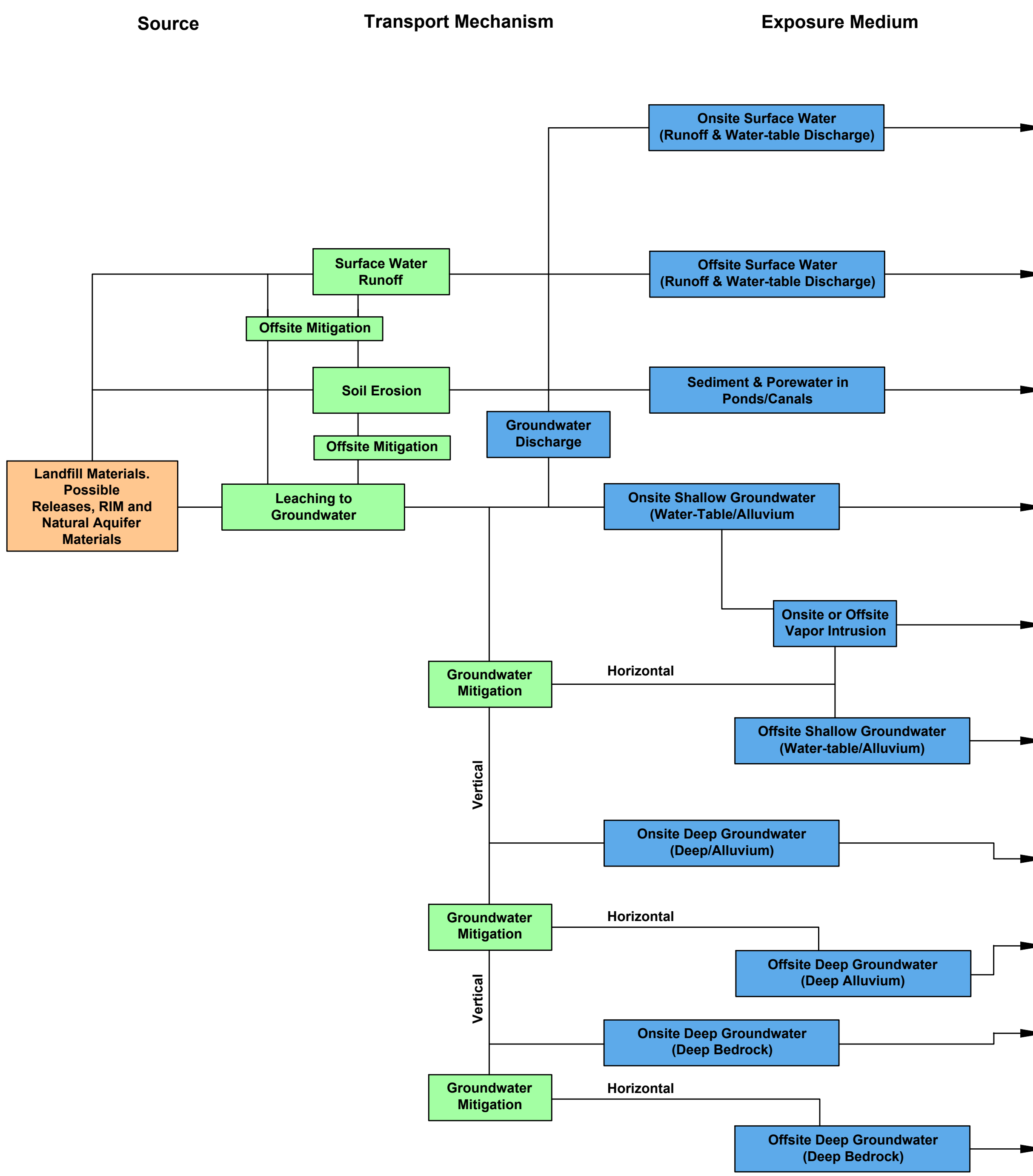
FIGURE 3-15e
KEOKUK FORMATION
GROUNDWATER ELEVATION CONTOUR MAP
SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 4/21/20	File: 3-15e_201309KS_Fig3-15e.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\3-15E_201309KS_FIG3-15E.MXD



Potential Exposure Routes	Current Potential Receptors									Future Potential Receptors									
	Onsite				Offsite					Onsite				Offsite					
	Onsite Commercial/ Industrial Worker	Onsite Construction/ Utility Worker	Onsite Remediation Worker	Hypothetical Onsite Trespasser	Hypothetical Offsite Resident (Adult/Child)	Offsite Commercial/ Industrial Worker	Offsite Construction/ Utility Worker	Hypothetical Offsite Recreationalist	Ecological Receptors	Onsite Commercial/ Industrial Worker	Onsite Construction/ Utility Worker	Onsite Remediation Worker	Hypothetical Onsite Trespasser	Hypothetical Offsite Resident	Offsite Commercial/ Industrial Worker	Offsite Commercial/ Utility Worker	Hypothetical Offsite Farmer	Hypothetical Offsite Recreationalist	Ecological Receptors
Incidental Ingestion				PC									PC						
Dermal Contact				PC									PC						
Inhalation of Volatile Particulate Emissions (Outdoor Air)				PC									PC						
Ingestion of Fish Tissue				PC									PC						
Direct Radiation				PC									PC						
Incidental Ingestion								PC	PC								PC	PC	PC
Dermal Contact								PC	PC								PC	PC	PC
Inhalation of Volatile Particulate Emissions (Outdoor Air)								PC	PC								PC	PC	PC
Ingestion of Fish Tissue								PC	PC									PC	PC
Direct Radiation								PC	PC								PC	PC	PC
Incidental Ingestion								PC	PC									PC	PC
Dermal Contact								PC	PC									PC	PC
Direct Radiation								PC	PC									PC	PC
Incidental Ingestion		PC	PC	PC							PC	PC	PC						
Dermal Contact		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Outdoor Air)		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Indoor Air)	PC									PC									
Direct Radiation		PC	PC	PC							PC	PC	PC						
Inhalation of Volatile Emissions (Outdoor Air)		PC	PC	PC			PC	PC	PC		PC	PC	PC			PC	PC	PC	PC
Inhalation of Volatile Emissions (Indoor Air)	PC				PC	PC				PC				PC	PC				
Inhalation of Volatile Emissions (Burrow Air)									PC										PC
Incidental Ingestion							PC									PC	PC		
Dermal Contact							PC									PC	PC		
Inhalation of Volatile Emissions (Outdoor Air)							PC									PC	PC		
Inhalation of Volatile Emissions (Indoor Air)					PC	PC								PC	PC				
Direct Radiation							PC									PC	PC		
Ingestion as Potable Water	PC									PC									
Dermal Contact via Working/Bathing	PC									PC									
Inhalation of Volatile Emissions via Bathing	PC									PC									
Ingestion as Potable Water					PC	PC								PC	PC		PC		
Dermal Contact via Working/Bathing					PC	PC								PC	PC		PC		
Inhalation of Volatile Emissions via Bathing					PC	PC								PC	PC		PC		
Ingestion as Potable Water	PC									PC									
Dermal Contact via Working/Bathing	PC									PC									
Inhalation of Volatile Emissions via Bathing	PC									PC									
Ingestion as Potable Water					PC	PC								PC	PC		PC		
Dermal Contact via Working/Bathing					PC	PC								PC	PC		PC		
Inhalation of Volatile Emissions via Bathing					PC	PC								PC	PC		PC		

NOTES:

1. EXCLUDES WIND TRANSPORT (ASSUMED PART OF OU-1)
2. THE CSM WILL BE UPDATED BASED ON THE RESULTS OF THE PROPOSED OU-3 RI ACTIVITIES PRIOR TO THE BASELINE RISK ASSESSMENT
3. ☐ - NOT APPLICABLE OR NEGLIGIBLE
4. PC - POTENTIALLY COMPLETE EXPOSURE PATHWAY SUBJECT TO FURTHER QUALITATIVE OR QUANTITATIVE ASSESSMENT AND REFINEMENT IN THE BASELINE RISK ASSESSMENT ACCORDING TO THE INFORMATION OBTAINED FROM THE PROPOSED OU-3 RI ACTIVITIES
5. OU - OPERABLE UNIT
6. RI - REMEDIAL INVESTIGATION
7. RIM - RADIOLOGICALLY IMPACTED MATERIAL

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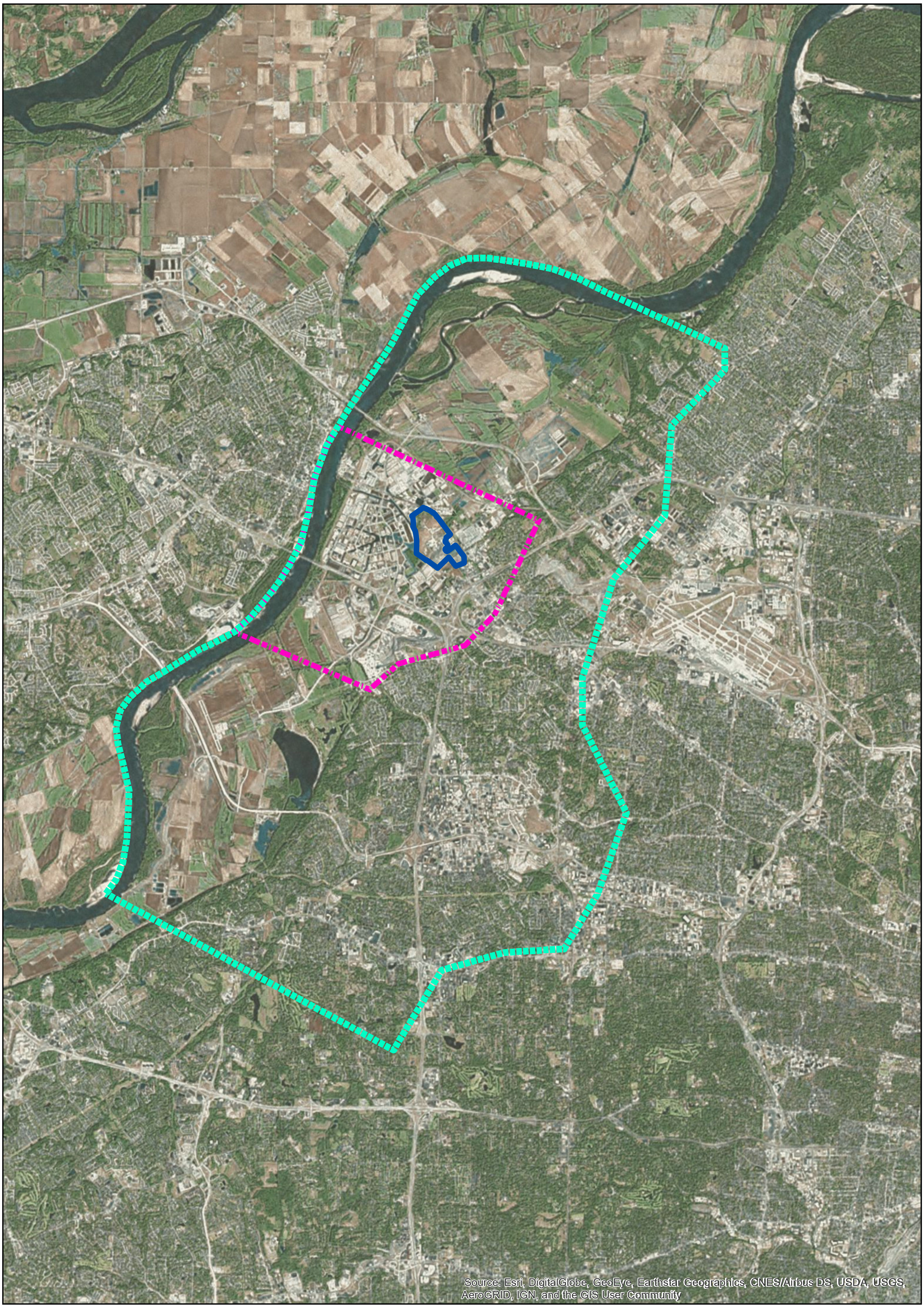
FIGURE 3-16

PRELIMINARY CONCEPTUAL SITE MODEL

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITIY STUDY
WORK PLAN

Drawn By: JLP	Checked By: AR	Scale: NONE	Date: 4/20/20	File: 63N-RIFSWP_CSMCHART_202004



EXPLANATION

- STUDY AREA
- PRELIMINARY GROUNDWATER MODELING DOMAIN
- SUPERFUND SITE BOUNDARY

N

0 8,000 '

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FIGURE 3-17

OU-3 STUDY AREA AND PRELIMINARY GROUNDWATER MODELING DOMAIN

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: WC	Scale: 1 " = 8,000 '	Date: 4/21/20	File: 3-17_OU-3_Fig3-17.mxd

