Design Phase Investigation Work Plan

P-1 Plume Area
Former Emerson Street Landfill
NYSDEC Site #828023

Location:

1700 Emerson Street
Rochester, New York 14606

Prepared for:

City of Rochester
Division of Environmental Quality
Room 300-B
Rochester, New York 14614

LaBella Project No. 210173

August 2020

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CERTIFICATION

I Daniel P. Noll certify that I am currently a NYS registered professional engineer and that this Design Phase Investigation Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

_____081996_____ __8/21/2020__

NYS Professional Engineer # Date Signature

1. Introduction

This Design Phase Investigation was developed for the P-1 Plume located at 1700 Emerson Street (formerly 1655 Lexington Avenue) in the City of Rochester, Monroe County, New York on the Former Emerson Street Landfill (FESL) (refer to Figure 1). This work plan was completed in accordance with New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation (DER) *Technical Guidance for Site Investigation and Remediation* ("DER-10"). A Remedial Investigation (RI) was conducted from 2012-2017 which built upon previous investigations completed at the Site in the late 1980s, 1994 and 2001. LaBella completed a Feasibility Study dated April 2019. The NYSDEC issued a Proposed Remedial Action Plan (PRAP) dated February 2020 and a Record of Decision (ROD) dated March 2020. The selected remedy as detailed in the ROD includes the following:

a) Remedial Design
b) Site Cover
c) Vapor Mitigation
d) Zero Valent Iron (ZVI) Permeable Reactive Barrier (PRB)
e) Monitored Natural Attenuation (MNA)
f) Institutional Control
g) Site Management Plan

A Pilot Test was completed in 2017 which identified the need to relate the PRB further south from the source area. The purpose of this Design Phase Investigation is to supplement data collected during the pilot test in order to design the PRB including the type of ZVI and dosing, the length, width and depth of the PRB, and the injection method. A Remedial Action Work Plan (RAWP) will be developed following completion of this Design Phase Investigation. The RAWP will detail the elements of the remedy listed above as included in the ROD.

The City entered into an Order-On-Consent with the NYSDEC in 2009. A portion of the FESL is designated as Inactive Hazardous Waste Disposal Site (IHWDS) Site #828023. A majority of the FESL has been delisted from the IHWDS; however, three (3) parcels (1660, 1700, and 1740 Emerson Street) comprising approximately sixteen (16) acres are currently listed as a Class 3 site on the NYSDEC Registry of Inactive Hazardous Waste Disposal Sites (refer to Figure 2). A "3" classification indicates a site "at which contamination does not presently constitute significant threat to public health or the environment." The apparent source area is at the 1700 Emerson Street parcel which is the largest of the three (3) IHWDS parcels and is owned by the City.

2. Site Description and History

The FESL consists of approximately 250-acres of land comprised of 45 individual parcels of which 7 are owned by the City of Rochester (Refer to Figure 2 for FESL footprint). The remaining 38 parcels are owned by 25 private owners. The FESL is predominantly occupied by industrial and commercial properties (15 and 20, respectively based on use codes). The surrounding area generally contains industrial and commercial properties. Residential properties are also located off-Site to the

northeast. The three (3) parcels included in the IHWDS (1660, 1700, and 1740 Emerson Street) are zoned M-1, Industrial District.

The FESL was operated by the City as a landfill beginning between sometime in the 1940s until 1971. The landfill was used to dispose of ash derived from the incineration of municipal solid waste at the City's incinerators which were located south of Emerson Street and east of Colfax Street on the FESL. Ash fill and construction and demolition debris were the primary waste materials placed in the landfill. Landfilling began south of Emerson Street and gradually expanded northward and eastward to include areas between Emerson Street, Lexington Avenue, Colfax Street and Lee Road, and south of Emerson Street to the east and west of Colfax Street. Fires due to incomplete incineration of municipal solid waste and open burning of refuse reportedly occurred in the late 1960s and early 1970s due to operational problems with the incinerators. Fill during this timeframe was north of Emerson Street. In May of 1971, the City's incinerators were shut down; however, un-incinerated municipal refuse continued to be placed north of Emerson Street until August of 1971. In August 1971, refuse disposal was ceased at FESL and disposal shifted to a different county landfill. In 1971, the landfill was officially closed and a contract for the closure of the eastern half of the landfill specified 2 feet of cover material (preferred to be a sandy loam) to be placed and compacted to 30% in 1 foot lifts. In September 1971, a contract was awarded for the closure of the western portion of the landfill. Since closure, portions of the Site have been developed by various private parties.

The 2009 Order-on-Consent required the City to develop and implement a vapor intrusion (SVI) Work Plan. The SVI Work Plan was developed, approved by NYSDEC and implemented from 2009-2011. The work included soil and groundwater sampling across the FESL as well as SVI assessments at buildings on the FESL. The findings of the initial SVI assessment were detailed in a report titled *Soil Vapor Intrusion Assessment Report: Data Review, Site Screening & Site* Prioritization dated June 2011 (hereinafter referred to as the "*2011 SVI Assessment Report"*). The 2011 SVI Assessment Report identified several buildings at a risk of SVI due to CVOCs associated with the FESL. Subsequently, a work plan titled *Soil Vapor Intrusion Investigation Work Plan: Phase II Parcel Specific Investigation* (hereinafter referred to as the "*SVI Work Plan"*) was submitted to the NYSDEC and NYSDOH in April 2013 to complete SVI sampling within the buildings determined to be at high risk for SVI due to the FESL. The NYSDEC and NYSDOH provided comments to the SVI Work Plan on April 23, 2015 and the SVI Work Plan Work Plan was resubmitted in January 2016 to address the NYSDEC and NYSDOH comments. The SVI Work Plan was implemented beginning in March 2016 and two (2) of the seven (7) buildings tested required mitigation; 575 Colfax Street and 1740 Emerson Street. It should be noted that only the 1740 Emerson Street building was determined to require mitigation as a result of CVOCs due to the FESL (i.e., the P-1 Plume). The owners of 575 Colfax Street and 1740 Emerson Street were notified about SVI conditions. Subsequently, mitigation systems were installed/ activated in the buildings at 575 Colfax Street and 1740 Emerson Street and Construction Completion Reports have been completed and submitted to NYSDEC and NYSDOH.

