Pilot/Bench Test Work Plan

Former Chamberlain Manufacturing
Corporation Site
Waterloo, Iowa

Prepared for:
Chamberlain Manufacturing Corporation
Elmhurst, Illinois

Prepared by:
ENVIRON International Corporation
Austin, Texas

Date:
January 2014

Project Number:
21-29014A

ENVIRON

Contents

List of Tables

List of Figures

1 Introduction

The former Chamberlain Manufacturing property (the "Subject Site") is located at 550 Esther Street in the City of Waterloo, Black Hawk County, Iowa (Figure 1-1). The Subject Site is an irregularly shaped parcel containing approximately 22.8 acres. The layout of the site and the surrounding area is shown on Figure 1-2.

The Subject Site manufactured metal washer wringers and projectile metal parts from approximately 1919 until 1996 when it was sold to Atlas Warehouse L.C. for use as a storage facility. The Subject Site was subsequently abandoned and is currently vacant. The City of Waterloo acquired the Subject Site from Atlas Warehouse L.C. in 2005 in an effort to facilitate redevelopment and has demolished the remaining structures of the Subject Site.

The Subject Site is zoned Heavy Industrial (M-2) by the City. The Subject Site is adjoined by park land to the north and south, single family residential housing to the west, and Virden Creek followed by a golf course to the east. Virden Creek is within approximately 100 feet of the Subject Site at its closest point. Gates Park adjoins the Subject Site to the north across Louise Street, to the east across Virden Creek, and to the south across the railroad tracks. Single family residences are located across East 4th Street to the west of the Subject Site. Single family residences are also located along the east side of East 4th between Anita and Louise Streets

The redevelopment plan and future use of the Subject Site have not yet been determined, so residential, commercial/industrial, and recreational use will be considered as potential future property uses for the Subject Site.

1.1 Purpose

This Pilot/Bench Test Work Plan (PBTWP) has been developed by ENVIRON International Corporation (ENVIRON) on behalf of Chamberlain Manufacturing Corporation (Chamberlain) to describe various tests and investigations that will be performed as part of the Corrective Measures Study for the Subject Site. The tests and investigations described herein will assist with the selection and design of corrective measures to address impacted groundwater. Further investigation of soil conditions will be described in a separate work plan.

The PBTWP is intended to collect data necessary to evaluate the active corrective measure alternatives for groundwater treatment of in-situ (batch injection) oxidation and both in-situ (batch injection) and ex-situ (groundwater extraction, treatment, and re-circulation) enhanced anaerobic dechlorination of TCE in groundwater. This data will also be useful in evaluating the monitored natural attenuation alternative. Additional corrective measure alternatives, such as the use of institution controls, will still be evaluated in the Corrective Measures Study (CMS), but do not require further investigation.

1.2 Site Geology and Hydrogeology

The Subject Site land surface is generally flat, sloping downwards from the northeast to the southwest. It is located in the dissected till plains of the central lowlands province. The soils in the region have been classified by the US Soil Conservation Service as the Sparta loamy fine sand series, which consists of nearly level to moderately steep, excessively drained soils on alluvial terrace and uplands. The Sparta soils formed in sand deposited mainly by wind, and have a rapid permeability and a low water capability. Approximately 60 to 100 feet of sand and gravel deposits lie between the Sparta soils and underlying Silurian and Devonian-age bedrock.

The description of the near-surface geology and hydrogeology can be further refined by observations made during the investigations performed to date at the Site. Based on the soil borings performed at the Subject Site during the Phase II Environmental Site Assessment in August and September 2004, the surface soils are generally fill materials or topsoil. The fill/topsoil is generally 2 to 4 feet thick and is underlain by a sand or silty-sand layer. In most locations, a relatively low permeability lens is present within the sand layer, which is composed of sandy clay, clayey silt, or silty clay. This lower permeability lens, where present, ranges from 2 to 6 feet in thickness and is encountered between 8 and 14 feet below ground surface (bgs). In two locations (i.e., SB-38 and SB-60), this lower permeability layer appears to be more extensive as it extends to the termination depths of the borings at 30 feet bgs.

Groundwater is found in unconsolidated and consolidated aquifers in the area. The depth to the potentiometric surface in monitoring wells installed at the Subject Site ranged from 8 to 24 feet bgs during the October 2011 sampling event. The groundwater flow direction was observed to be to the south and southwest. Groundwater in both the unconsolidated deposits and the Silurian- and Devonian-age bedrock units is likely to flow to the southwest, toward the Cedar River. Perched groundwater exists at the Subject Site, within fill material overlying native soils.