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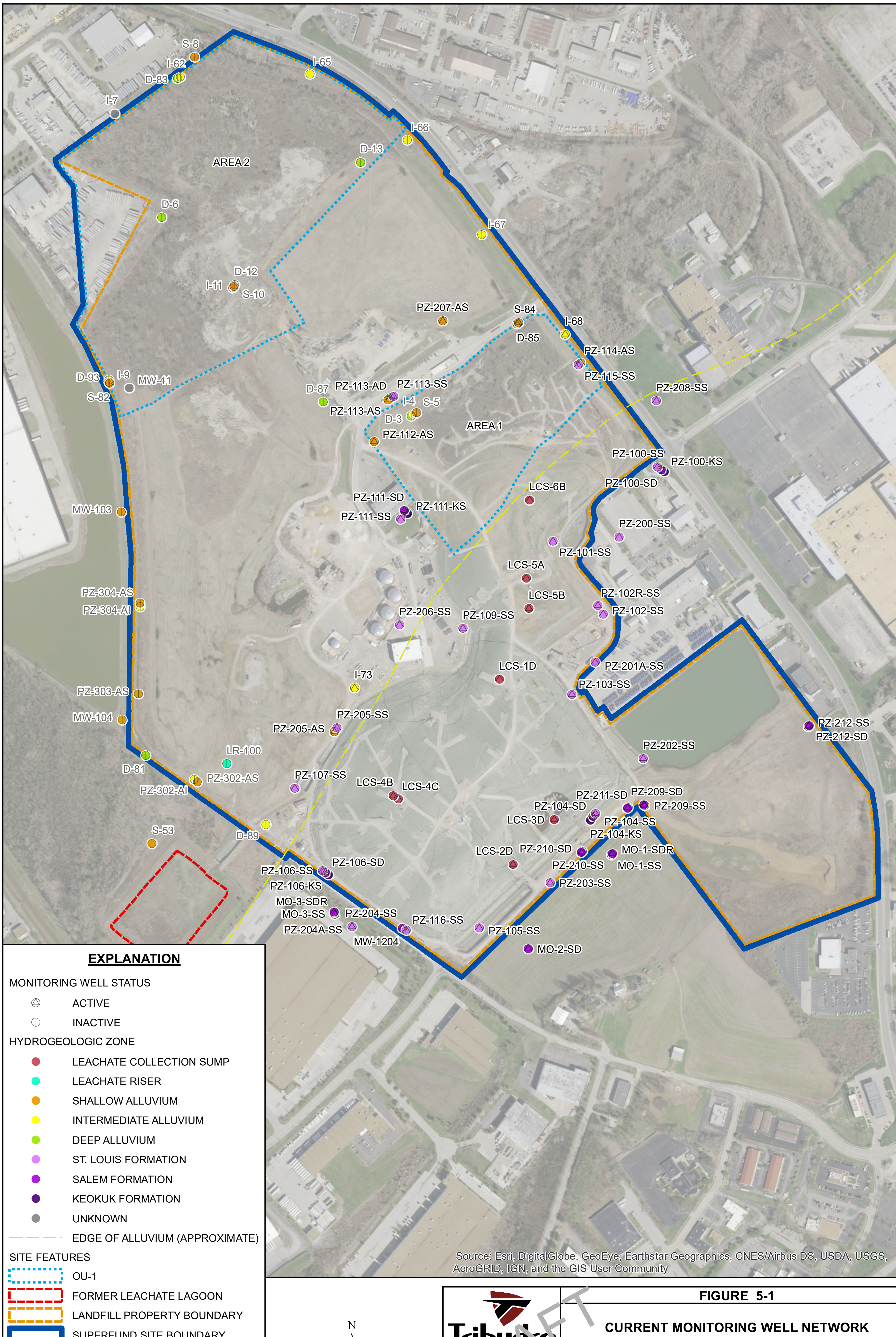

NOTE:

THE LOCATION OF MW-1201 UNKNOWN AND IS NOT DISPLAYED

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FIGURE 5-1

CURRENT MONITORING WELL NETWORK

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 500 '	Date: 4/17/20	File: 5-1_MWNetwork_Fig5-1.mxd

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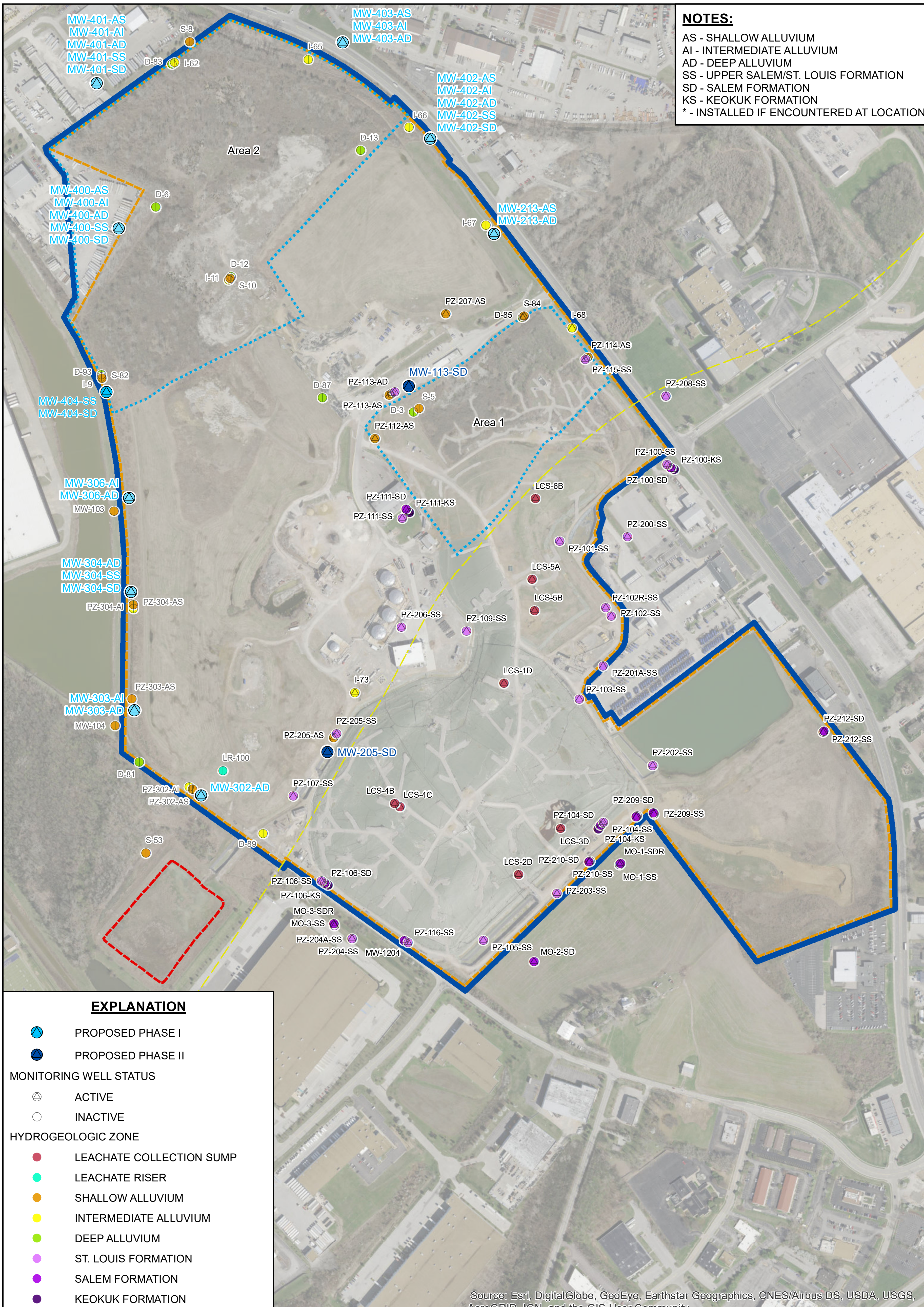

NOTES:

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST. LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED PHASE I
PROPOSED PHASE II

MONITORING WELL STATUS
ACTIVE
INACTIVE

HYDROGEOLOGIC ZONE
LEACHATE COLLECTION SUMP
LEACHATE RISER
SHALLOW ALLUVIUM
INTERMEDIATE ALLUVIUM
DEEP ALLUVIUM
ST. LOUIS FORMATION
SALEM FORMATION
KEOKUK FORMATION
UNKNOWN
EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES
OU-1
FORMER LEACHATE LAGOON
LANDFILL PROPERTY BOUNDARY
SUPERFUND SITE BOUNDARY

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FIGURE 5-2

PROPOSED ON-SITE AND NEAR-SITE MONITORING WELLS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 500 '	Date: 4/22/20	File: 5-2_On-SiteMW_Fig5-2.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-2_ON-SITEMW_FIG5-2.MXD

EXPLANATION

PROPOSED OFF-SITE MONITORING WELL	
MONITORING WELL STATUS	
ACTIVE	
INACTIVE	
EDGE OF ALLUVIUM (APPROXIMATE)	
SITE FEATURES	
OU-1	
FORMER LEACHATE LAGOON	
LANDFILL PROPERTY BOUNDARY	
SUPERFUND SITE BOUNDARY	

HYDROGEOLOGIC ZONE

- LEACHATE COLLECTION SUMP
- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST. LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION
- UNKNOWN

NOTES:

1. PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES OR LACK OF ACCESS BY LANDOWNERS
2. 500-SERIES BEDROCK WELLS INSTALLED DURING PHASE II
3. DEFINITIONS:
   AS - SHALLOW ALLUVIUM
   AI - INTERMEDIATE ALLUVIUM
   AD - DEEP ALLUVIUM
   SS - UPPER SALEM/ST. LOUIS FORMATION
   SD - SALEM FORMATION
   KS - KEOKUK FORMATION

* - INSTALLED IF ENCOUNTERED AT LOCATION

N

0 800 '

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FIGURE 5-3

PROPOSED OFF-SITE MONITORING WELLS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 800 '	Date: 4/22/20	File: 5-3_Off-SiteMW_Fig5-3.mxd

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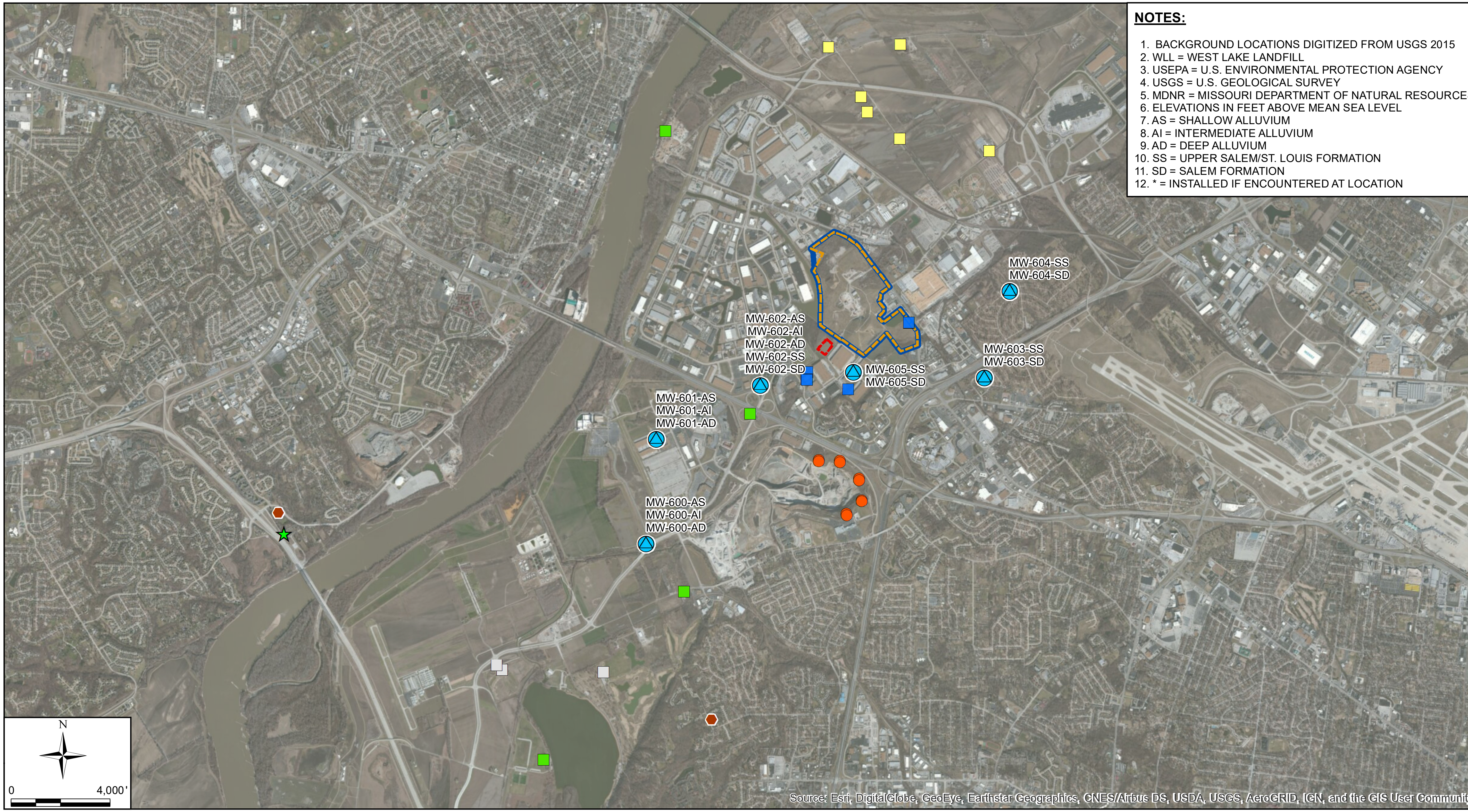

NOTES:

1. BACKGROUND LOCATIONS DIGITIZED FROM USGS 2015
2. WLL = WEST LAKE LANDFILL
3. USEPA = U.S. ENVIRONMENTAL PROTECTION AGENCY
4. USGS = U.S. GEOLOGICAL SURVEY
5. MDNR = MISSOURI DEPARTMENT OF NATURAL RESOURCES
6. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
7. AS = SHALLOW ALLUVIUM
8. AI = INTERMEDIATE ALLUVIUM
9. AD = DEEP ALLUVIUM
10. SS = UPPER SALEM/ST. LOUIS FORMATION
11. SD = SALEM FORMATION
12. * = INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED BACKGROUND MONITORING WELL

USGS BACKGROUND DATA SOURCE

WLL RESPONDENTS 2013 SAMPLE

USEPA 2013 ALLUVIAL WELL SAMPLE

USGS-RP 2013 ALLUVIAL WELL SAMPLE

USGS-RP 2013 BEDROCK SAMPLE

MDNR CHAMP LANDFILL EXPANSION SAMPLE

HISTORICAL USGS DATA

MDNR PUBLIC-DRINKING WATER BRANCH

FORMER LEACHATE LAGOON

LANDFILL PROPERTY BOUNDARY

SUPERFUND SITE BOUNDARY

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FIGURE 5-4a

PROPOSED BACKGROUND MONITORING WELLS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 4,000 '	Date: 4/17/20	File: 5-4a_BGMW_Fig5-4a.mxd