The findings of the SVI Investigation were detailed in a report titled *Soil Vapor Intrusion Investigation Report* dated March 2018. For properties where SVI testing was completed and it was determined that SVI mitigation was not warranted, property-specific reports were developed, approved by the NYSDEC and NYSDOH, and provided to each property owner. Owners of properties that did not warrant SVI testing were notified that no further work was required due to the FESL. The above reports should be referenced for additional details regarding SVI at the FESL.

Previous investigations have been conducted at the FESL since the 1980s, which includes the most recent Remedial Investigation (RI) for the P-1 Plume that was conducted in accordance with the *Remedial Investigation Work Plan: P-1 Plume Area* dated November 2012 and five (5) subsequent addenda. The purpose of the RI was to define the nature and extent (areal and vertical extent) of VOCs, specifically CVOCs in soil, fill, groundwater and the bedrock matrix in the vicinity of the P-1 Plume. Previous investigations have identified CVOCs including trichloroethene (TCE), tetrachloroethylene (PCE) and breakdown compounds (mainly vinyl chloride and cis-1,2-dichloroethene) in groundwater at concentrations up to 69 parts per million (ppm) total CVOCs in groundwater. Previous investigations have defined the P-1 Plume as depicted on Figure 3. Refer to the RI Report by LaBella and GEI dated June 2018 for details.

A pilot test was conducted in 2017 to evaluate two (2) different injection methods for construction of a PRB; pneumatic injections and a blast enhanced bedrock trench. Micro-scale ZVI (Hepure Ferrox Flow) was utilized for both pilot test locations. The pilot tests were located just to the north of LAB-SBW-15 and LAB-SBW-16 in order to use these wells for monitoring purposes and also due to the topography. While both injection methods proved successful in reducing concentrations of CVOCs in bedrock groundwater, it was determined the full scale PRB should be moved further southward (hydraulically downgradient) of the P-1 Plume source area.

3. Standards, Criteria and Guidelines

This section identifies the Standards, Criteria and Guidelines (SCGs) for the Site.

Soil SCGs: The following SCGs for soil are applicable for the Site:

- New York Codes, Rules, and Regulations (NYCRR) Subpart 375-6 Remedial Program Soil Cleanup Objectives (RPSCOs) for the Protection of Groundwater;
- NYCRR Subpart 375-6 RPSCOs for Commercial Use.
- NYCRR Subpart 375-6 RPSCOs for Industrial Use.

Groundwater SCGs: The following SCGs for groundwater are applicable for the Site:

- NYSDEC Part 703 Groundwater Standards;
- Technical and Operational Guidance Series (TOGS) 1.1.1 Ambient Water Quality Standards and Guidance Values.

Soil Gas SCGs: Currently, no state regulatory (NYSDEC or NYSDOH) guidance values exist for soil gas.

Bedrock: Currently, no state regulatory (NYSDEC or NYSDOH) guidance values exist for bedrock.

4. Remedial Action Objectives

The primary Remedial Action Objectives (RAOs) are as follows:

Groundwater RAOs:

a. Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards;
b. Prevent contact with, or inhalation of volatiles, from contaminated groundwater; and
c. Prevent off-Site migration of contaminants in groundwater at levels exceeding drinking water standards.

Soil RAOs:

a. Prevent ingestion/ direct contact with contaminated soil;
b. Prevent inhalation of or exposure from contaminants volatilizing from contaminants in soil; and
c. Prevent migration of contaminants that would result in groundwater or surface water contamination.

Soil Vapor RAOs

a. Mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a site.

5. Design Phase Investigation

The design phase activity will include additional monitoring well installation and groundwater sampling and analysis. This objectives of this work will be to support the following design details:

1. optimal positioning of the PRB hydraulically downgradient of the P-1 plume source area;
2. bench scale treatability testing to evaluate optimal ZVI amendment type and associated dosing (including complete degradation, reaction rate kinetics, and estimating longevity of PRB);
3. selection of delivery method of ZVI amendment (i.e., blast enhanced bedrock fracture zone or pneumatic injections).

5.1 Monitoring Well Installation

Three (3) new monitoring wells, LAB-SBW-17, LAB-SBW-18 and LAB-SBW-19, will be installed at locations shown on Figure 3. Groundwater sample collection and analysis will support refinement of the downgradient plume concentration mapping to support PRB placement. Two (2) of the wells may be used as downgradient monitoring wells to evaluate the performance of the PRB. Prior to the start of drilling, a synoptic round of groundwater elevations will be collected in all wells in the P-1 Plume Area.

At each proposed monitoring well location, a soil boring will be advanced to sampler refusal at the bedrock surface. Soil cores will be retrieved using macrocore liners or split spoons and will be continuously logged by a LaBella and/or GEI geologist. Soil impacts in the form of visible and/or olfactory impairment, and/or indication of detectable volatile organic compounds (VOCs) by a photo-ionization detector (PID) will be identified during boring advancement. Based on previous work completed at the Site the P-1 Plume is anticipated to be located only within the bedrock zone in this area. As such, soil sampling is not currently included in the work plan. However, in the event PID

readings are significantly elevated (e.g., greater than 250 ppm) then soil samples may be collected for VOC analysis.

Upon reaching the bedrock surface, the augers will be advanced approximately 2-3 feet into the top of rock to provide a rock-socket for a permanent casing. A 6-inch diameter permanent steel casing will be cement-grouted in-place in the top of rock socket using a tremie pipe. The grout will be allowed to cure for a minimum of 24 hours prior to corehole advancement. Following the installation of the casing, an HQ core barrel will be advanced to a depth of 20 feet below the bottom of the permanent casing in 10-foot increments. In order to minimize the potential of potable water loss during rock coring, an attempt will be made to utilize air-coring methods during the advancement of the core barrel. If air-coring proves to be unsuccessful, potable water will be utilized as a drilling fluid. At the completion of bedrock coring, the HQ core hole will be reamed using a 3 7/8" roller bit, and the monitoring well will be completed as an open bedrock hole. All drilling equipment utilized during the installation and testing of each well will be decontaminated between monitoring well installations.

Details of the rock coring procedure including drill rate, water loss, and the presence of voids noted during core barrel advancement will be recorded on appropriate field forms. The retrieved rock core will be logged by a Labella or GEI geologist, and will include a description of rock type, the presence of natural and mechanical breaks, calculation of rock-quality designation (RQD), voids, and the presence of any odors or staining associated with the rock core. Rock core will be archived in wooden core boxes.