1.3 Potential Treatment Areas

There are currently two identified on-site areas of elevated groundwater concentrations where active corrective measures are being evaluated in the CMS; one located near monitoring wells MW-1 and MW-5, and a second one near monitoring wells MW-12 and MW-16. The monitoring well locations are shown on Figure 1-3. The primary constituents of concern (COCs) in groundwater are trichloroethene (TCE) and its anaerobic degradation products.

It should be noted that MW-5, MW-12, and MW-16 were destroyed during the recent slab demolition activities at the Site (MW-4, MW-6, MW-13, MW-14 and OSMW-2 were also destroyed). For the purposes of this work plan, it is assumed that MW-5 and MW-12 will be replaced in approximately the same location as shown in Figure 1-3. Risk Assessment Summary

The April 2010 Risk Assessment performed by Tetra Tech on behalf of the Environmental Protection Agency (EPA) identified potential unacceptable risks at the Subject Site.[1] The risk assessment evaluated chemicals of potential concern (COPCs) based on previous soil, groundwater, and indoor air screening. The COPCs identified and evaluated in the risk assessment were:

---

[1] The Health Consultation of the Former Chamberlain Manufacturing Site prepared by the Iowa Department of Public Health dated April 27, 2012 and Comments on the Tetra Tech Risk Assessment Report prepared by ENVIRON dated September 7, 2012 did not identify any actual risks at the Subject Site other than the vapor intrusion risk that is currently being addressed as an interim measure.

- Soil – TCE, arsenic, barium, cadmium, mercury, and selenium.
- Groundwater – 1,1,1-trichloroethane (TCA), 1,1,2-TCA, 1,2-dichloropropane, cis-1,2-dichloroethene (cDCE), trans-1,2-dichloroethene, benzene, chloroform, ethylbenzene, tetrachloroethene (PCE), TCE, vinyl chloride, total xylenes, arsenic, cadmium, chromium, and mercury.
- Indoor air and soil gas – chloroform, PCE, and TCE.

Tetra Tech calculated cumulative risks from exposure to soil and groundwater to various receptors including current and future residents (both on- and off-site), commercial/industrial workers, construction workers, recreational users, and trespassers. Tetra Tech calculated potential unacceptable risks (lifetime excess cancer risks greater than EPA's risk range of 10^{-6} to 10^{-4} or a hazard index greater than one) for future industrial/commercial workers, future construction workers, and future on-site adult child and residents. Most of the calculated risk is due to ingestion and direct contact exposure with groundwater. This risk, however, is largely theoretical as the City of Waterloo provides drinking water to residents and the use of groundwater from private wells is currently restricted. Tetra Tech calculated acceptable cumulative risk levels for trespassers, and adult and child recreational visitors for all pathways. Inspection of the risk assessment calculations presented in Appendix D of the Risk Assessment Report indicates that TCE in groundwater, mercury in perched groundwater, and arsenic, cadmium, and mercury in soil are the principal risk drivers at the Subject Site as they represent the majority of the risk and hazard quotients calculated.

Groundwater

Investigations by Chamberlain have identified groundwater contamination on- and off-site. Groundwater monitoring wells on the Subject Site have identified a TCE plume beneath both the Subject Site and the area to the southwest of the Subject Site. The 2010 Risk Assessment Report concluded that based on the results of these investigations, ingestion of and direct contact with TCE in on-site groundwater for a residential exposure scenario represents an excess lifetime cancer risk of approximately 10^{-3}, due primarily to the presence of TCE.

In the 2010 Risk Assessment, it was assumed that lower aquifer groundwater could be used as a potable water supply in the future, assuming residential exposure and absent the current institutional controls prohibiting groundwater use. If groundwater associated with the site was used as a potable water supply, several exposure pathways to adult and child residents can occur such as ingestion, direct contact, and inhalation of vapors from the water while it is in use. However, groundwater present in the upper (perched) and lower aquifer are not being used as a drinking water source. The proposed corrective measure(s) will address the EPA's goal of restoring groundwater resources, where practicable.

On Site Soils

The 2010 Risk Assessment Report demonstrated that calculated risks to commercial/industrial workers from on-site soils were within acceptable risk ranges. The report also concluded that the calculated risks to future adult residents from surface soil are within acceptable ranges. The excess lifetime cancer risks for the child resident from exposure to soil is also within the acceptable range, but the hazard index slightly exceeds one (1.6), due to the presence of cadmium in soil (individual hazard quotient was equal to 0.96). No individual hazard quotient exceeded one, but the summed hazard index was slightly greater than one. The exposure point concentrations calculated by Tetra Tech represented the 95% upper confidence limit of the mean for soil on the entire Subject Site. Chamberlain recognizes that additional evaluation based on lot sizes may be necessary if and when the City develops a site-specific redevelopment plan for the property.