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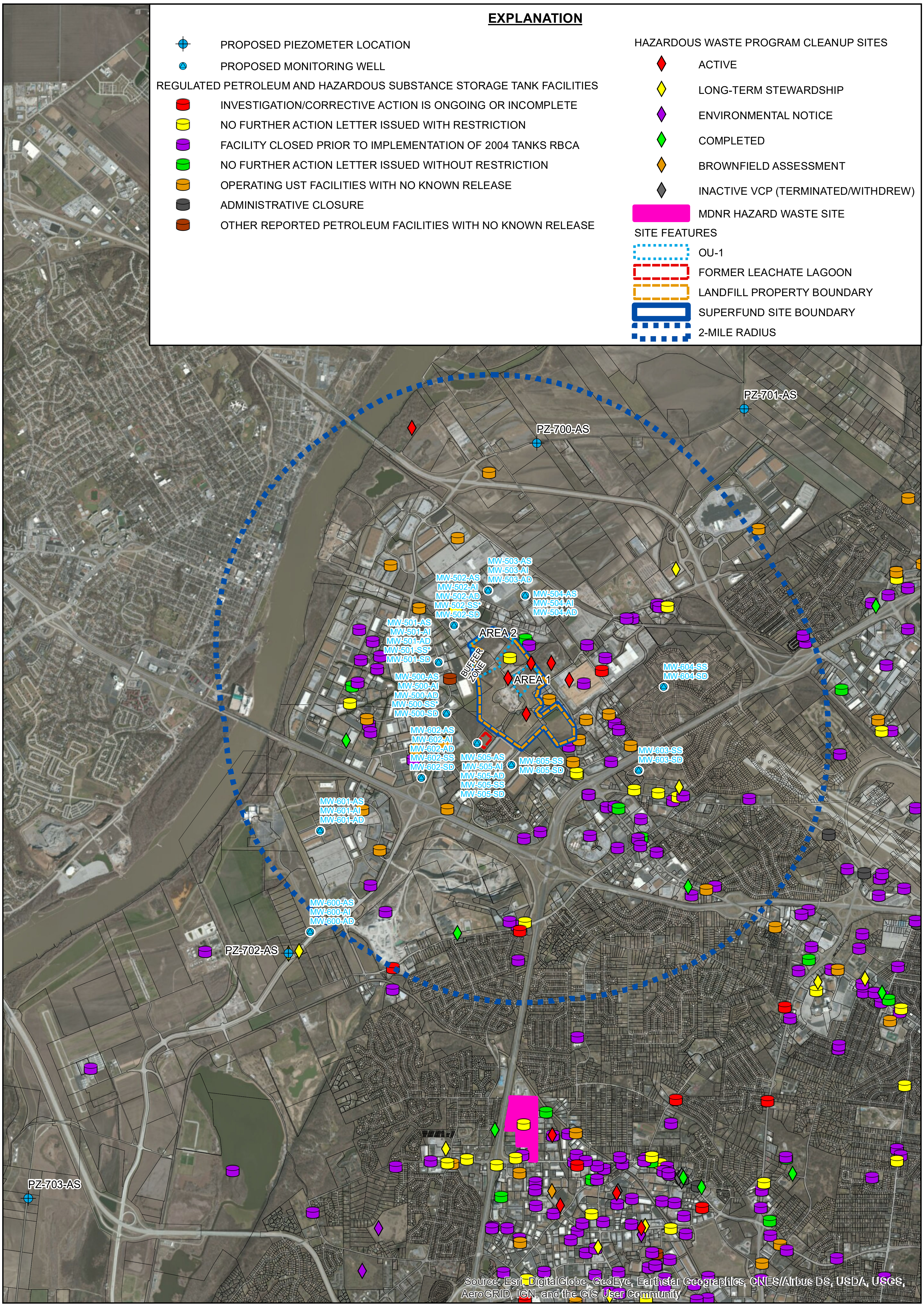

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-4B_PROPWELLS_MDNR_FIG5-4B.MXD

NOTES:

1. MDNR - MISSOURI DEPARTMENT OF NATURAL RESOURCES
2. CLEANUP SITES AND TANK LOCATION DATA DOWNLOADED FROM MDNR SITE (03/11/2020)
3. RBCA - RISK BASED CORRECTIVE ACTION

N

0 3,000 Feet

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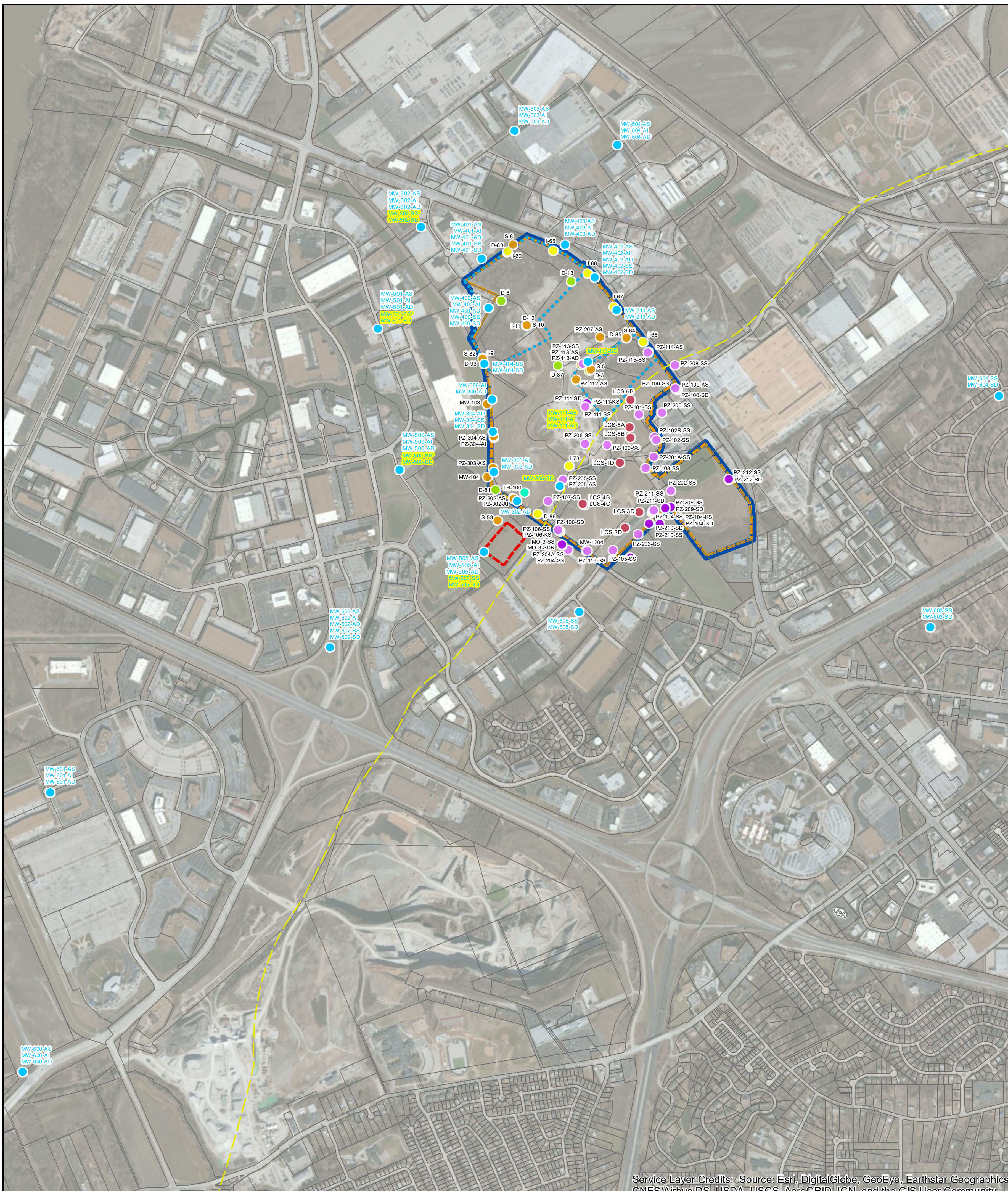
FIGURE 5-4b

PROPOSED WELL/PIEZOMETER LOCATIONS AND MDNR SITES

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: KEJ	Checked By: DC	Scale: 1 " = 4,000 ft	Date: 4/18/20	File: 5-4b_PropWells_MDNR_Fig5-4b.mxd



EXPLANATION

- PROPOSED MONITORING WELL
- EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

- OU-1
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

HYDROGEOLOGIC ZONE

- LEACHATE COLLECTION SUMP
- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST. LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION

NOTES:

1. PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES OR LACK OF ACCESS BY LANDOWNERS
2. SEE FIGURE 5-5g FOR LOCATIONS OF PROPOSED PIEZOMETERS
3. HIGHLIGHTED WELLS PROPOSED TO BE INSTALLED DURING PHASE II AS OUTLINED IN WORK PLAN SECTION 4.3
4. DEFINITIONS:
   AS - SHALLOW ALLUVIUM
   AI - INTERMEDIATE ALLUVIUM
   AD - DEEP ALLUVIUM
   SS - UPPER SALEM/ST. LOUIS FORMATION
   SD - SALEM FORMATION
   KS - KEOKUK FORMATION

* - INSTALLED IF ENCOUNTERED AT LOCATION

N

0 1,600 '

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FIGURE 5-5a

PROPOSED MONITORING WELL NETWORK

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,600 '	Date: 4/22/20	File: 5-5a_RevMW_Fig5-5a.mxd

M:\WTO\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-5A_REVMW_FIG5-5A.MXD

EXPLANATION

- PROPOSED PHASE I WELL
- PROPOSED PHASE II WELL
- LEACHATE RISER
- SHALLOW ALLUVIAL WELL
- EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

- OU-1
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTES:

1. SEE FIGURE 5-5g FOR LOCATIONS OF PROPOSED PIEZOMETERS
2. LEACHATE RISERS SCREENED AT SIMILAR ELEVATIONS TO SHALLOW ALLUVIAL WELLS

N

0 1,500 '

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FIGURE 5-5b

PROPOSED AND EXISTING WELLS SHALLOW ALLUVIUM

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 4/22/20	File: 5-5b_MWAS_Fig5-5b.mxd

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FIGURE 5-5c

PROPOSED AND EXISTING WELLS INTERMEDIATE ALLUVIUM

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 4/22/20	File: 5-5c_MWAI_Fig5-5c.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-5D_MWAD_FIG5-5D.MXD

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FIGURE 5-5d

**PROPOSED AND EXISTING WELLS
DEEP ALLUVIUM**

**WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN**

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 4/22/20	File: 5-5d_MWAD_Fig5-5d.mxd

EXPLANATION

- PROPOSED PHASE I WELL
- PROPOSED PHASE II WELL
- LEACHATE COLLECTION SUMP
- ST. LOUIS FORMATION WELL
- EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

- OU-1
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

NOTES:

1. LEACHATE COLLECTION SUMPS SCREENED ACROSS SIMILAR ELEVATIONS TO BEDROCK WELLS

* - INSTALLED IF ENCOUNTERED AT LOCATION

N

0 1,500 '

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FIGURE 5-5e

PROPOSED AND EXISTING WELLS
ST. LOUIS/UPPER SALEM FORMATION

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 4/22/20	File: 5-5e_MWSS_Fig5e.mxd

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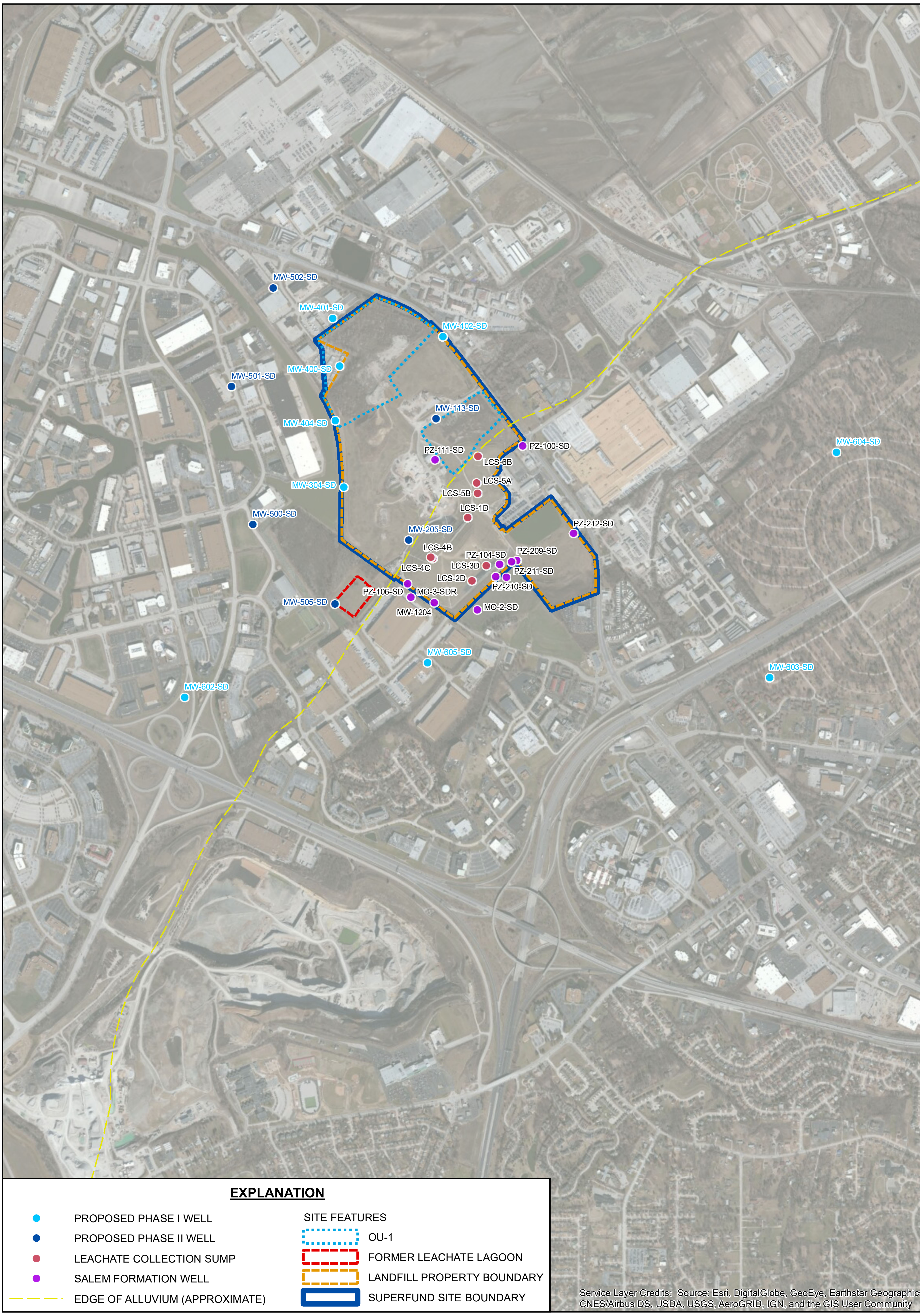

EXPLANATION

- PROPOSED PHASE I WELL
- PROPOSED PHASE II WELL
- LEACHATE COLLECTION SUMP
- SALEM FORMATION WELL
- EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

- OU-1
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

NOTES:

1. LEACHATE COLLECTION SUMPS SCREENED ACROSS SIMILAR ELEVATIONS TO BEDROCK WELLS

* - INSTALLED IF ENCOUNTERED AT LOCATION

N

0 1,500 '

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FIGURE 5-5f

PROPOSED AND EXISTING WELLS SALEM FORMATION

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 4/22/20	File: 5-5f_MWSD_Fig5f.mxd

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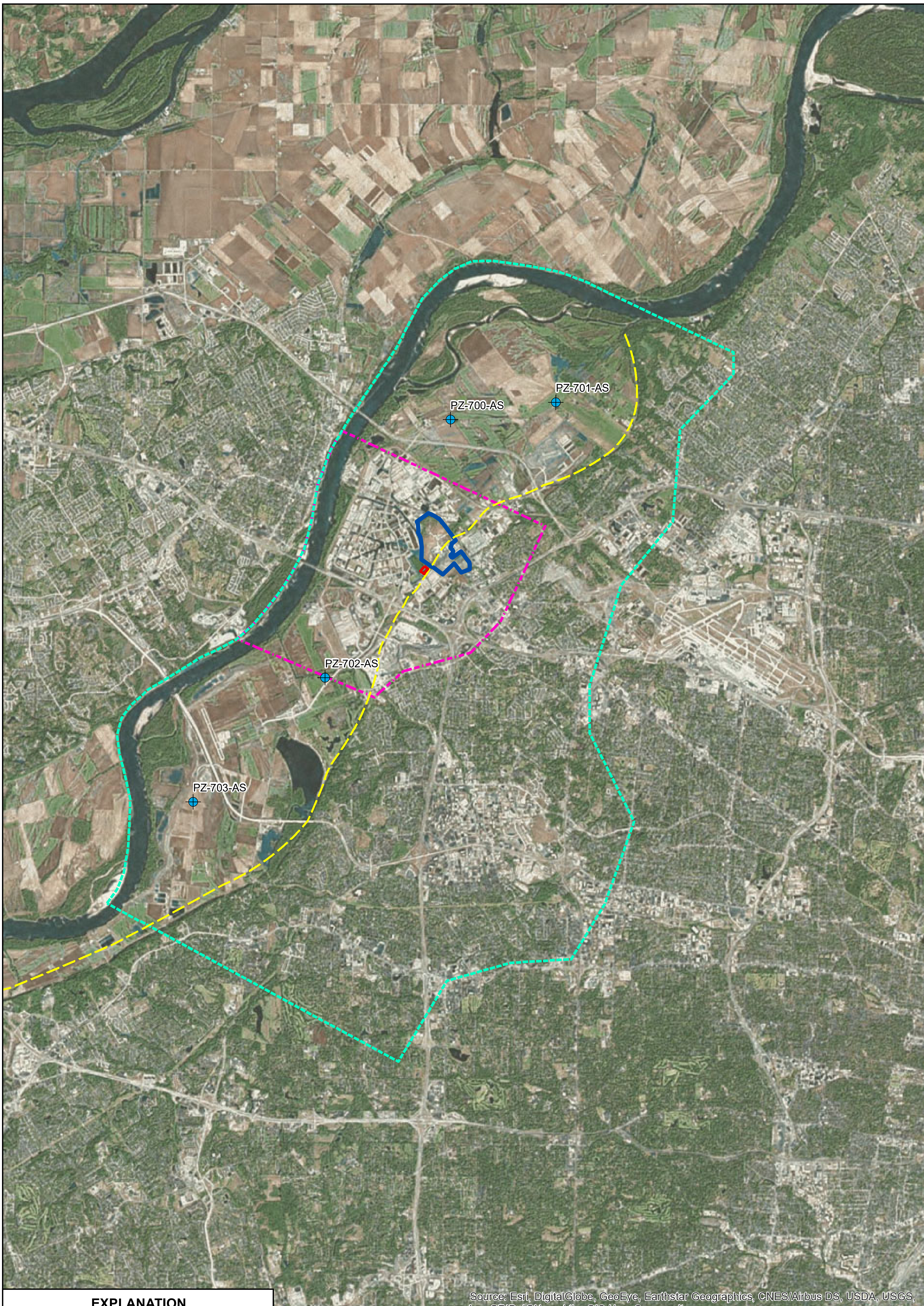

EXPLANATION

- PROPOSED PIEZOMETER LOCATION
- EDGE OF ALLUVIUM (APPROXIMATE)
- STUDY AREA
- PRELIMINARY GROUNDWATER MODELING DOMAIN
- FORMER LEACHATE LAGOON
- SUPERFUND SITE BOUNDARY

N

0 8,000 '

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FIGURE 5-5g

PROPOSED PIEZOMETER LOCATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: WC	Scale: 1 " = 8,000 '	Date: 4/17/20	File: 5-5g_PropPZ_Fig5g.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-5G_PROPPZ_FIG5G.MXD

EXPLANATION

- MISSOURI RIVER STAFF GAUGE - USGS06935965
- PROPOSED STAFF GAUGE
- FORMER LEACHATE LAGOON
- LANDFILL PROPERTY BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 3,000 '

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FIGURE 5-6

PROPOSED STAFF GAUGE LOCATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: AMR	Scale: 1 " = 3,000 '	Date: 4/8/20	File: 5-6_ProposedStaffGauge_Fig5-6.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-6_PROPOSEDSTAFFGAUGE_FIG5-6.MXD

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FIGURE 5-7

PROPOSED HYDRAULIC PROFILING TOOL TRANSECT

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

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Drawn By: MGS	Checked By: AMR	Scale: 1 " = 100 '	Date: 4/21/20	File: 5-7_ProposedHPT_Fig5-7.mxd

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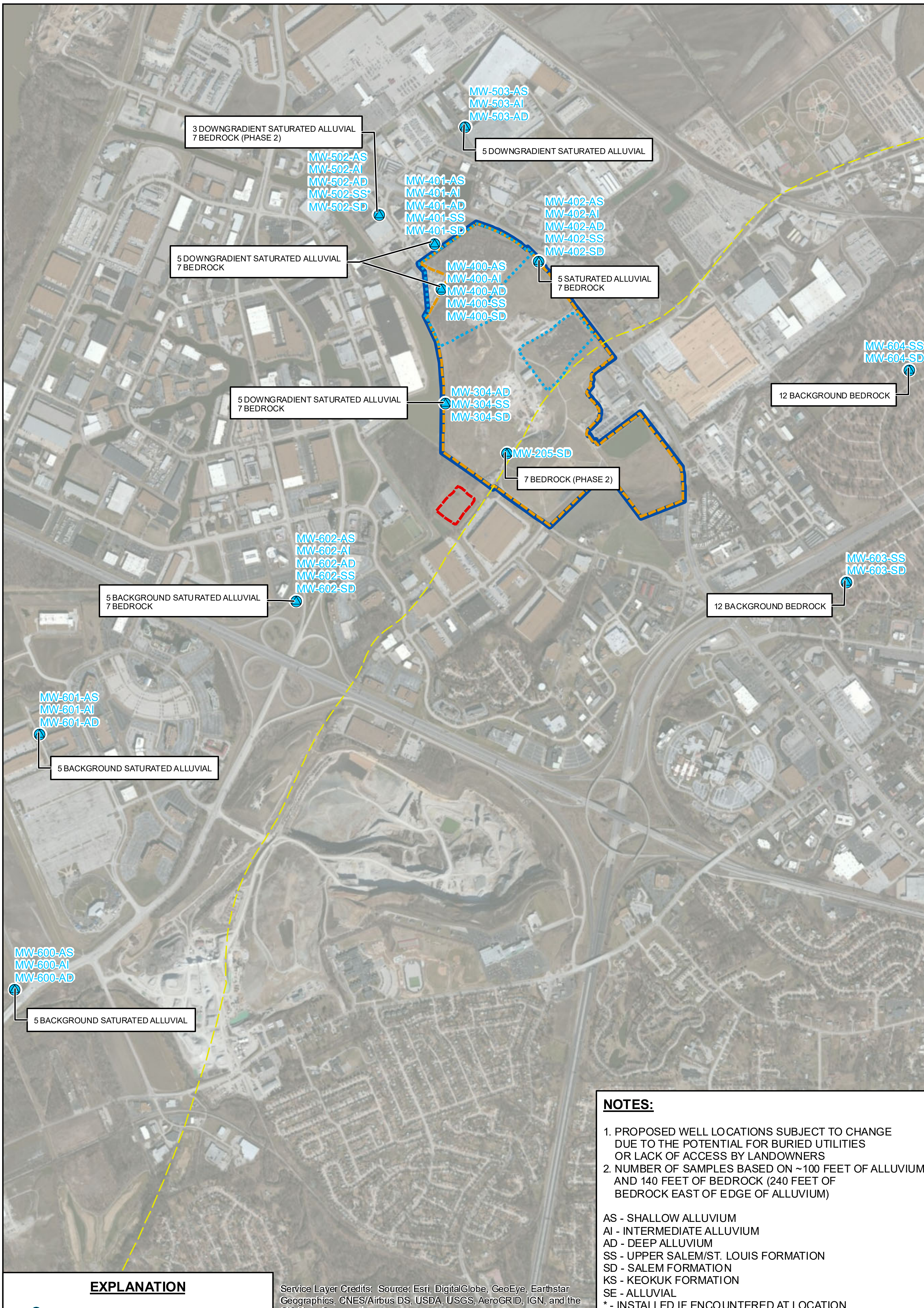

NOTES:

1. PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES OR LACK OF ACCESS BY LANDOWNERS
2. NUMBER OF SAMPLES BASED ON ~100 FEET OF ALLUVIUM AND 140 FEET OF BEDROCK (240 FEET OF BEDROCK EAST OF EDGE OF ALLUVIUM)

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST. LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
SE - ALLUVIAL
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED MONITORING WELL
EDGE OF ALLUVIUM (APPROXIMATE)
SITE FEATURES
OU-1
FORMER LEACHATE LAGOON
LANDFILL PROPERTY BOUNDARY
SUPERFUND SITE BOUNDARY

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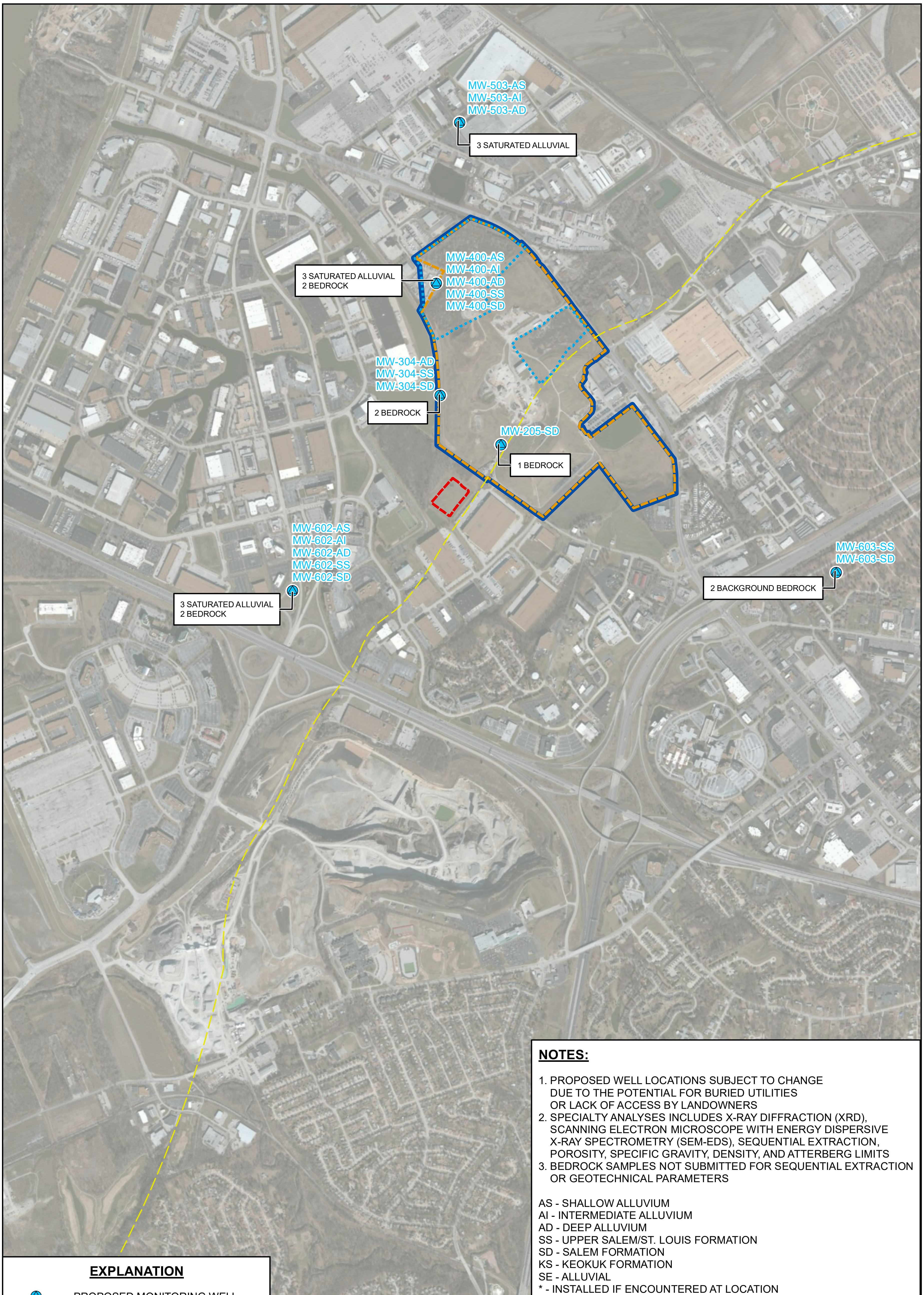
FIGURE 5-8a

ALLUVIAL/BEDROCK ANALYSES SAMPLE LOCATIONS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,600 '	Date: 4/22/20	File: 5-8a_SoilBedrockSamples_Fig5-8a.mxd



NOTES:

1. PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES OR LACK OF ACCESS BY LANDOWNERS
2. SPECIALTY ANALYSES INCLUDES X-RAY DIFFRACTION (XRD), SCANNING ELECTRON MICROSCOPE WITH ENERGY DISPERSIVE X-RAY SPECTROMETRY (SEM-EDS), SEQUENTIAL EXTRACTION, POROSITY, SPECIFIC GRAVITY, DENSITY, AND ATTERBERG LIMITS
3. BEDROCK SAMPLES NOT SUBMITTED FOR SEQUENTIAL EXTRACTION OR GEOTECHNICAL PARAMETERS