A section of core having evidence of impact (or core in the upper five feet of bedrock biased toward fracture zones) will be selected from the center well for use in bench scale treatability testing described in Section 5.3.). In addition, a section of core having evidence of impact (or core in the upper five feet of bedrock near the most significant fracture zone) will be selected from each of the three (3) wells for analysis. The selected core interval will be immediately wrapped in aluminum foil for preservation, placed in a plastic bag, and packed in ice for delivery to the laboratory. The rock core will be frozen, crushed and placed in a sample jar containing methanol for extraction via EPA Method 5035 and analyzed by EPA Method 8260 following two weeks of preservation.

Evidence for potential hydraulic communication with nearby monitoring wells (spouting, presence of air bubbles) will be evaluated and documented during the coring and reaming process. Each newly installed monitoring well will be developed following completion of rock coring in accordance with the 2012 Remedial Investigation Work Plan (RIWP). Following well development, a Well-Vu Camera will be used to observe fractures in each well. Video will be recorded and depths of fractures will be noted.

All soil, drilling fluids and well purge water generated during the installation and development of each monitoring well will be containerized as described in the RIWP. The location and elevation of each monitoring well will be surveyed using a survey-grade GPS.

5.2 Groundwater Sampling and Analysis

The three (3) new monitoring wells (LAB-SBW-17, LAB-SBW-18, and SBW-18) as well as LAB-SBW-15, LAB-SBW-16, and GMX-MW-3 will be sampled using low flow sampling methods in accordance with

the 2012 RIWP. Each monitoring well will be sampled for TCL VOCs by Method 8260. Two (2) groundwater samples will be collected from each well at depth-discrete intervals to evaluate for the presence of possible differential CVOC concentrations in shallower and deeper bedrock fractures in the sample interval. Samples will be collected at a depth of approximately 2-feet below the bottom of the permanent steel casing to evaluate CVOC presence near the top of bedrock and a sample will be collected approximately 5-feet from the bottom of the open bedrock hole. Approximate TCL VOC ample depths for existing wells will be as follows:

Approximate Depths to Top of Pump During Sampling

Well ID	Total Well Depth (ft bgs)	Approximate Casing Depth (ft bgs)	Sample Depths (ft bgs)
GMX-MW-3	29	19	21 24
LAB-SBW-15	44.6	24.6	26.6 39.6
LAB-SBW-16	49	29	31 44
LAB-SBW-17	TBD	TBD	2-ft below top of casing 5-feet from bottom of well
LAB-SBW-18	TBD	TBD	
LAB-SBW-19	TBD	TBD	

Additionally, samples will be collected from both intervals from the three (3) new wells and analyzed for the following parameters:

- Ethane
- Ethane
- Sulfate
- Sulfide
- Iron II
- Nitrate
- Nitrite
- Chloride

Each interval will be purged using low-flow techniques ahead of sampling as described in the RIWP. In order to ensure representative formation groundwater is evaluated at each interval, well purging will extend beyond typical water quality stabilization criteria as described in the RIWP and will continue for either 30 minutes beyond parameter stabilization or until three additional gallons of water are purged from each interval.

Samples will be collected in laboratory-supplied containers and transferred under chain of custody procedures to Eurofins TestAmerica for analysis. A complete round of groundwater elevations will be collected from the P-1 plume area monitoring wells as part of the groundwater sampling event.

The Community Air Monitoring Plan (CAMP) and Quality Control Plan (QCP) included in the 2012 RIWP will be implemented.

5.3 Treatability Study

Bench scale treatability testing will be conducted to determine the optimal ZVI amendment and dosing and support the selection of delivery method of ZVI amendment into an enhanced bedrock fracture zone. The treatability study will include two (2) tests conducted by XDD Environmental in Stratham, New Hampshire, as summarized below. Refer to Appendix 1 for XDD Environmental's proposal.

5.3.1 ZVI Kinetics Test

This bench scale test will determine the optimal ZVI amendment and dose required to treat COCs in groundwater with a goal of achieving at least an 80% reduction in CVOCs in groundwater. The data will also provide insight into the necessary PRB width perpendicular to groundwater flow based on the kinetics reaction.

The following ZVI products are proposed for the bench scale testing:

- Hepure- Ferrox Flow (used for the pilot test)– 95% ZVI. 125-micron average particle size.
- Hepure – Ferrox Target – 95% ZVI. 44-micron average particle size
- Hepure – Ferrox Plus eZVI – 40% ZVI, food grade soy bean oil, emulsifiers, thickeners and proprietary nutrient blend including nitrogen, phosphorus and vitamin B12, and sodium lactate.

Two (2) doses of each product will be selected for testing (i.e., 6 tests total). Dosing will be determined based on discussions with the remedial vendors and XDD Environmental. Testing will be completed in 20 degree Celsius batch reactors. A control will be set up with no ZVI product. A duplicate for each of the six (6) tests will also be set up but will not be analyzed unless the original reactor is compromised in some way. Bedrock will not be used in these tests; only groundwater and ZVI will be used.

Sampling will be conducted as follows:

- Analytical testing will be completed by Absolute Resource Associates (ARA) located in Portsmouth, New Hampshire with the exception of ORP and pH which will be completed by XDD.
- A baseline groundwater sample will be collected from LAB-SBW-18 and analyzed for TCL VOCs, pH, and ORP. Results will be reviewed prior to setting up the tests. Samples may be spiked if concentrations of CVOCs are too low to evaluate the effects of the ZVI.
- Samples will be collected at the following time points until the remedial goals (at least 80% reduction in CVOCs) have been reached.
    - Day 0 (baseline)
    - Day 0.5
    - Day 1
    - Day 2

    - Day 3
    - Day 4
    - Day 5
    - Additional days as needed, up to Day 10
- Samples at these time points will be analyzed for TCL VOCs, pH, and ORP. Testing will continue until the objectives have been met (anticipated to be within 5 days). In addition, samples will be analyzed for alkalinity, sulfate, and dissolved gasses on Day 0 and the final day. One day turnaround time may be requested from the lab.

5.3.2 ZVI Column/ Metals Test

A column test will be conducted using groundwater and bedrock from the Site (LAB-SBW-17, LAB-SBW-18 and LAB-SBW-19) and the ZVI product and dose that demonstrates the best results from the kinetics test. The objectives of this test are to:

- Confirm the ZVI product and dose is successful in a column test resembling Site conditions (i.e., similar groundwater flow rate and bedrock from the Site).
- Determine if the change in groundwater chemistry (i.e., ORP, pH) due to the ZVI results in changes in dissolved metals in groundwater.
- Provide a more accurate evaluation of the PRB width needed.