The major portion of the excess cancer risk due to exposures to soils estimated by Tetra Tech was associated with the presence of naturally occurring arsenic. The 95% upper confidence limit of the mean concentrations for both surface soils and subsurface soils were 6.5 mg/kg and 5.6 mg/kg, respectively, which are lower than the 7.14 mg/kg identified as a background value for Blackhawk County, Iowa,[2] indicating that the risks associated with arsenic in the soils are not related to the Subject Site. Furthermore, the Subject Site soil data for arsenic do not exceed the Iowa generic statewide soil standard.[3] As noted in the Scope of Work of the Unilateral Administrative Order for the Subject Site, the media cleanup standards may take into account naturally occurring background concentrations for metals. Notwithstanding the above, corrective measures such as isolated hot spot soil investigation and removal, or placement of engineered barriers consistent with a future development plan may be implemented in response to EPA's indicated preference for some source removal. Additional investigation of the two identified sample locations where arsenic is present at greater than the Iowa Statewide Standard is proposed below to aid in the design of potential corrective measures.

The City of Waterloo, through its consultant, HR Green, has also requested that certain anomalies noted in a 2004 geophysical survey, located in the northeast portion of the Site, be investigated. Chamberlain will retain a qualified environmental professional to review the results of the metal detection and ground penetrating radar (GPR) survey, and will investigate anomalies to the extent that they may represent structures containing or which historically contained hazardous substances. This potential investigation may include completion of test pits or trenches.

Indoor Air

Indoor air quality risks have been evaluated, and TetraTech identified indoor air concentration risks and hazards driven by the presence of TCE. The most likely exposure of TCE to off-site residents is via intrusion of vapors from groundwater to indoor air. Chamberlain has already actively implemented the corrective measure of residential sub-slab and indoor air monitoring and mitigation to address risks to human health for this exposure pathway.

Construction Workers

The risk assessment identified an on-site potential unacceptable risk from exposure to TCE and mercury from groundwater and various metals in soil to construction workers in trenches. Construction workers exposed to groundwater while working in a trench may inhale vaporized TCE or mercury. The selected corrective measure will address the potential risks to

---

[2] United States Geological Survey, National Geochemical Survey Database, http://mrdata.usgs.gov/geochem/select.php

[3] https://programs.iowadnr.gov/riskcalc/pages/standards.aspx

construction workers in trenches, likely through an appropriate health and safety plan for future construction work in on-site trenches.

2 Recommended Pilot-Scale Tests

2.1 Membrane Interface Probe (MIP) Investigations

A comprehensive evaluation of remedial alternatives to address impacted soil and groundwater is based on a detailed understanding of subsurface COC concentrations. Typically, COCs are not distributed evenly throughout the subsurface. Variations in soil grain size, the geochemistry of soils, and COCs lead to relatively different concentrations of COCs even over very short distances. To develop a more detailed understanding of the distribution of COCs below the groundwater table, ENVIRON proposes to advance a series of direct push borings fitted with membrane interface probe (MIP) tooling.

The MIP system is a direct push tool that produces vertical profiles of VOC concentrations in relation to depth and lithology in the subsurface. The MIP system operates by heating the soil and groundwater adjacent to the probe to 120 °C to volatize VOCs in the immediate vicinity of the MIP membrane. This heating allows for the volatized VOCs to diffuse across the membrane into a closed, inert gas loop that carries these vapors to a series of detectors housed at the surface. Each detector analyzes these gases to produce a continuous data profile, plotted with respect to depth, indicating the presence of the COCs.

Each detector operates differently and therefore detects different compounds. For the vendor anticipated to provide the MIP tooling, Vironex, the MIP system consists of an electron capture detector (ECD), a halogen specific detector (XSD), a photo-ionization detector (PID), and a flame-ionization detector (FID). Soil conductivity (EC), which serves as a proxy for sediment size, is also measured while advancing the MIP tooling. The EC measurements can then be compared to the chemical logs to better understand the subsurface distribution of VOCs.

The MIP investigations will focus on locations within the areas of elevated TCE concentrations in groundwater that have been identified during previous investigations. Additional locations will be sampled near the expected perimeters of these areas, also as indicated by previous investigation data. Taken together, the MIP data will provide a more detailed understanding of where the COCs are concentrated in the subsurface.

For the groundwater area within the northeastern portion of the Subject Site, the focus of the MIP investigation will be in the vicinity of monitoring wells MW-1 and MW-5 (Figure 2-1). Adjacent to MW-1, a direct push boring (MIP-01) with the MIP tooling will be advanced. Subsequently, eight step-out borings (i.e., MIP-02 through MIP-09) will be advanced around this location, with the first ring of four step-out borings approximately 20 feet from the initial boring, and the second ring of four borings 20 feet further out (each one 40 feet from the initial boring). The proposed locations shown on Figure 2-1 may be adjusted in the field based on field conditions encountered at the time of the investigation. Additional MIP sampling locations may be selected in the field based on the data gathered from the initial set of borings.