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST. LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
SE - ALLUVIAL
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED MONITORING WELL
EDGE OF ALLUVIUM (APPROXIMATE)
SITE FEATURES
OU-1
FORMER LEACHATE LAGOON
LANDFILL PROPERTY BOUNDARY
SUPERFUND SITE BOUNDARY

N

0 1,600 '

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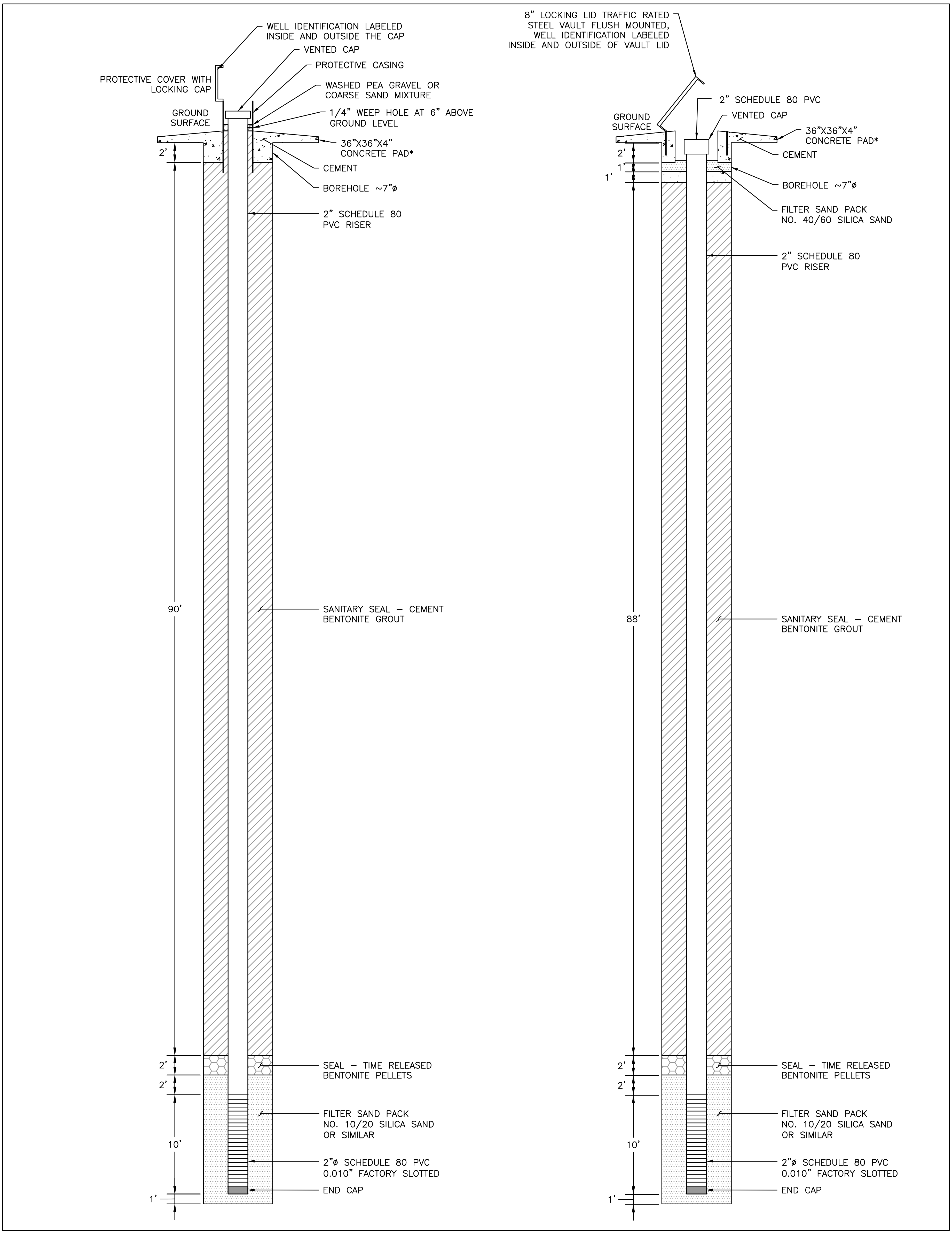
FIGURE 5-8b

SPECIALTY ANALYSES SAMPLE LOCATIONS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,600 '	Date: 4/22/20	File: 5-8b_MineralExtract_Fig5-8b.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GISMAPPING\202003_RIFS_WP\5-8B_MINERALEXTRACT_FIG5-8B.MXD



NOTES:

1. DRAWING IS SCALED VERTICALLY TO SHOW DEPTH. HORIZONTAL SCALE IS ADJUSTED TO SHOW FEATURES AND IS INDEPENDENT OF VERTICAL SCALE.
2. BGS = BELOW GROUND SURFACE
3. ACTUAL INTERVALS MAY VARY BASED ON FIELD CONDITIONS.
4. ALL MONITORING WELLS WILL BE CONSTRUCTED ACCORDING TO MISSOURI DEPARTMENT OF NATURAL RESOURCES MONITORING WELL CONSTRUCTION CODE (10 CSR 23-4) AND WILL BE PERMITTED PRIOR TO CONSTRUCTION WHERE APPLICABLE.
5. ALL MONITORING WELLS WILL BE INSTALLED BY A LICENSED WELL CONTRACTOR AND OVERSEEN BY AN ENVIRONMENTAL OR ENGINEERING ENTITY WITH A RESTRICTED MONITORING WELL CONTRACTOR'S PERMIT.
6. * = SURFACE COMPLETIONS ARE NOT TO SCALE

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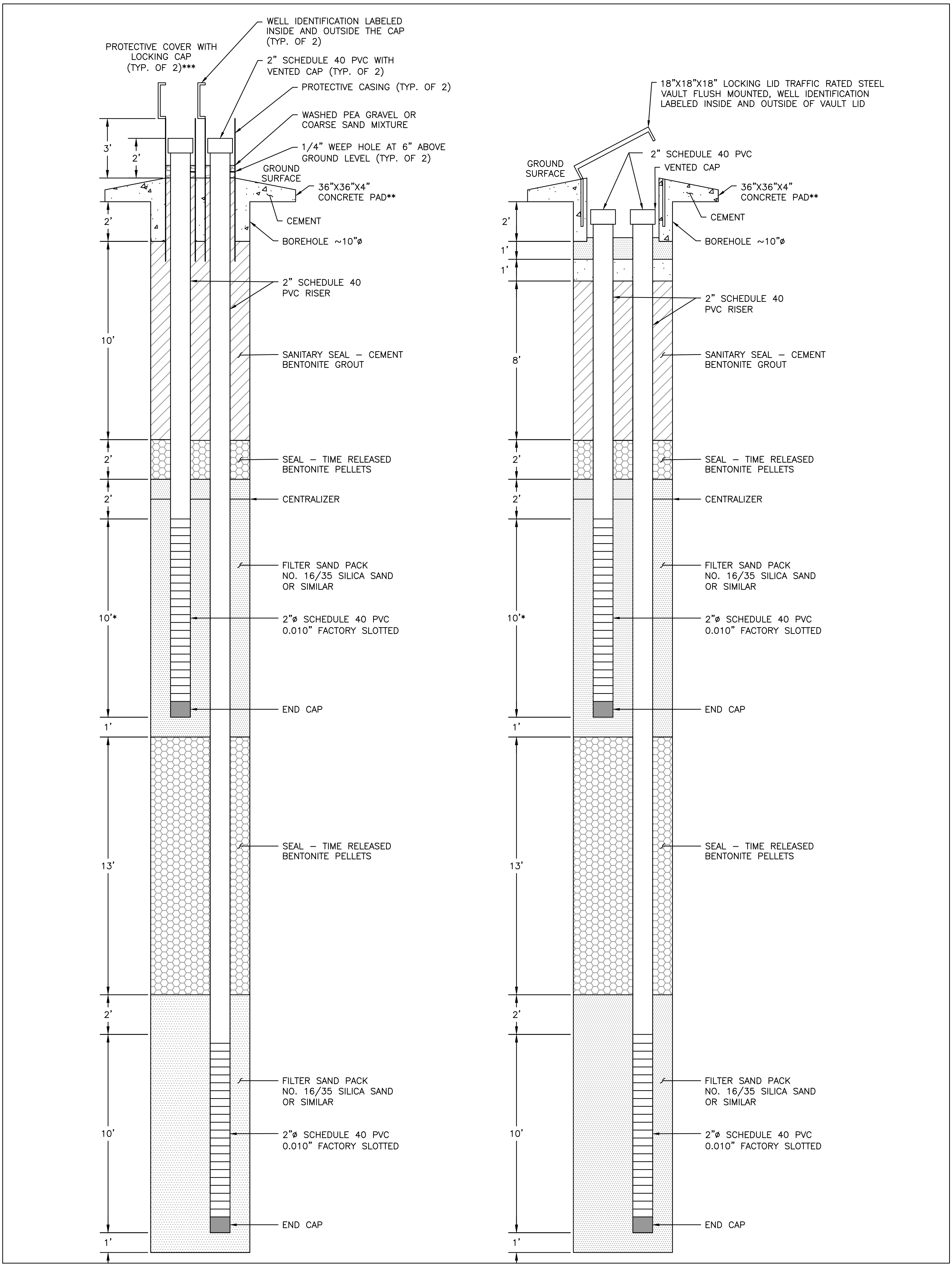
FIGURE 5-9a

EXAMPLE MONITORING WELL CONSTRUCTION DETAILS SINGLE ALLUVIAL AQUIFER MONITORING WELLS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DMB	Checked By: MGS	Scale: NONE	Date: 4/8/2020	File: 63N_MONWELLDETAIL202003

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL_ACP\CADD\SINGLEFIGURES\63N_MONWELLDETAIL202003



NOTES:

1. DRAWING IS SCALED VERTICALLY TO SHOW DEPTH. HORIZONTAL SCALE IS ADJUSTED TO SHOW FEATURES AND IS INDEPENDENT OF VERTICAL SCALE.
2. BGS = BELOW GROUND SURFACE
3. ACTUAL INTERVALS MAY VARY BASED ON FIELD CONDITIONS.
4. ALL MONITORING WELLS WILL BE CONSTRUCTED ACCORDING TO MISSOURI DEPARTMENT OF NATURAL RESOURCES MONITORING WELL CONSTRUCTION CODE (10 CSR 23-4) AND WILL BE PERMITTED PRIOR TO CONSTRUCTION WHERE APPLICABLE.
5. ALL MONITORING WELLS WILL BE INSTALLED BY A LICENSED WELL CONTRACTOR AND OVERSEEN BY AN ENVIRONMENTAL OR ENGINEERING ENTITY WITH A RESTRICTED MONITORING WELL CONTRACTOR'S PERMIT.
6. ** = SURFACE COMPLETIONS ARE NOT TO SCALE
7. *** = NESTED WELLS MAY BE CONSTRUCTED WITH AN ABOVE-GROUND VAULT SURFACE COMPLETION.

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FIGURE 5-9b

EXAMPLE MONITORING WELL CONSTRUCTION DETAILS NESTED ALLUVIAL AQUIFER MONITORING WELLS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DMB	Checked By: MGS	Scale: NONE	Date: 4/8/2020	File: 63N_MONWELLDETAIL202003

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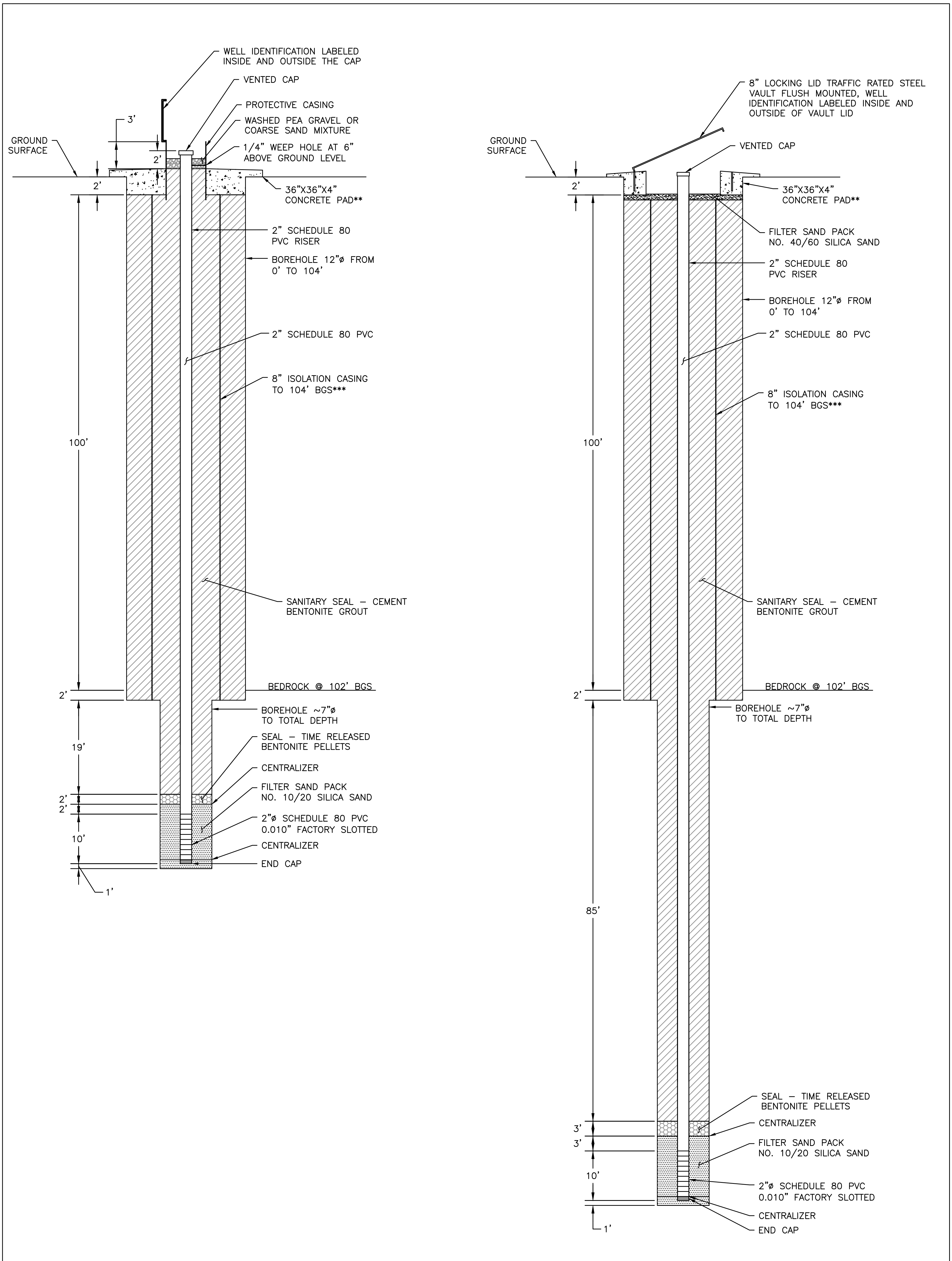