Two (2) column tests will be constructed; one with groundwater only as a control, and one with groundwater and bedrock. Columns will be constructed of 1-inch stainless steel with a length to be determined based on the results of the kinetics test.

Sampling will be conducted as follows:

- Day 0 – control sample only - VOCs, pH, ORP, alkalinity, sulfate, dissolved gases, TAL metals
- Final day (determined based on kinetics test) – control and test column - VOCs, pH, ORP, alkalinity, sulfate, dissolved gases, TAL metals

The treatability tests will require the following volume of groundwater and bedrock from the Site.

- 13 gallons groundwater (50 liters) collected in 1 liter amber glass or HDPE
- Four (4) 16 oz jars (or equivalent) of bedrock

Samples will be collected from LAB-SBW-18 within the planned PRB (refer to Figure 3). If additional bedrock volume is needed, samples may also be collected from the uppermost portion of LAB-SBW-17 and LAB-SBW-19. Samples will be shipped to XDD Environmental on ice under standard chain of custody procedures.

XDD Environmental will provide a report summarizing the findings of the treatability tests which will be used in developing the PRB design.

6. Remedial Design

Following completion of the well installation, sampling, and treatability study, a RAWP will be developed with a detailed design of the PRB and cover system. The work plan will include:

- Construction details for the cover system
- Grading plans and erosion control measures for construction of the cover system
- Design and specifications for the bedrock PRB treatment zone including:
  - PRB treatment zone location and width
  - Specification and volumes for the ZVI product
  - ZVI delivery method specifications for pneumatic or low-pressure injection into an enhanced bedrock fracture system
- Construction schedule
- Community Air Monitoring Plan
- Overview of Site Management Plan (MNA monitoring strategy)

7. Schedule

A schedule for the design phase investigation and remedial design is provided below. A detailed construction schedule will be provided in the RAWP.

August-September 2020	Design Phase Investigation Well Installation and Sampling
September-December 2020	Design Phase Investigation Treatability Study
December 2020	Remedial Action Work Plan
Spring 2021	Begin Remedy Construction

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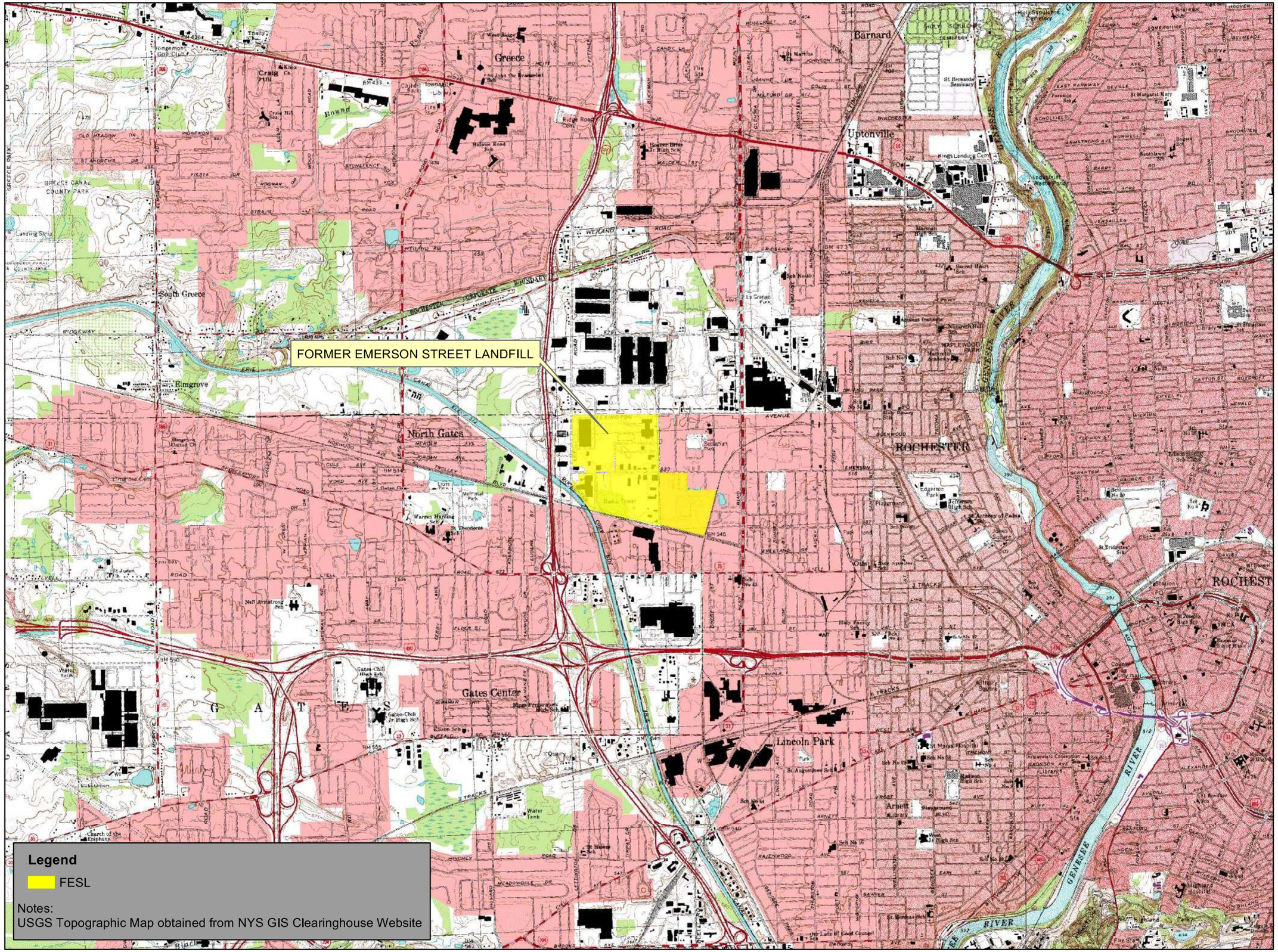
FIGURES



\\Projects2\Projects\NZ-2\Rochester, City\210173 FESL\Drawings\DPI\Figure 1- Site Location.mxd

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DESIGN PHASE INVESTIGATION WORK PLAN
P-1 PLUME AREA
FORMER EMERSON STREET LANDFILL
NYSDEC SITE #828023