With respect to the groundwater area of elevated TCE concentration within the southwestern portion of the Subject Site, the focus of the MIP investigation will be in the vicinity of monitoring wells MW-12 and MW-16 (Figure 2-2). Between these wells, a direct push boring (i.e., MIP-10) with the MIP tooling will be advanced. Subsequently, eight step-out borings (i.e., MIP-11 through MIP-18) will be advanced around this location, with the first ring of four step-out borings approximately 20 feet from the initial boring, and the second ring of four borings 20 feet further out (each one 40 feet from the initial boring). The proposed locations shown on Figure 2-1 may be adjusted in the field based on field conditions encountered at the time of the investigation. Additional MIP sampling locations may be selected in the field based on the data gathered from the initial set of borings.

Based on existing monitoring well data, the MIP borings are anticipated to extend to depths of approximately 35 to 55 feet bgs. If field data indicate, select MIP borings may be advanced to deeper depths, if possible.

2.2 Hydraulic Profiling Tool/Groundwater Sampling (HPT-GWS) Investigations

In addition to refining an understanding of the distribution of COCs in the subsurface, predicting the response of the subsurface geology to the injection of fluids will also be important in the event that future remedial actions include injection of remediation amendments. To this end, ENVIRON proposes to advance four borings via direct push technology to assess the hydraulic properties of the Subject Site. Two of the borings will be Hydraulic Pressure Test (HPT) borings, to measure hydraulic conductivity, and two borings will be for high pressure injection testing using a High Resolution Injection Tool (HRIT).

The HPT is a direct push tool that continuously injects a small amount of drinking water (approximately 200 mL/minute) during advancement, and measures the pressure response with a downhole transducer. The HPT therefore provides a continuous log of hydraulic conductivity plotted with respect to depth. Two direct push borings (i.e., HPT-01 and HPT-03) will be advanced with the HPT tooling, one in each area (Figures 2-1 and 2-2), to a minimum of 35 feet bgs, and deeper if time allows. The locations and depths targeted for injection testing will be based upon the findings of the MIP investigation, so the locations shown on Figures 2-1 and 2-2 may be adjusted in the field.

The HRIT is a direct push tool that has an integrated pressure transducer and electrical conductivity sensors. While the tool is advanced through the subsurface, electrical conductivity readings are continuously collected, providing the operator with an indication of the type of lithology at a given depth. In parallel with the MIP and HPT data, the HRIT can then be used to select specific intervals for high pressure injection testing.

In a high pressure injection test, fluid (in the case of this test, drinking water) is pumped under pressure into the subsurface as a means of evaluating how the target interval will respond to fluid injection. Based upon the EC and MIP data, a target interval for injection testing will be selected. Injection pressures will emulate those that would be expected during injection of remediation amendments, and are expected to have flow rates of 15 gallons per minute (gpm) or greater. Once injection of drinking water commences, injection pressures and flow rates will be continuously monitored, and pressure and flow rate over time will be measured for that target interval. Two direct push borings (i.e., HPT-02 and HPT-04) will be advanced using the HRIT tooling, one in each of the areas (see Figures 2-1 and 2-2). The locations and depths targeted for injection testing will be based upon the findings of the MIP and HPT investigations, so the locations shown on Figures 2-1 and 2-2 may be adjusted in the field.

The injection data from both types of hydraulic injection testing provides an assessment of the hydraulic conductivity of the subsurface nearby the test point. This can then be used to estimate overall injection performance in the target intervals. This is critical for determining planned injection volumes and flow rates, as well as the radius of influence of the injection, which would dictate the spacing of remediation injection points.

For each of the types of hydraulic injection testing, drinking water will be employed as the testing fluid. While the exact total volume of water is dependent upon the amount of testing conducted, it is expected that less than 500 gallons of drinking water would be used to complete all of the proposed tests.

2.3 In-Situ Hydraulic Conductivity (Slug) Tests

An in-situ hydraulic conductivity test is a method of obtaining approximate values of hydraulic conductivities in the immediate vicinity of the well screen through the use of a single well, and will be conducted in monitoring wells MW-1, replacement MW-5, and replacement MW-12 (see Figure 2-3) as part of pilot-scale testing. Essentially instantaneous lowering of the water level in a well can be achieved by quickly removing water with a bailer or by partially or completely submerging an object (or slug) in the water, allowing the water level to reach equilibrium, and then quickly removing the object. If the aquifer is very permeable, the water level in the well may rise very rapidly as water levels return to static conditions. Such rapid rises can be measured with pressure transducers. As part of the in-situ hydraulic conductivity tests to be conducted at the Site, a data logger and a pressure transducer will be utilized to measure and record the changes in water levels. The resulting water level data will be analyzed using the method of Bouwer and Rice (1976). If zones with high hydraulic conductivity are encountered during slug testing, it may be appropriate to conduct pneumatic slug tests. High conductivity tests approaching 0.07 cm/s or greater with oscillatory responses will require analysis by methods other than Bouwer and Rice, such as the analysis described by R.K. Springer and LW. Gelhar in their 1991 article published by the U.S. Geological Survey entitled *Characterization of Large-Scale Aquifer Heterogeneity in Glacial Outwash by Analysis of Slug Tests with Oscillatory Response, Cape Cod, Massachusetts*.