NOTES:

1. DRAWING IS SCALED VERTICALLY TO SHOW DEPTH. HORIZONTAL SCALE IS ADJUSTED TO SHOW FEATURES AND IS INDEPENDENT OF VERTICAL SCALE.
2. BGS = BELOW GROUND SURFACE
3. ACTUAL INTERVALS MAY VARY BASED ON FIELD CONDITIONS.
4. ALL MONITORING WELLS WILL BE CONSTRUCTED ACCORDING TO MISSOURI DEPARTMENT OF NATURAL RESOURCES MONITORING WELL CONSTRUCTION CODE (10 CSR 23-4) AND WILL BE PERMITTED PRIOR TO CONSTRUCTION WHERE APPLICABLE.
5. ALL MONITORING WELLS WILL BE INSTALLED BY A LICENSED WELL CONTRACTOR AND OVERSEEN BY AN ENVIRONMENTAL OR ENGINEERING ENTITY WITH A RESTRICTED MONITORING WELL CONTRACTOR'S PERMIT.
6. ** = SURFACE COMPLETION IS NOT TO SCALE
7. *** = 8" ISOLATION CASTING TO 2' BELOW BEDROCK SURFACE

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FIGURE 5-9c

EXAMPLE MONITORING WELL CONSTRUCTION DETAILS BEDROCK AQUIFER MONITORING WELLS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DMB	Checked By: MGS	Scale: NONE	Date: 4/8/2020	File: 63N_MONWELLDETAIL202003

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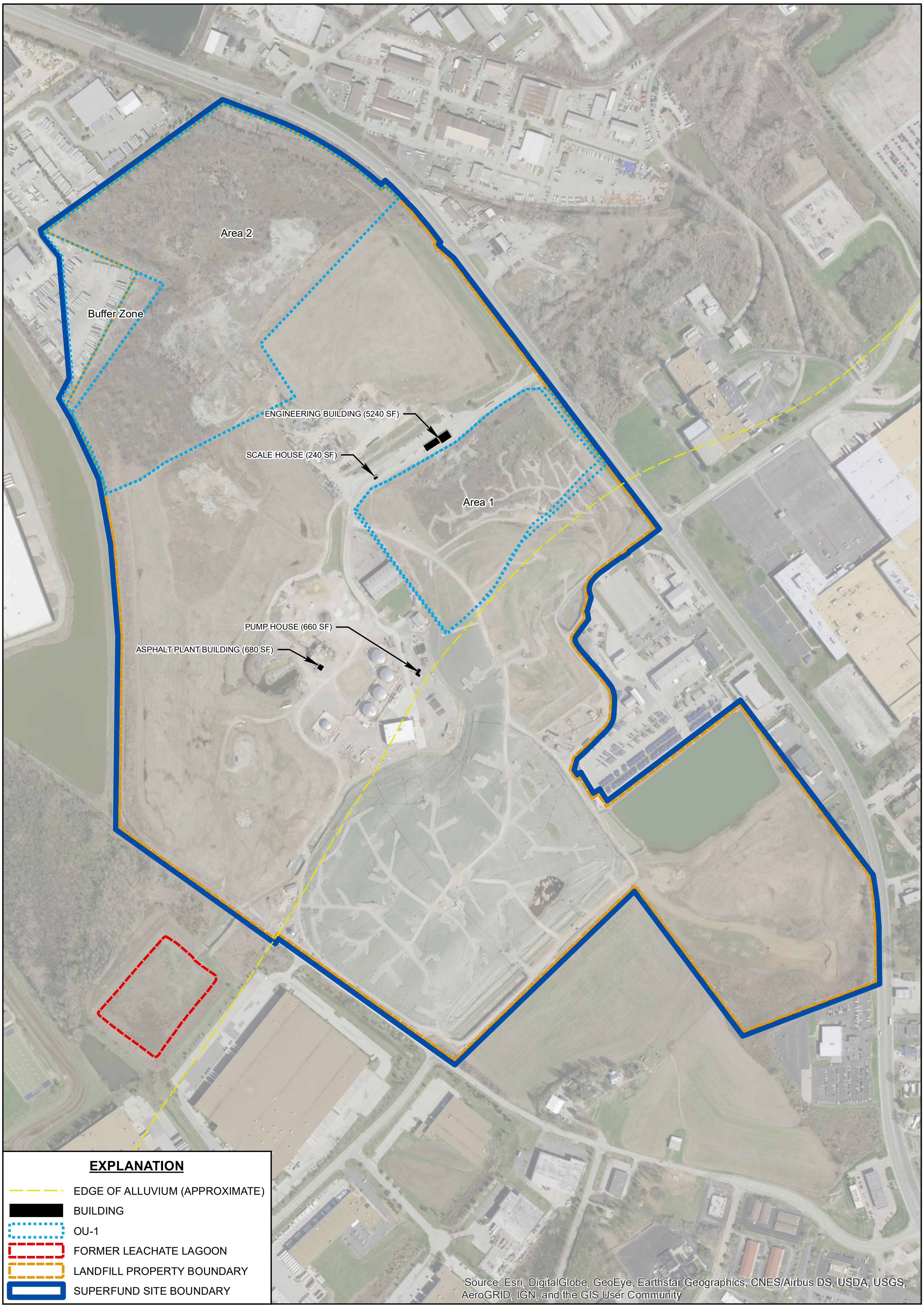

NOTES:

1. SF = SQUARE FEET
2. SCALE HOUSE EQUIPPED WITH SUBSLAB DEPRESSURIZATION SYSTEM
3. ENGINEERING OFFICE EQUIPPED WITH HVAC FAN FOR ODOR REMOVAL

N

0 500'

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FIGURE 5-10

VAPOR SAMPLING LOCATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: DH	Checked By: AR	Scale: 1 " = 500 '	Date: 4/21/20	File: 5-10_IndoorAirLoc_Fig5-10.mxd

M:\WTOZ\WESTLAKELANDFILL_ACP\GIS\MAPPING\202003_RIFS_WP\5-10_INDOORAIRLOC_FIG5-10.MXD

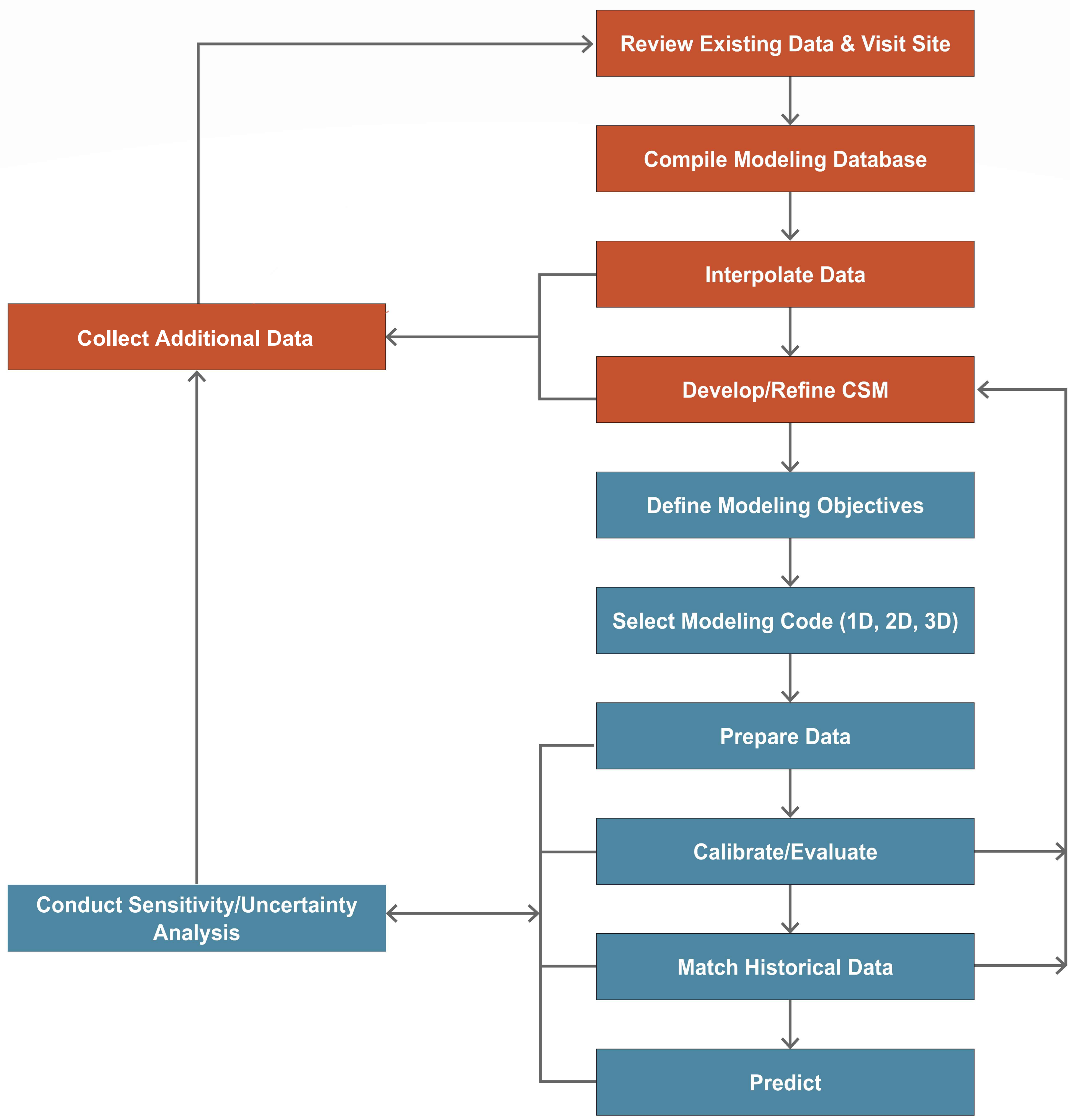

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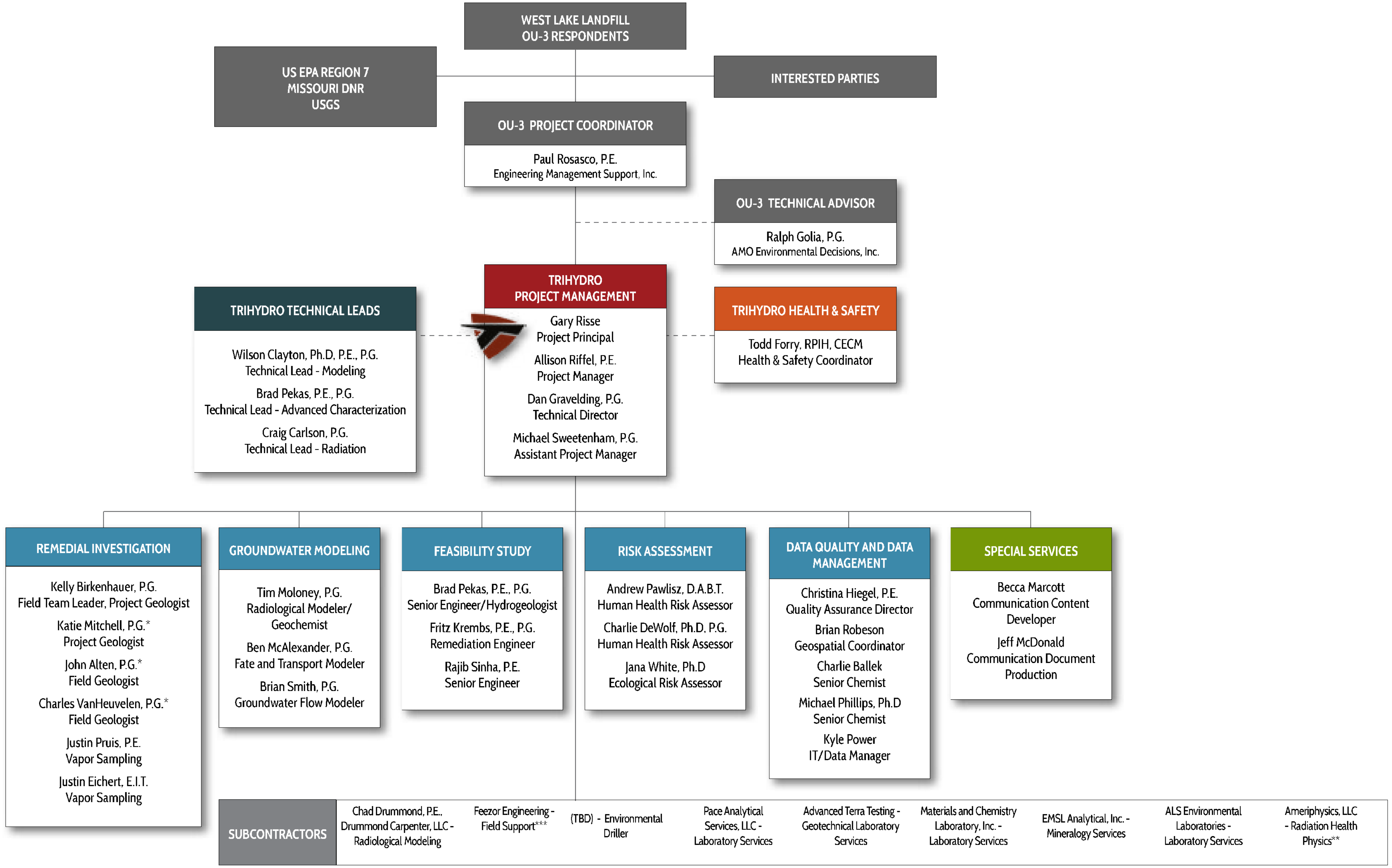
FIGURE 5-11