CITY OF ROCHESTER

SITE LOCATION MAP

N
W E
S

0 1,500 3,000
Feet

1 inch = 3,000 feet
Intended to print as 11x17

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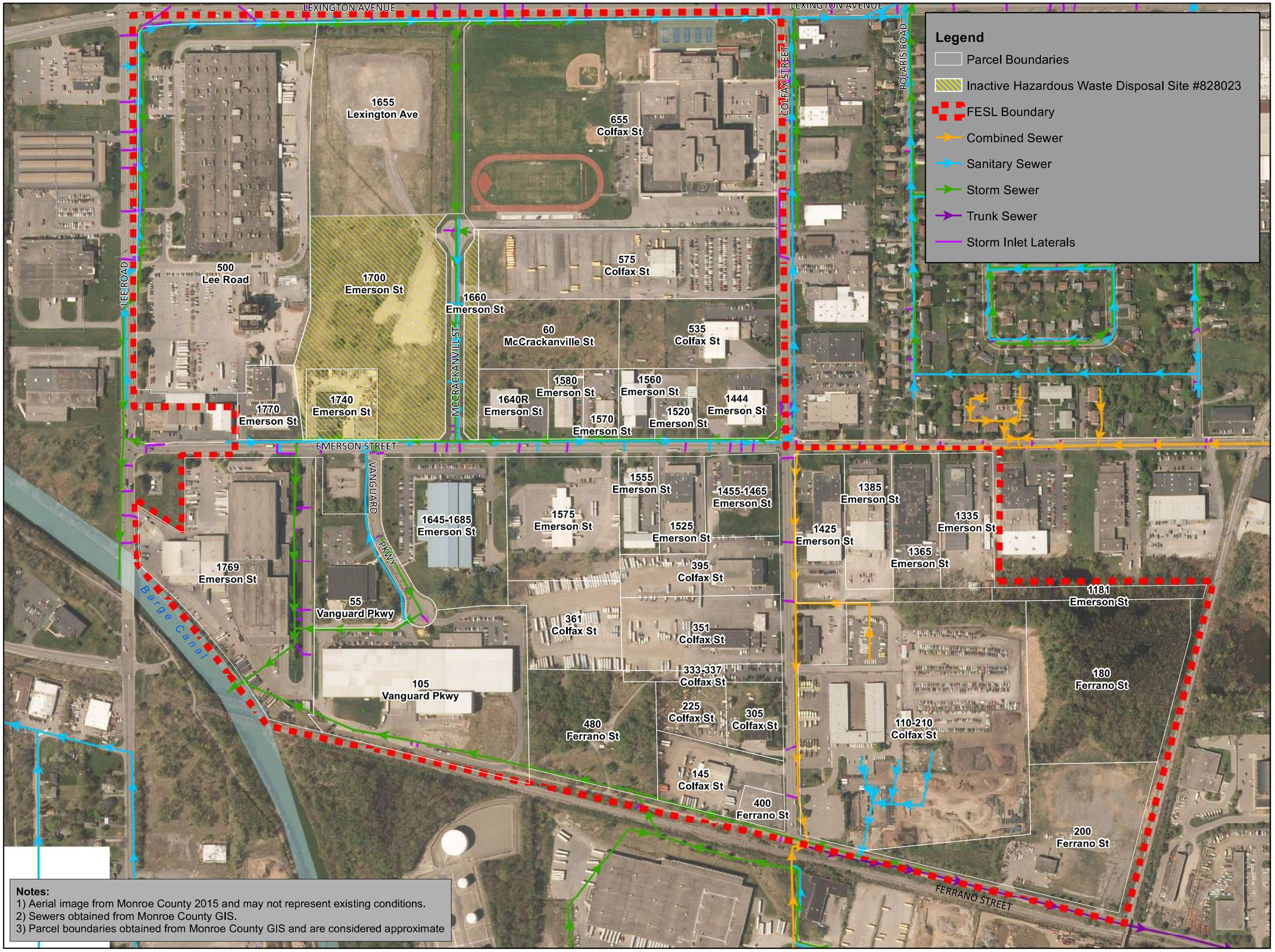
FIGURE 1



Notes:
1) Aerial image from Monroe County 2015 and may not represent existing conditions.
2) Sewers obtained from Monroe County GIS.
3) Parcel boundaries obtained from Monroe County GIS and are considered approximate

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DESIGN PHASE INVESTIGATION WORK PLAN
P-1 PLUME AREA
FORMER EMERSON STREET LANDFILL
NYSDEC SITE #828023