2.4 Short-Term Aquifer Pumping Tests

Short-term (i.e., 1- to 4-hour) pumping tests will be conducted on monitoring wells MW-9 to represent the MW-1/MW-5 area, and replacement MW-12 to represent the MW-12/MW-16 area (see Figure 2-3). This data will be used to supplement hydraulic information to be obtained through the in-situ hydraulic conductivity testing described in Section 2.3. The objective of the short-term pumping tests is to estimate the expected groundwater yield from a pumping well and the aquifer's capacity to receive injected groundwater. These factors would allow for design of a groundwater recirculation system that would circulate one pore volume of groundwater through an identified treatment zone within a prescribed timeframe.

3 Recommended Bench-Scale Tests

3.1 Soil Oxidant Demand

In conjunction with the MIP and HRIT investigation, soil oxidant demand (SOD) and fractional organic carbon (FOC) will be assessed via the collection of four to eight soil samples. Measurement of these parameters would allow for a better understanding of the appropriate oxidant dosage to be used in the event of future implementation of in-situ chemical oxidation, as well as an evaluation of the relative mass of organic COCs that are adsorbed onto soil sediments as opposed to in solution in the aquifer.

The final locations and depths for the collection of these soil samples will be selected based upon the findings of the MIP investigation. Two locations will be selected from each potential groundwater treatment area. If different lithologies are encountered within these locations, a one soil sample will be collected from each of the lithologies. The soil samples will be collected using direct push methodology.

3.2 Groundwater Volatile Organic Compounds

To confirm recent groundwater monitoring results and to collect additional information regarding aquifer geochemistry, a comprehensive groundwater sampling event is proposed. This groundwater sampling event will include the available on- and off-site monitoring wells. The monitoring wells to be included in the comprehensive sampling event are listed in Table 3-1, along with the characteristics of the wells (if known). If these monitoring wells are inaccessible or do not have sufficient water, a sample will not be collected; however, the sampling event will still be considered complete. The methods that will be used for the sampling are outlined below. Additional details are provided in the approved Quality Assurance Project Plan (QAPP), dated August 18, 2006.

Groundwater Sample Collection and Handling

Prior to purging, water levels will be measured in the available monitoring wells at the Subject Site to facilitate the production of a water level contour map. The water level contour map will be evaluated to determine if additional monitoring well installation may be warranted to further define the extent of impacted groundwater. Field parameters used to measure well stabilization during testing will, at a minimum, include pH, temperature, turbidity, and specific conductance.

The monitoring wells will then be sampled using low-flow sampling methods and instruments in accordance with USEPA's *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (Puls and Barcelona, 1996). Prior to sample collection, each monitoring well will be purged at a low pumping rate (less than 0.5 liters per minute) using a peristaltic pump or submersible/bladder pump (where needed) with dedicated intake and discharge tubing. The field parameters of pH, specific conductance, turbidity, dissolved oxygen, temperature, and oxidation-reduction potential will be measured during well purging using a water quality meter fitted with a flow-through cell and recorded in the field notebook or on designated field purge logs. After the field parameters stabilize, a groundwater sample will be collected from designated tubing into laboratory-supplied sample containers, labeled, placed on ice in coolers, and transported to the analytical laboratory for analysis. Groundwater samples will be analyzed for VOCs using SW-846 Method 8260. Appropriate chain-of-custody protocols will be followed throughout sample handling.

Monitoring equipment will be calibrated according to manufacturers' recommendations. All down-hole sampling equipment will be decontaminated prior to the collection of each sample using an Alconox™ solution wash and potable water rinse. New intake and discharge tubing will be used for purging and sampling and disposed of after each use.

Quality Control

The following QA/QC samples will be collected:

- Field Duplicates – 1 duplicate per 10 analytical samples.
- MS/MSD – 1 MS/MSD per 20 analytical samples.
- Trip Blanks – 1 trip blank for every container used to store and transport VOC samples.