GROUNDWATER MODELING PROCESS FLOW DIAGRAM

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: REP	Checked By: MH	Scale: NONE	Date: 4/20/2020	File: 63N-RIFSWP_FLOWCHART_202004



NOTES:

US EPA - UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
DNR - DEPARTMENT OF NATURAL RESOURCES
USGS - UNITED STATES GEOLOGICAL SURVEY
OU-3 - OPERABLE UNIT 3
P.E. - PROFESSIONAL ENGINEER
P.G. - PROFESSIONAL GEOLOGIST
USACE - UNITED STATES ARMY CORPS OF ENGINEERS
RPIH - REGISTERED PROFESSIONAL INDUSTRIAL HYGIENIST
CECM - CERTIFIED ENVIRONMENTAL COMPLIANCE MANAGER
E.I.T - ENGINEER IN TRAINING
D.A.B.T - DIPLOMAT OF THE AMERICAN BOARD OF TOXICOLOGY
PH.D - DOCTOR OF PHILOSOPHY
TBD - TO BE DETERMINED
IT - INFORMATION TECHNOLOGY
LLC - LIMITED LIABILITY COMPANY
* MAY SERVE AS SITE QUALITY CONTROL OFFICER AND/OR SITE HEALTH AND SAFETY OFFICER AT ANYTIME.
** RADIATION SAFETY OFFICER AND RADIOLOGICAL CONTROL SUPERVISOR
*** RADIOLOGICAL CONTROL SUPERVISOR

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FIGURE 10-1

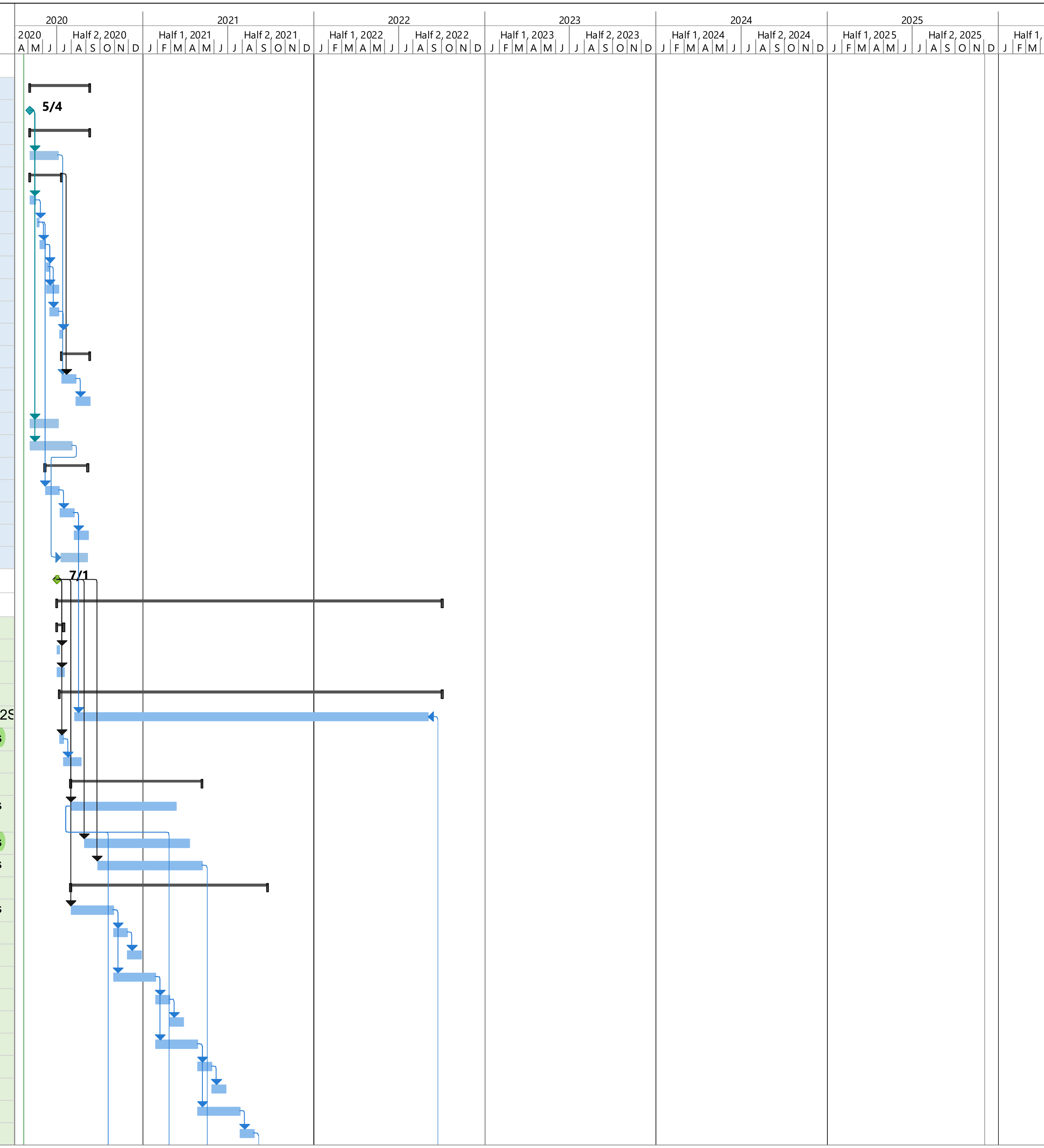
PROJECT ORGANIZATIONAL CHART

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: KEJ	Checked By: MS		Date: 4/22/20	File: 10-1_OrgChart_Fig10-1.mxd

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**OU-3 RI/FS Order Effective Date**	**0 days**	**Wed 2/6/19**	**Wed 2/6/19**	
2		**Initial Tasks**	**92 days**	**Mon 5/4/20**	**Tue 9/8/20**	
3		**Initial Tasks Start Date**	**0 days**	**Mon 5/4/20**	**Mon 5/4/20**	
4		**Well Inventory**	**92 days**	**Mon 5/4/20**	**Tue 9/8/20**	
5		Offsite Well Inventory (MDNR/EDR/Water Records Research)	60 edays	Mon 5/4/20	Fri 7/3/20	3
6		Onsite Well Inventory (80 Existing Wells)	50 days	Mon 5/4/20	Fri 7/10/20	
7		Field Preparation	10 days	Mon 5/4/20	Fri 5/15/20	3
8		Fluid Levels and Total Depths	5 days	Mon 5/18/20	Fri 5/22/20	7
9		Sediment Removal	10 days	Mon 5/25/20	Fri 6/5/20	8
10		Downhole Camera Inspection	5 days	Mon 6/8/20	Fri 6/12/20	9
11		Well Redevelopment	20 days	Mon 6/8/20	Fri 7/3/20	9
12		Well Repair	15 days	Mon 6/15/20	Fri 7/3/20	10
13		Well Survey	5 days	Mon 7/6/20	Fri 7/10/20	12
14		Prepare Well Inventory Report	42 days	Fri 7/10/20	Tue 9/8/20	
15		Draft Report	30 edays	Fri 7/10/20	Sun 8/9/20	5,6
16		USEPA Review	30 edays	Sun 8/9/20	Tue 9/8/20	15
17		Apply For Well Permits	60 edays	Mon 5/4/20	Fri 7/3/20	3
18		Access Agreements	90 edays	Mon 5/4/20	Sun 8/2/20	3
19		Monthly Fluid Levels (Existing Wells, Leachate, Surface Water)	65 days	Fri 6/5/20	Fri 9/4/20	
20		June 2020	29 edays	Fri 6/5/20	Sat 7/4/20	8FS+10 days
21		July 2020	30 edays	Mon 7/6/20	Wed 8/5/20	20FS+1 day
22		Prepare Potentiometric Surface Contour Maps	30 edays	Wed 8/5/20	Fri 9/4/20	21
23		Staff Gauge Installation	40 days	Thu 7/9/20	Wed 9/2/20	18FS-17 days
24		**OU-3 RI/FS Work Plan - USEPA Approval**	**0 days**	**Wed 7/1/20**	**Wed 7/1/20**	
25		**OU-3 RI Implementation**	**588 days**	**Wed 7/1/20**	**Sat 10/1/22**	
26		**Prepatory Activities**	**11 days**	**Wed 7/1/20**	**Thu 7/16/20**	
27		Notifications	5 edays	Wed 7/1/20	Mon 7/6/20	24
28		Subcontracting	15 edays	Wed 7/1/20	Thu 7/16/20	24
29		**Field Activities**	**585 days**	**Mon 7/6/20**	**Sat 10/1/22**	
30		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water)	540 days	Fri 8/7/20	Thu 9/1/22	21FS+1 day,72S
31		HPT Pilot Test (4)	8 edays	Mon 7/6/20	Tue 7/14/20	24FS+5 edays
32		HPT Assessment at Proposed Drilling Locations (19)	38 edays	Tue 7/14/20	Fri 8/21/20	31
33		**Well Installation**	**200 days**	**Fri 7/31/20**	**Thu 5/6/21**	
34		Install Phase I Wells (65) and Phase II Wells (17), Aquifer Matrix Sampling, Geophysical Logging, Packer Testing	160 days	Fri 7/31/20	Thu 3/11/21	24FS+22 days
35		Well Development	160 days	Fri 8/28/20	Thu 4/8/21	24FS+42 days
36		Slug Testing	160 days	Fri 9/25/20	Thu 5/6/21	24FS+62 days
37		**Onsite Vapor Sampling and Evaluation**	**300 days**	**Thu 7/30/20**	**Thu 9/23/21**	
38		Onsite Indoor Air Sampling 1	90 edays	Thu 7/30/20	Wed 10/28/20	24FS+22 days
39		Vapor Laboratory Analysis	30 edays	Wed 10/28/20	Fri 11/27/20	38
40		Vapor Data Validation	30 edays	Fri 11/27/20	Sun 12/27/20	39
41		Onsite Indoor Air Sampling 2	90 edays	Wed 10/28/20	Tue 1/26/21	38
42		Vapor Laboratory Analysis	30 edays	Tue 1/26/21	Thu 2/25/21	41
43		Vapor Data Validation	30 edays	Thu 2/25/21	Sat 3/27/21	42
44		Onsite Indoor Air Sampling 3	90 edays	Tue 1/26/21	Mon 4/26/21	41
45		Vapor Laboratory Analysis	30 edays	Mon 4/26/21	Wed 5/26/21	44
46		Vapor Data Validation	30 edays	Wed 5/26/21	Fri 6/25/21	45
47		Onsite Indoor Air Sampling 4	90 edays	Mon 4/26/21	Sun 7/25/21	44
48		Vapor Laboratory Analysis	30 edays	Sun 7/25/21	Tue 8/24/21	47



Schedule dependent on agency review times.
Deadlines in red font specified in the ASAOC.

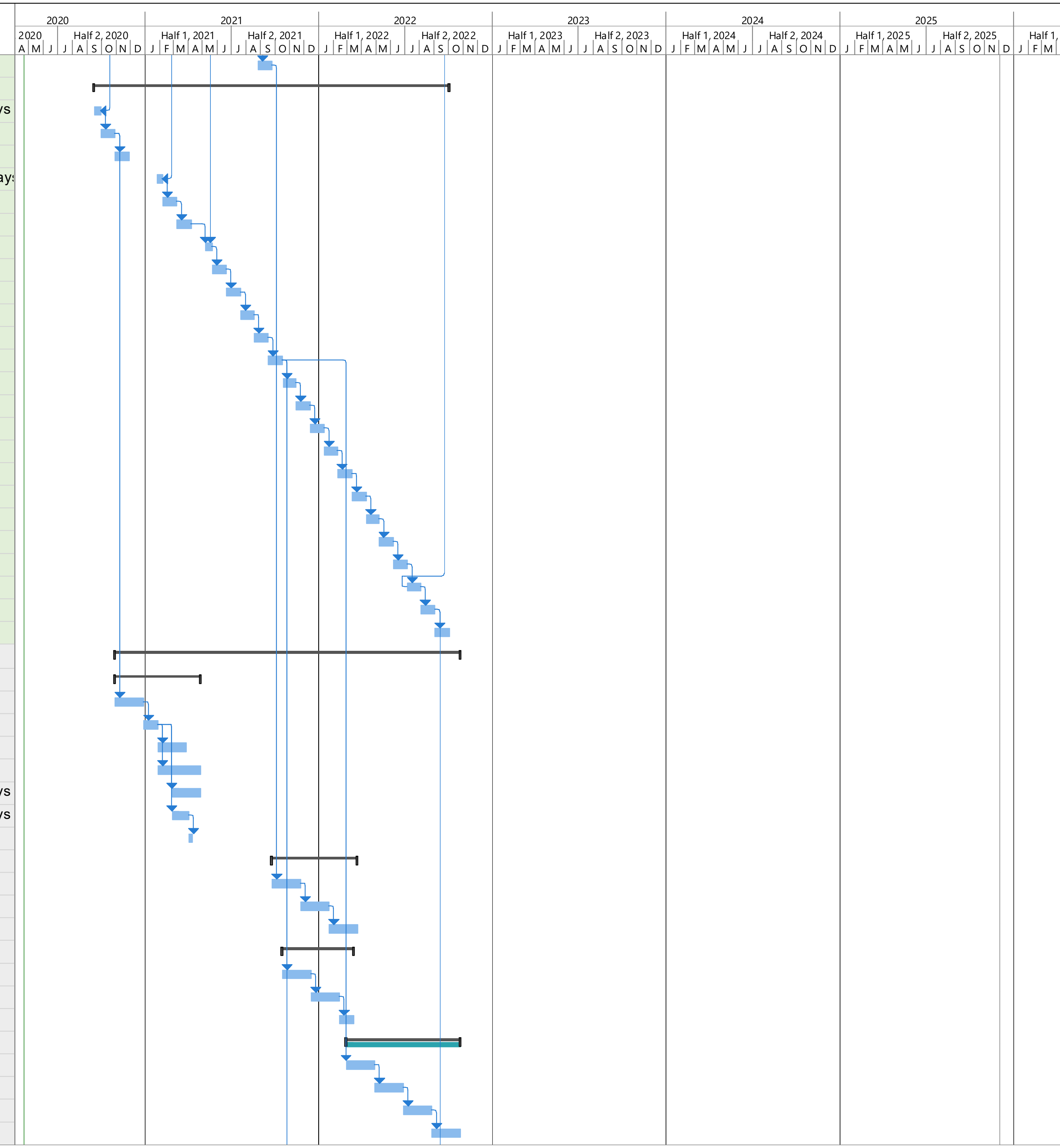
Task | Milestone | Summary | Manual Task | Deadline