CITY OF ROCHESTER

FORMER EMERSON STREET LANDFILL FOOTPRINT

N
W E
S

0 400 Feet

1 inch = 400 feet

Intended to print as 11x17

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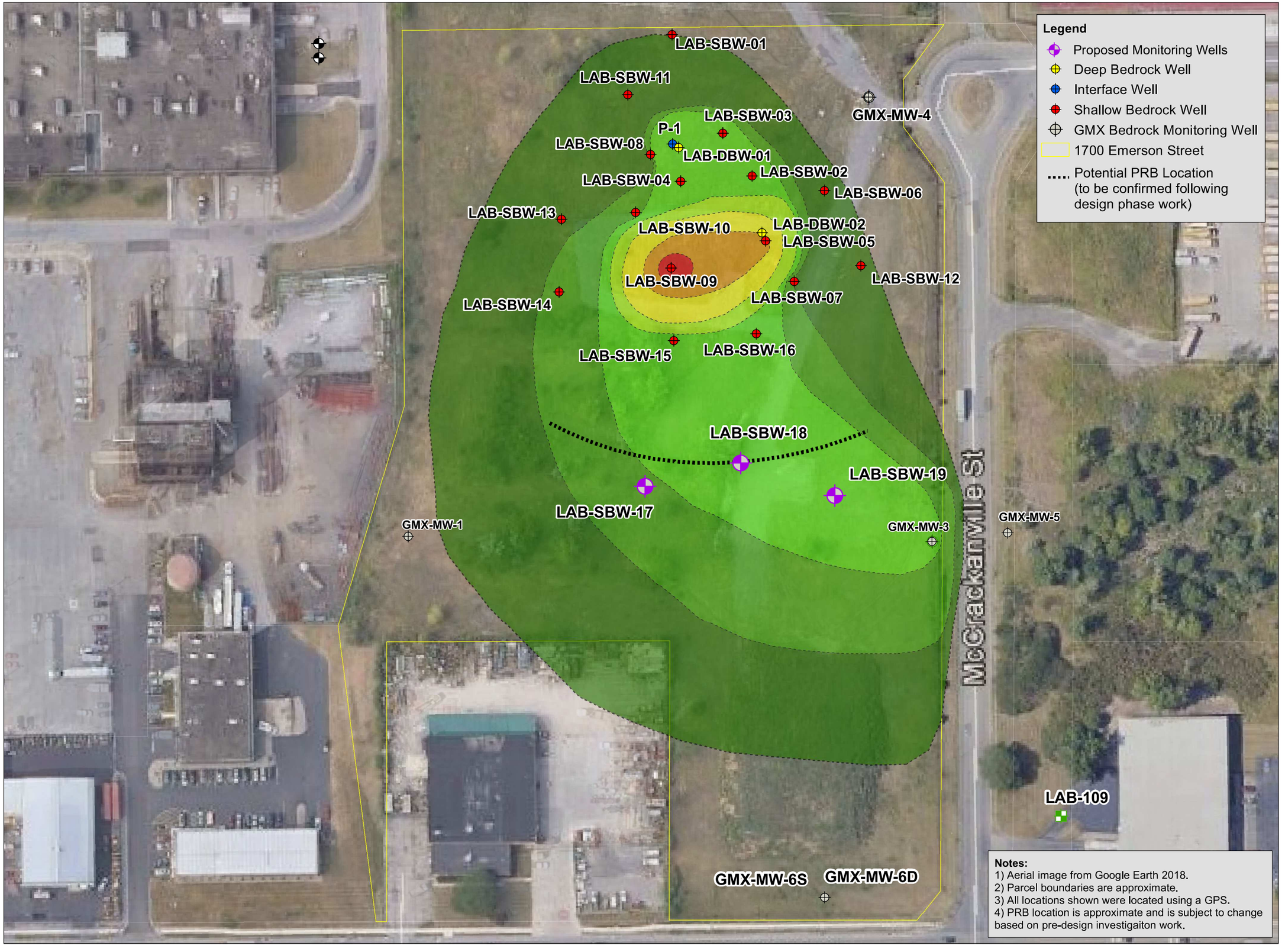
FIGURE 2

\\Projects2\Projects\NZ-2\Rochester, City\210173 FESL\Drawings\DPI\Figure 2- FESL Boundary.mxd



Notes:
1) Aerial image from Google Earth 2018.
2) Parcel boundaries are approximate.
3) All locations shown were located using a GPS.
4) PRB location is approximate and is subject to change based on pre-design investigaiton work.

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DESIGN PHASE INVESTIGATION WORK PLAN
P-1 PLUME AREA
FORMER EMERSON STREET LANDFILL
NYSDEC SITE #828023

CITY OF ROCHESTER

Proposed Design-Phase Wells and Approximate Permeable Reactive Barrier Location

N
W E
S

0 100
Feet

1 inch = 100 feet

Intended to print on 11x17

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FIGURE 3

Path: \\Projects2\Projects\NZ-2\Rochester, City\210173 FESL\Drawings\DPI\Figure 3 - PRB and Well Location.mxd

APPENDIX 1

XDD Environmental Proposal

August 11, 2020 (revised August 15, 2020) *Via e-Mail* (AABarber@LaBellaPC.com)

Ms. Ann A. Barber, P.E.
LaBella Associates
300 State Street, Suite 201
Rochester, NY 14614

RE: Proposed Scope of Work for Bench Scale Testing Services
Former Emerson Street Landfill, Rochester, New York
XDD Proposal No. p2029

Dear Ms. Barber,

XDD ENVIRONMENTAL, LLC (XDD) is pleased to submit this proposal to LaBella Associates (LaBella) for bench scale testing services to support the proposed remediation activities at the Former Emerson Street Landfill, located in Rochester, New York (Site).

1.0 INTRODUCTION AND BACKGROUND

The Site consists of a former landfill impacted with volatile organic compounds (VOCs) in bedrock and overburden and bedrock groundwater. The proposed remediation strategy is to install a permeable reactive barrier (PRB) consisting of Zero Valent Iron (ZVI) to address the chlorinated volatile organic compounds (CVOCs) in groundwater at the Site.

A pilot test was previously conducted at the Site in two areas which received a total of approximately 28,000 pounds (lbs.) of micro scale ZVI. The ZVI was applied into a blasted bedrock trench in the western area, and pneumatically injected in the eastern area of the Site.

2.0 RECOMMENDED APPROACH

The purpose of the proposed bench test is to evaluate the potential for various ZVI amendments to treat the CVOCs in groundwater within bedrock fractures downgradient of the Site source area. The general scope of work (SOW) will include the following

1. ZVI Kinetics Test. The kinetics test will determine the optimal ZVI amendment and dose required to treat the CVOCs in groundwater in the absence of bedrock, with a goal of achieving a minimum 80% reduction in total CVOCs concentrations compared to the source area, or to be determined depending on the starting concentrations in the proposed PRB area. The data would also serve to provide insight into the treatment zone length needed in the bedrock perpendicular to groundwater flow, based on the determined reaction kinetics.
2. ZVI Column / Metals Test. A column test will be conducted with Site groundwater in contact with crushed bedrock using the ZVI product and dose that demonstrates the best results from the kinetics test. The objectives from this test will be to:
    a. confirm the ZVI product and dose is successful in a column test, which oftentimes more closely resembles Site conditions (i.e., groundwater flow rate, contact with bedrock).
    b. determine if the change in groundwater geochemistry (i.e., ORP, pH) due to the ZVI will result in changes in dissolved metals concentrations.
    c. Provide a more accurate evaluation of the treatment zone length needed in the bedrock perpendicular to groundwater flow.

3.0 BENCH SCALE TESTING

3.1 SAMPLE HANDLING

The groundwater and bedrock used in the bench scale testing will be collected by LaBella and shipped to XDD. Upon receipt of groundwater and bedrock samples at XDD's laboratory, a groundwater sample will be submitted for laboratory analysis of baseline VOCs. The baseline sample will be submitted to Absolute Resource Associates (ARA) located in Portsmouth, NH for VOCs analysis using United States Environmental Protection Agency (EPA) Method 8260. A standard turn-around-time (TAT) will be requested and the results will be reviewed prior to setting up the tests. If the baseline concentrations are considered to be too low to obtain

meaningful results from the testing, the option to spike the groundwater with one or more CVOCs can be considered. Costs do not include spiking the groundwater, if necessary.