3.3 Groundwater Geochemical Parameters

The purpose for this task is to obtain baseline hydrogeologic and geochemical data necessary to evaluate applicable remedial options, and to develop a conceptual remedial design for groundwater remediation. In conjunction with the groundwater sampling event described above in Section 3.2, four monitoring wells (i.e., MW-1, MW-5, MW-12 and MW-16) will be sampled for the following natural attenuation parameters: sulfate (Method 300), ethene/ethane/methane (Method 8015), dissolved iron (Method 6010B/200.7), total organic carbon (Method 9060), nitrate+nitrite (Method 353.2), and alkalinity (Method 2320B). For QA/QC purposes, one field duplicate sample will be submitted for laboratory analysis of the natural attenuation parameters listed above. The field parameters of dissolved oxygen and oxidation-reduction potential collected from monitoring wells MW-1, MW-5, MW-12, and MW-16 as part of the low-flow sampling procedure described above will be incorporated into the evaluation of natural attenuation. Rationales for the recommended pre-design in-field and laboratory testing parameters are provided in the following subsections.

Dissolved Oxygen

Dissolved oxygen is the most thermodynamically-favored electron acceptor used by microbes for the biodegradation of natural as well as anthropogenic carbon. Dissolved oxygen concentrations greater than 1 mg/L, in conjunction with elevated concentrations of chlorinated volatile organic compounds (CVOCs) and the absence of total organic carbon, indicate that additional substrate may be required to support anaerobic bioremediation.

Oxidation-Reduction Potential

The oxidation-reduction potential of groundwater is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. Redox reactions in groundwater are usually biologically mediated, and therefore the oxidation-reduction potential of a groundwater system depends on and influences rates of biodegradation. The oxidation-reduction potential of groundwater generally ranges between -400 millivolts (mV) and +800 mV; however, most biological processes operate only within prescribed ranges of oxidation-reduction potential. Characterization of the range of oxidation-reduction potential within the reaction zone therefore provides an indirect indicator of the redox reactions (including anaerobic dechlorination of CVOCs) that may be occurring. Oxidation-reduction potential values greater than 0 mV, in conjunction with elevated levels of dissolved oxygen and the absence of total organic carbon, indicate that additional substrate may need to be added to promote anaerobic dechlorination.

Total Organic Carbon

Total organic carbon is an indicator of natural organic carbon as part of baseline site characterization, and is an indicator of substrate distribution during anaerobic bioremediation performance monitoring. Total organic carbon concentrations greater than 20 mg/L are desired within an anaerobic treatment zone. Stable or declining total organic carbon concentrations less than 20 mg/L, in conjunction with elevated concentrations of CVOCs and alternate electron acceptors indicate that additional substrate is required to sustain the treatment zone (Air Force Center for Environmental Excellence, 2004, "Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents").

Sulfate

Sulfate is an alternate electron acceptor for microbial respiration in the absence of oxygen, nitrate, and ferric iron. Depleted concentrations of sulfate relative to background values indicate that the groundwater environment is sufficiently reducing to sustain sulfate reduction and for anaerobic dechlorination to occur. Sulfate concentrations less than 20 mg/L are desirable, but not required, for anaerobic dechlorination to occur. High concentrations of sulfate in conjunction with the absence of total organic carbon indicate that additional substrate may be required to promote anaerobic dechlorination.

Nitrate

Nitrate is an alternate electron acceptor for microbial respiration in the absence of oxygen. Depleted concentrations of nitrate relative to background values indicate that the groundwater environment is sufficiently reducing to sustain nitrate reduction. Nitrate concentrations less than 1 mg/L are desirable for anaerobic dechlorination to occur.

Ferrous Iron

In some cases ferric iron is used as an electron acceptor during anaerobic biodegradation of organic carbon; however, ferric iron is typically present in solid mineral form. During this process, ferric iron is reduced to ferrous iron, which is soluble in water. Elevated concentrations of ferrous iron indicate that the groundwater environment is sufficiently reducing to sustain iron reduction and for anaerobic dechlorination to occur. However, ferrous iron concentrations may be biased low due to co-precipitation with sulfides. Dependent on the amount of fermentable substrate and bioavailable iron already present in the aquifer, a site may not exhibit a substantial increase in ferrous iron if ferric iron is already low or depleted.

Methane/Ethane/Ethene

During methanogenesis, acetate is split to form carbon dioxide and methane, or carbon dioxide is used as an electron acceptor and is reduced to methane. Elevated concentrations of methane indicate that fermentation is occurring in a highly anaerobic environment and that reducing conditions are appropriate for anaerobic dechlorination of CVOCs to occur. Elevated concentrations of ethene and ethane indicate that anaerobic dechlorination of CVOCs is already occurring. Methane concentrations greater than 1 mg/L are desirable, but not required, for anaerobic dechlorination to occur. Methane concentrations less than 1 mg/L and the accumulation of cDCE or vinyl chloride may indicate that additional substrate is required to drive reducing conditions into an environment suitable for reduction of these compounds. If elevated concentrations of ethene or ethane are not detected, potential accumulation of cDCE or vinyl chloride should be monitored.