Edays - Calendar
Days - Working Days
SLERA – Screening Level Ecological Risk Assessment
RI/FS – Remedial Investigation / Feasibility Study
Onsite Indoor Air Vapor Testing Duration 90 Days Based on Duration of Long-Term 90-Day Radon Test

Date: Wed 4/22/20

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
49		Vapor Data Validation	30 edays	Tue 8/24/21	Thu 9/23/21	48
50		**Quarterly Groundwater Sampling**	**534 days**	**Tue 9/15/20**	**Sat 10/1/22**	
51		Interim Groundwater Sampling 1	10 days	Tue 9/15/20	Tue 9/29/20	34SF+60 edays
52		Groundwater Laboratory Analysis	30 edays	Tue 9/29/20	Thu 10/29/20	51
53		Groundwater Data Validation	30 edays	Thu 10/29/20	Sat 11/28/20	52
54		Interim Groundwater Sampling 2	10 days	Mon 1/25/21	Sat 2/6/21	34SF+190 eday
55		Groundwater Laboratory Analysis	30 edays	Sat 2/6/21	Mon 3/8/21	54
56		Groundwater Data Validation	30 edays	Mon 3/8/21	Wed 4/7/21	55
57		Groundwater Sampling 3	10 days	Fri 5/7/21	Thu 5/20/21	36,56
58		Groundwater Laboratory Analysis	30 edays	Thu 5/20/21	Sat 6/19/21	57
59		Groundwater Data Validation	30 edays	Sat 6/19/21	Mon 7/19/21	58
60		Groundwater Sampling 4	20 days	Tue 7/20/21	Mon 8/16/21	59
61		Groundwater Laboratory Analysis	30 edays	Mon 8/16/21	Wed 9/15/21	60
62		Groundwater Data Validation	30 edays	Wed 9/15/21	Fri 10/15/21	61
63		Groundwater Sampling 5	20 days	Mon 10/18/21	Fri 11/12/21	62
64		Groundwater Laboratory Analysis	30 edays	Fri 11/12/21	Sun 12/12/21	63
65		Groundwater Data Validation	30 edays	Sun 12/12/21	Tue 1/11/22	64
66		Groundwater Sampling 6	20 days	Wed 1/12/22	Tue 2/8/22	65
67		Groundwater Laboratory Analysis	30 edays	Tue 2/8/22	Thu 3/10/22	66
68		Groundwater Data Validation	30 edays	Thu 3/10/22	Sat 4/9/22	67
69		Groundwater Sampling 7	20 days	Mon 4/11/22	Fri 5/6/22	68
70		Groundwater Laboratory Analysis	30 edays	Fri 5/6/22	Sun 6/5/22	69
71		Groundwater Data Validation	30 edays	Sun 6/5/22	Tue 7/5/22	70
72		Groundwater Sampling 8	20 days	Wed 7/6/22	Tue 8/2/22	71
73		Groundwater Laboratory Analysis	30 edays	Tue 8/2/22	Thu 9/1/22	72
74		Groundwater Data Validation	30 edays	Thu 9/1/22	Sat 10/1/22	73
75		**Addendum Activities**	**518 days**	**Thu 10/29/20**	**Mon 10/24/22**	
76		Additional Well Addendum	128 days	Thu 10/29/20	Tue 4/27/21	
77		Draft Additional Well Addendum	60 edays	Thu 10/29/20	Mon 12/28/20	52
78		USEPA Review	30 edays	Mon 12/28/20	Wed 1/27/21	77
79		Apply for Well Permits	60 edays	Wed 1/27/21	Sun 3/28/21	78
80		Access Agreements	90 edays	Wed 1/27/21	Tue 4/27/21	78
81		Install Step In/Step Out Wells	60 edays	Fri 2/26/21	Tue 4/27/21	78FS+30 edays
82		Install Piezometers for Aquifer Pumping Test	25 days	Fri 2/26/21	Thu 4/1/21	78FS+30 edays
83		Conduct Aquifer Pumping Test	5 days	Fri 4/2/21	Thu 4/8/21	82
84		**Vapor Intrusion Addendum**	**128 days**	**Thu 9/23/21**	**Tue 3/22/22**	
85		Draft Offsite Vapor Sampling Addendum	60 edays	Thu 9/23/21	Mon 11/22/21	49
86		USEPA Review	60 edays	Mon 11/22/21	Fri 1/21/22	85
87		Contingent - Vapor Field Tasks	60 edays	Fri 1/21/22	Tue 3/22/22	86
88		**Sediment/Surface Water Addendum**	**106 days**	**Fri 10/15/21**	**Mon 3/14/22**	
89		Draft Sediment/Surface Water Addendum	60 edays	Fri 10/15/21	Tue 12/14/21	62
90		USEPA Review	60 edays	Tue 12/14/21	Sat 2/12/22	89
91		Contingent - Sediment/Surface Water Field Tasks	30 edays	Sat 2/12/22	Mon 3/14/22	90
92		**SLERA Addendum**	171 days	Sat 2/26/22	Mon 10/24/22	
93		Draft SLERA Addendum	60 edays	Sat 2/26/22	Wed 4/27/22	62
94		USEPA Review	60 edays	Wed 4/27/22	Sun 6/26/22	93
95		Complete SLERA	60 edays	Sun 6/26/22	Thu 8/25/22	94
96		SLERA Report	60 edays	Thu 8/25/22	Mon 10/24/22	95



Schedule dependent on agency review times.
Deadlines in red font specified in the ASAOC.

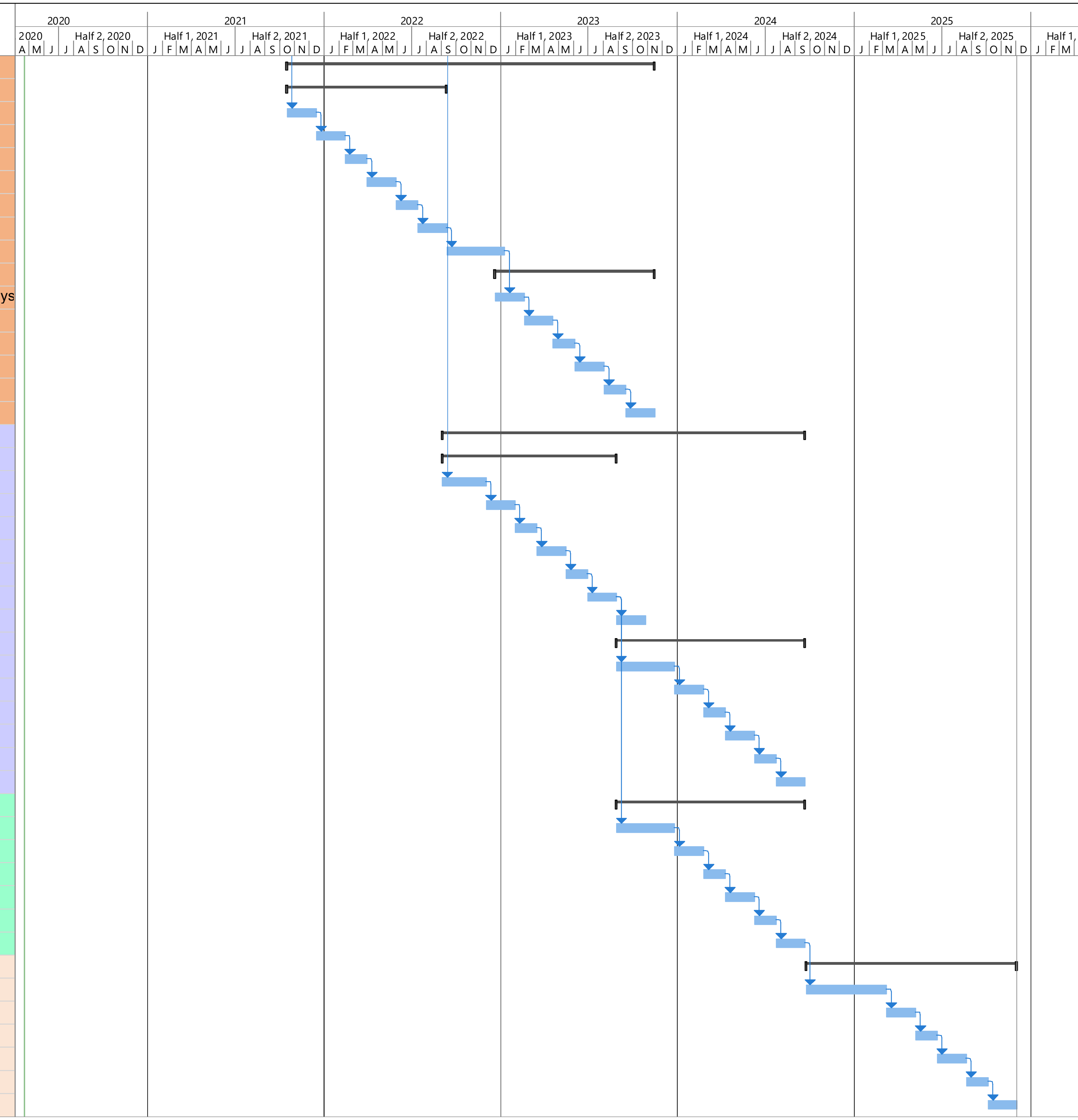
Task | Milestone | Summary | Manual Task | Deadline

Edays - Calendar
Days - Working Days
SLERA – Screening Level Ecological Risk Assessment
RI/FS – Remedial Investigation / Feasibility Study
Onsite Indoor Air Vapor Testing Duration 90 Days Based on Duration of Long-Term 90-Day Radon Test

Date: Wed 4/22/20

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
97		**Groundwater Modeling Work Plan, Simulations and Report**	**542 days**	**Fri 10/15/21**	**Tue 11/14/23**	
98		**Groundwater Modeling Work Plan**	**235 days**	Fri 10/15/21	Sat 9/10/22	
99		Draft Report	60 edays	Fri 10/15/21	Tue 12/14/21	62
100		USEPA Review	60 edays	Tue 12/14/21	Sat 2/12/22	99
101		Draft Final Report	45 edays	Sat 2/12/22	Tue 3/29/22	100
102		USEPA Review	60 edays	Tue 3/29/22	Sat 5/28/22	101
103		Final Report	45 edays	Sat 5/28/22	Tue 7/12/22	102
104		USEPA Approval	60 edays	Tue 7/12/22	Sat 9/10/22	103
105		**Conduct Groundwater Modeling Simulations**	**120 edays**	**Sat 9/10/22**	**Sun 1/8/23**	**104**
106		**Groundwater Modeling Report**	236 days	Mon 12/19/22	Tue 11/14/23	
107		Draft Report	60 edays	Mon 12/19/22	Fri 2/17/23	105FS-20 edays
108		USEPA Review	60 edays	Fri 2/17/23	Tue 4/18/23	107
109		Draft Final Report	45 edays	Tue 4/18/23	Fri 6/2/23	108
110		USEPA Review	60 edays	Fri 6/2/23	Tue 8/1/23	109
111		Final Report	45 edays	Tue 8/1/23	Fri 9/15/23	110
112		USEPA Approval	60 edays	Fri 9/15/23	Tue 11/14/23	111
113		**Baseline Risk Assessment**	**536 days**	**Thu 9/1/22**	**Fri 9/20/24**	
114		**Baseline Risk Assessment Work Plan**	**256 days**	**Thu 9/1/22**	**Sun 8/27/23**	
115		Draft Report	90 edays	Thu 9/1/22	Wed 11/30/22	73
116		USEPA Review	60 edays	Wed 11/30/22	Sun 1/29/23	115
117		Draft Final Report	45 edays	Sun 1/29/23	Wed 3/15/23	116
118		USEPA Review	60 edays	Wed 3/15/23	Sun 5/14/23	117
119		Final Report	45 edays	Sun 5/14/23	Wed 6/28/23	118
120		USEPA Approval	60 edays	Wed 6/28/23	Sun 8/27/23	119
121		**Conduct Baseline Risk Assessment**	**60 edays**	**Sun 8/27/23**	**Thu 10/26/23**	**120**
122		**Baseline Risk Assessment Report**	**280 days**	**Sun 8/27/23**	**Fri 9/20/24**	
123		Draft Report	120 edays	Sun 8/27/23	Mon 12/25/23	120
124		USEPA Review	60 edays	Mon 12/25/23	Fri 2/23/24	123
125		Draft Final Report	45 edays	Fri 2/23/24	Mon 4/8/24	124
126		USEPA Review	60 edays	Mon 4/8/24	Fri 6/7/24	125
127		Final Report	45 edays	Fri 6/7/24	Mon 7/22/24	126
128		USEPA Approval	60 edays	Mon 7/22/24	Fri 9/20/24	127
129		**RI Report**	**280 days**	**Sun 8/27/23**	**Fri 9/20/24**	
130		Draft Report	120 edays	Sun 8/27/23	Mon 12/25/23	120
131		USEPA Review	60 edays	Mon 12/25/23	Fri 2/23/24	130
132		Draft Final Report	45 edays	Fri 2/23/24	Mon 4/8/24	131
133		USEPA Review	60 edays	Mon 4/8/24	Fri 6/7/24	132
134		Final Report	45 edays	Fri 6/7/24	Mon 7/22/24	133
135		USEPA Approval	60 edays	Mon 7/22/24	Fri 9/20/24	134
136		**Feasibility Study**	**312 days**	**Mon 9/23/24**	**Tue 12/2/25**	
137		Draft Report	120 edays	Mon 9/23/24	Fri 3/7/25	135
138		USEPA Review	60 edays	Fri 3/7/25	Tue 5/6/25	137
139		Draft Final Report	45 edays	Tue 5/6/25	Fri 6/20/25	138
140		USEPA Review	60 edays	Fri 6/20/25	Tue 8/19/25	139
141		Final Report	45 edays	Tue 8/19/25	Fri 10/3/25	140
142		USEPA Approval	60 edays	Fri 10/3/25	Tue 12/2/25	141



Schedule dependent on agency review times.
Deadlines in red font specified in the ASAOC.

Task | Milestone | Summary | Manual Task | Deadline

Edays - Calendar Days
Days - Working Days
SLERA – Screening Level Ecological Risk Assessment
RI/FS – Remedial Investigation / Feasibility Study
Note: Duration for Indoor Air Sampling Based on 90-Day Radon Test

Date: Wed 4/22/20