The bedrock will be broken up into pieces resembling a fractured bedrock structure (the range in size of the bedrock pieces will be determined after consultation with LaBella). The samples collected for the bench scale testing will be stored at approximately 4 degrees Celsius (°C) until test setup.

3.2 ZVI KINETICS TEST

The ZVI products that will be used in the bench scale testing will be obtained from two suppliers of remediation products, Hepure and Regenesis. Three ZVI products are proposed for the kinetics testing at two dosages for each product. The final selection of products and dosages to be tested will be based on recommendations from the vendor and after consultation with LaBella. As of the date of this proposal, the ZVI products proposed for the kinetics test are as follows:

1. Hepure - Ferox Flow: 95% ZVI; powder that provides high reactivity and long treatment life; -100/+325 Mesh ZVI (125-micron average particle size)
    a. Low Dose
    b. High Dose
2. Hepure - Ferox Target: 95% ZVI; powder that provides high reactivity with a shorter treatment life than Ferox Flow; -325 Mesh ZVI (44-micron average particle size)
    a. Low Dose
    b. High Dose
3. Regenesis – S-MicroZVI®: 40% ZVI; colloidal, sulfidated-ZVI supplied as a liquid suspension (suspended in glycerol); <5-micron particle size. The sulfidated particle coating provides an increased stability and longevity.
    a. Low Dose
    b. High Dose

The kinetics tests will be conducted in a series of batch reactors (160-milliliter [mL] borosilicate-glass serum bottles) at 15 °C to simulate field groundwater temperatures. The bottles will first be purged with argon to create an anaerobic environment followed by the addition of groundwater (approximately 100 mL) in the absence of bedrock. Depending on the test condition, ZVI amendments will be added as necessary (refer to Table 1). The control reactor will be set up in the same manner as the amended test conditions but will contain no ZVI product.

Each reactor will be sealed with a Teflon-lined, rubber septa through which small samples can be removed by syringe. For each test condition, replicate reactors will be set up and will be monitored/sacrificed for each sampling point as shown in Table 1. In addition, duplicate reactors will be constructed for each sampling point, but will not be sacrificed for analysis unless the original reactor is compromised in some way. A duplicate of the control will be sacrificed at each time point for the determination of analytical precision.

3.2.1 TESTING DURATION AND ANALYSES

The proposed sampling points and analyses for the kinetics test are shown on Table 1. The kinetics test will be conducted over a period of up to 10 days or longer, which may vary based on the bench testing progress, with the goal of having sufficient confidence in projecting meeting the groundwater remedial goals. Including Day 0, a total of 8 time points are assumed. Costs do not include analyses for an additional time point past 10 days, if needed depending on previous results. If interim results indicate remedial goals are achieved sooner, test conditions from later time points will not be sacrificed for analyses, resulting in cost savings passed on to LaBella. Costs assume standard TATs; unit rates for the analyses and expedited TATs are provided in Section 7.0, should additional time points and/or expedited TATs be necessary.

pH, oxidation-reduction potential (ORP), and VOCs will be measured for all test conditions at each time point. In addition, alkalinity, sulfate, and dissolved gasses (methane, ethane, and ethene) will be analyzed on Day 0 and the final time point[1] for each test condition. A third, interim time point for alkalinity, sulfate, and dissolved gasses is provided as a separate cost item. All analyses will be conducted by ARA with the exception of pH and ORP, which will be conducted in XDD's laboratory. pH and ORP measurements will be conducted by removing small amounts of liquid by syringe through the septa. pH and ORP will be measured using an Orion 9103BN micro-electrode.

3.3 ZVI COLUMN / METALS TEST

The column / metals test will be conducted using the ZVI product and dose that demonstrates the best results in the kinetics test. The ZVI product and dose will be selected after consultation with LaBella, with input from the ZVI product vendor, if needed. Two test columns will be

1 Samples for alkalinity, sulfate, and dissolved gasses will be collected at each time point and stored at 4 °C until VOCs results are received and evaluated. If VOCs results indicate sufficient reduction has been achieved and that another time point is not needed, the alkalinity, sulfate, and dissolved gasses samples will be subsequently submitted to the laboratory for analysis. If an additional time point is needed, the samples will be not be submitted for alkalinity, sulfate, and dissolved gasses analyses.

constructed, a control column with groundwater and crushed bedrock only, and a column with groundwater, crushed bedrock, and the ZVI product and dose determined from the results of the kinetics test (refer to Table 2 for test conditions and analyses). The column testing will be conducted at 15 °C to simulate field groundwater temperatures.

The column testing will be conducted using 1-inch ID (nominal) stainless steel (SS 304) columns with sanitary clamp fittings. The column length will depend on the results of the kinetics test (e.g., if kinetics test indicates sufficient reduction of CVOCs in 2 days, and if a groundwater flow rate of 2 feet per day is assumed, the column length would be 4 feet). It is assumed that the column will have a maximum length of 4 feet; therefore, if the kinetics test results indicate a longer time period is needed to achieve remedial goals, the column test results will be extrapolated.

The columns will be constructed with SS 304 reducers fitted to both ends of the straight column section. Gaskets between the straight column section and reducers will consist of Buna-N[2] fitted with #60 Mesh SS screens to retain the crushed bedrock. All fittings and materials used in the column setup will consist of suitably inert materials compatible with VOCs sampling/handling.

3.3.1 TESTING DURATION AND ANALYSES

The proposed sampling points and analyses for the column / metals test are shown on Table 2. Groundwater samples from the control column will be analyzed on Day 0. Analyses will be conducted on the groundwater from the control and test column at the final time point, which will be determined based on the results of the kinetics test. In addition, there will likely be an initial period of equilibration between the groundwater and bedrock in the columns (i.e., retardation effects), which could delay the timing of the final sampling point.

The groundwater analyses at each time point will include pH, ORP, VOCs, alkalinity, sulfate, dissolved gasses, and target analyte list (TAL) dissolved metals. All analyses will be conducted by ARA with the exception of pH and ORP, which will be conducted in XDD's laboratory.

4.0 TECHNICAL MEMORANDUM

The bench test results will be summarized in a brief report with supporting tables and figures. Pilot-scale design, full-scale design, and full-scale cost projections are not included in this SOW.