Alkalinity

A positive correlation is typically exhibited between zones of microbial activity and increased alkalinity. Increases in alkalinity result from the dissolution of carbonate minerals driven by the production of carbon dioxide generated by the metabolism of microorganisms. Alkalinity is important in the maintenance of aquifer pH because it buffers the groundwater system against acids produced during anaerobic biodegradation. Controlling the range of pH in the reaction zone may be needed to maintain effective bioremediation.

4 Report of Preliminary Screening Results

It is anticipated that the scope of work described herein can be completed within 160 days from the approval of this PBTWP. The results of the tests and investigations described above will be reported in a Preliminary Screening Results Report within 60 days of the completion of testing. This report will include a summary of the field conditions, a description and evaluation of any deviations from the work plan, and a summary of the results.

5 References

Bouwer, H. and R.C. Rice. 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, vol 12, no. 3, pp423–428.

ENVIRON International Corporation. 2012. Comments on the Tetra Tech Risk Assessment Report, Former Chamberlain Corporation Site, Waterloo, Iowa, September 7.

Environmental Protection Agency. 2004. Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action.

Environmental Protection Agency. 1997. Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics in Ground Water.

Environmental Protection Agency. 1994. RCRA Corrective Action Plan (Final).

Environmental Protection Agency. 2010. Unilateral Administrative Order for Chamberlain Manufacturing Corporation, Waterloo, Iowa, April 20.

Howard R. Green Company. 2004. Phase I Environmental Site Assessment, EPA Brownfields Assessment Grant, Former Chamberlain Manufacturing Property, May.

Howard R. Green Company. 2005. Phase II Environmental Site Assessment, Former Chamberlain Manufacturing Property, January.

Howard R. Green Company. 2005. Supplemental Phase II Environmental Site Assessment, Former Chamberlain Manufacturing Property, September.

Howard R. Green Company. 2013. Memorandum Re: February 8, 2013 Air and Soil Sampling from Robin Husman to Noel Anderson and Chris Western of the City of Waterloo, March 20.

Iowa Administrative Code. 2012. Chapter 61: Water Quality Standards.

Iowa Administrative Code. 2008. Chapter 133. Rules for Determining Cleanup Actions and Responsible Parties.

Iowa Administrative Code. 2008. Chapter 137: Iowa Land Recycling Program and Response Action Standards.

Iowa Department of Public Health. 2012. Health Consultation for the Former Chamberlain Manufacturing Site, Waterloo, Iowa, April 27.

Terracon Consultants, Inc. 2006. Quality Assurance Project Plan, August 18.

Terracon Consultants, Inc. 2011. Groundwater Monitoring Report, October 2011 Sampling Event, Former Chamberlain Manufacturing Corporation, December 16.

Terracon Consultants, Inc. 2012. Vapor Intrustion Characterization Work Plan, October 14, 2010, Revised November 14, 2011, and Revised February 17, 2012.

Tetra Tech, Inc. 2010. Former Chamberlain Manufacturing Company Risk Assessment, April 6.

United States Geological Survey, National Geochemical Survey Database, http://mrdata.usgs.gov/geochem/select.php.