2 Buna-N is nitrile rubber which is generally considered to be compatible for VOCs sampling operations.

5.0 GROUNDWATER AND BEDROCK REQUIREMENTS

The groundwater and bedrock requirements summarized in the below table are conservative estimates in case of sample breakage or if additional time point(s) are requested. Samples should be collected in suitably inert material with minimal headspace.

Bench Scale Testing Groundwater and Bedrock Sample Requirements

Groundwater Requirements	
Volume	13 gallons / 50 L
Container	1-L amber glass bottles or HDPE carboys
Collection/Preservation	Minimize headspace, store and ship on ice
Bedrock Requirements	
Volume	Four (4) 16 oz. jars, or equivalent (~6.6 lbs/3 kg)
Container	Amber glass wide mouth jars or equivalent
Collection/Preservation	Minimize headspace, store and ship on ice

Samples should be shipped at approximately 4 degrees Celsius (°C) with a proper chain of custody and all materials double sealed to the below address.

XDD Environmental
Attn: Laurel Crawford
22 Marin Way, Unit #3
Stratham, NH 03885
Ph: 603-778-1100

6.0 SCHEDULE

The time required to complete the SOW by task is summarized below. Testing will begin immediately upon receipt of Site groundwater and bedrock and final approval of this proposal.

Task	Time Required
1. Project Design / Coordination	1 week
2. ZVI Kinetics Test	4 to 8 weeks* (assumes standard laboratory TAT)
3. ZVI Column / Metals Test (set up following kinetics test)	2 to 4 weeks** (assumes standard laboratory TAT)
4. Reporting	2 weeks
TOTAL	**9 to 15 weeks**

* test duration depends on interim results
** test duration may extend longer depending on initial equilibration period

Testing can be further expedited by requesting faster TATs from the laboratory (cost for expedited TAT is not included in this proposal but provided as a separate line item in Section 7.0).

8.0 CONDITIONS

XDD will perform the proposed SOW on a lump sum basis under subcontract to LaBella in accordance with mutually agreeable Terms and Conditions. Cost estimates assume groundwater and bedrock will be collected from the Site and shipped to the XDD laboratory in Stratham, NH by others. A signed contract will need to be in place before XDD can accept groundwater and bedrock required for testing. XDD will dispose of samples provided by the client in strict accordance with the sample collection and shipping protocol post-testing, in accordance with local regulations, for a fee which is included in the proposal costs. If requested by the client, XDD can ship the samples back to the Site at the client's expense and remove the disposal fee. XDD's proposal specifies the amount and type of samples required for the testing, any sample mass or volume that exceeds the requested values will be shipped back to the Site for disposal by the client or the client's designee at the client's sole expense.

This proposal is valid for 60 days from the date issued.

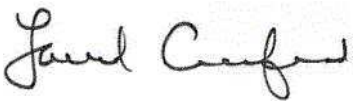
9.0 CONFIDENTIALITY

By presentation and receipt of this proposal by XDD, the recipient acknowledges that the information provided herein relating to XDD's technical approach, methods and costs are considered proprietary information of XDD. Use and distribution of the proposal contents, in part or whole, is limited to the reasonable and necessary procedures in evaluating if the project will be awarded to XDD.

XDD appreciates the opportunity to be of assistance to LaBella on this important project. Please do not hesitate to call me at 603-778-1100 should you have any questions on the contents of this proposal.

Sincerely,

XDD ENVIRONMENTAL, LLC



Laurel Crawford
Project Manager

Cc: Michael Marley, XDD
Dan Noll, LaBella

Table 1
Bench Test Setup - ZVI Kinetics Test
Former Emerson Street Landfill, Rochester, NY
XDD Proposal No. p2029

ZVI Kinetics Test													
Test Condition			pH and ORP [2] VOCs [3]									Akalinity, Sulfate, Dissolved Gasses [3]	
			Time Points (days) [4]									Time Points (days) [4]	
			0	0.5	1	2	3	4	5	10	TBD [5]	0	10 / Final
1	Baseline [1]		✓										
2	Control - groundwater only		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
	Duplicate 1		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
	Duplicate 2												
3	Hepure Ferox Flow	Dose 1		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
		Dose 2		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
4	Hepure Ferox Target	Dose 1		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
		Dose 2		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
5	Regenesis S-MicroZVI®	Dose 1		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
		Dose 2		✓	✓	✓	✓	✓	✓	✓			✓
		Duplicate											
Total Analyses			3	8	8	8	8	8	8	8		2	8
			59									10	

Notes:
ZVI = zero valent iron
VOCs = volatile organic compounds
[1] Baseline sample will be submitted prior to test setup to confirm groundwater is impacted with typical levels of VOCs detected at the site.
[2] pH and ORP measurements will be conducted in XDD's laboratory using an Orion 8103BN micro-electrode.
[3] Analyses will be conducted by Absolute Resource Associates, LLC (ARA) located in Portsmouth, NH.
[4] Time points are approximate and may vary depending on bench testing progress and interim results.
[5] Additional time point may not be needed or would be determined based on previous results.
[6] The kinetics test will be conducted using site groundwater only in batch reactors.
Duplicate reactors will be set up but not analyzed unless the original reactor is compromised in some way.

Table 2
Bench Test Setup - ZVI Column / Metals Test
Former Emerson Street Landfill, Rochester, NY
XDD Proposal No. p2029

ZVI Column / Metals Test			
Test Condition		**pH and ORP [1] VOCs, Alkalinity, Sulfate, Dissolved Gasses, and Dissolved Metals [2]**	
		Time Points (days)	
		0	TBD [3]
1	**Control - groundwater and crushed bedrock only**	✓	✓
2	**ZVI Amendment/Dose [4]**		✓
Total Analyses		1	2
		3	

Notes:
ZVI = zero valent iron
VOCs = volatile organic compounds
[1] pH and ORP measurements will be conducted in XDD's laboratory using an Orion 8103BN micro-electrode.
[2] Analyses will be conducted by Absolute Resource Associates, LLC (ARA) located in Portsmouth, NH. Dissolved gasses will include methane, ethane, and ethene. Dissolved metals will include the target analyte list (TAL) of metals.
[3] Final time point will depend on results from the kinetics test.
[4] ZVI amendment and dose will depend on results from the kinetics test.
[5] The column test will be conducted using site groundwater and crushed bedrock.