Tables

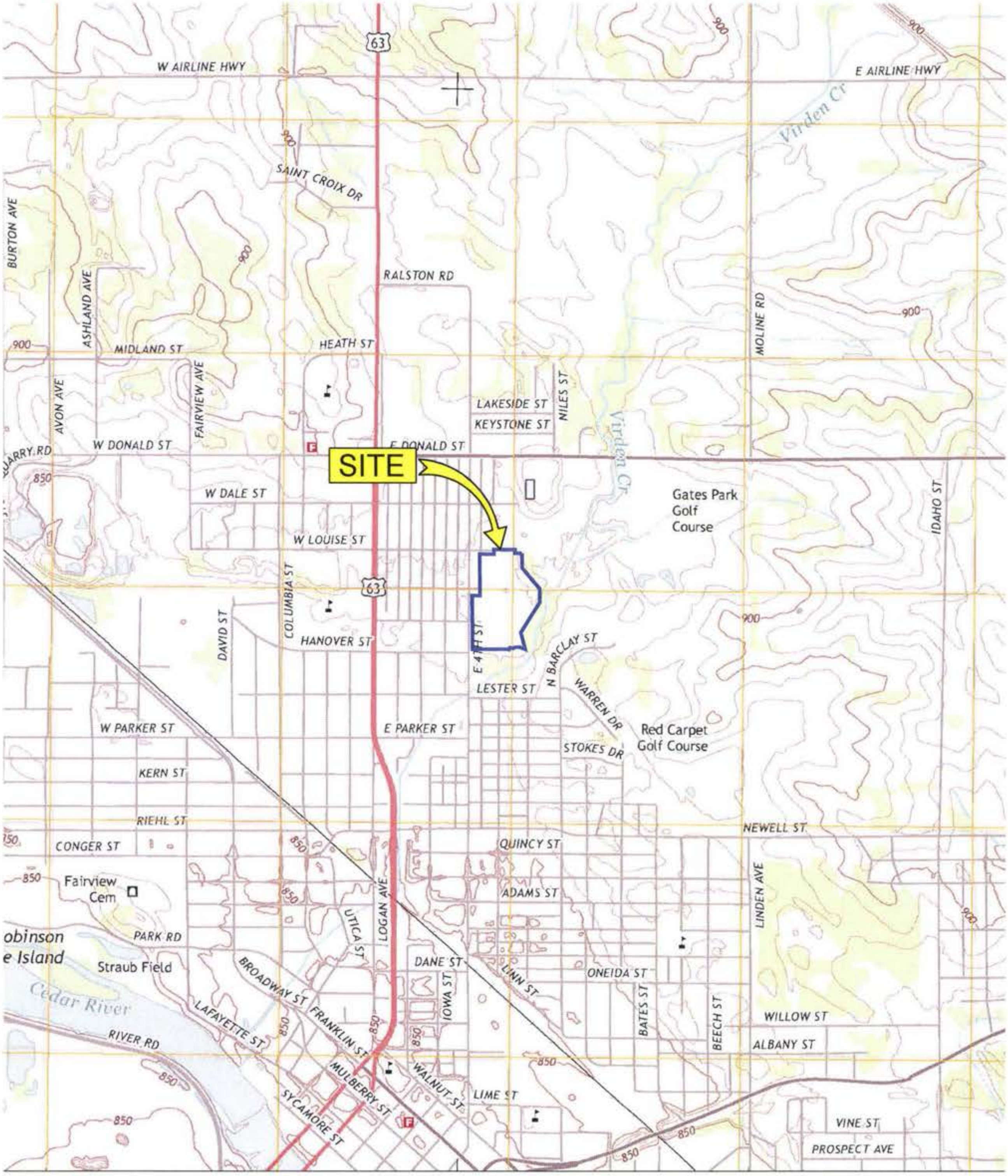
TABLE 3-1

Summary of Monitoring Wells for Comprehensive Groundwater Event
Former Chamberlain Manufacturing Corporation Site
Waterloo, Iowa

Monitoring Well	TOC Elevation (feet amsl)	Screened Interval (feet bgs)	Boring Depth (feet bgs)	Well Diameter (inches)
MW-1	861.44	14 - 29	30	2
MW-2	863.40	7 - 12	13	2
MW-3	863.36	9 - 14	15	2
MW-4	863.11	4 - 14	15	2
MW-5	864.06	19 - 29	30	2
MW-6	862.56	19 - 29	30	2
MW-7	865.50	19 - 29	30	2
MW-8	870.19	18 - 28	30	2
MW-9	863.26	19 - 29	30	2
MW-10	862.74	17 - 27	27	2
MW-11	863.08	8 - 13	14	2
MW-12	860.41	19 - 29	30	2
MW-13	862.57	-	-	-
MW-14	862.15	8 - 13	14	2
MW-15	Not Surveyed	59 - 64	64	-
MW-16	Not Surveyed	48 - 53	53	-
OSMW-1	862.76	15 - 25	25	2
OSMW-2	855.60	10 - 20	20	2
OSMW-3	851.91	9.5 - 19.5	20	2
OSMW-4	851.86	10 - 20	20	2
OSMW-5	863.60	17 - 27	28	2
OSMW-6	864.50	18.5 - 28.5	28.5	2
OSMW-7	858.42	-	-	-
OSMW-8	845.55	-	-	-
OSMW-9	854.97	17 - 27	27.5	-
OSMW-10	849.07	16 - 26	26.5	-
OSMW-11	846.41	14.5 - 24.5	25	-
OSMW-12	850.53	14 - 24	25	-
OSMW-13	Not Surveyed	10 - 20	20	-
OSMW-14	Not Surveyed	5 - 15	15	-
OSMW-15	871.70	16.5 - 26.5	27	-
OSMW-16	877.01	7.5 - 17.5	18	-

Key:
- = Unknown
amsl = above mean sea level
bgs = below ground surface

Figures



1 1/2 0 1 MILE

2000 0 2000 4000 6000 FEET

CONTOUR INTERVAL 10 FEET

SOURCE: U.S.G.S. 7.5 minute series (topographic)
Waterloo, Iowa North Quadrangle, 2013.

LEGEND

▬ APPROXIMATE PROPERTY BOUNDARY

N

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-1_Site Location Map.dwg

ENVIRON

SITE LOCATION MAP
FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

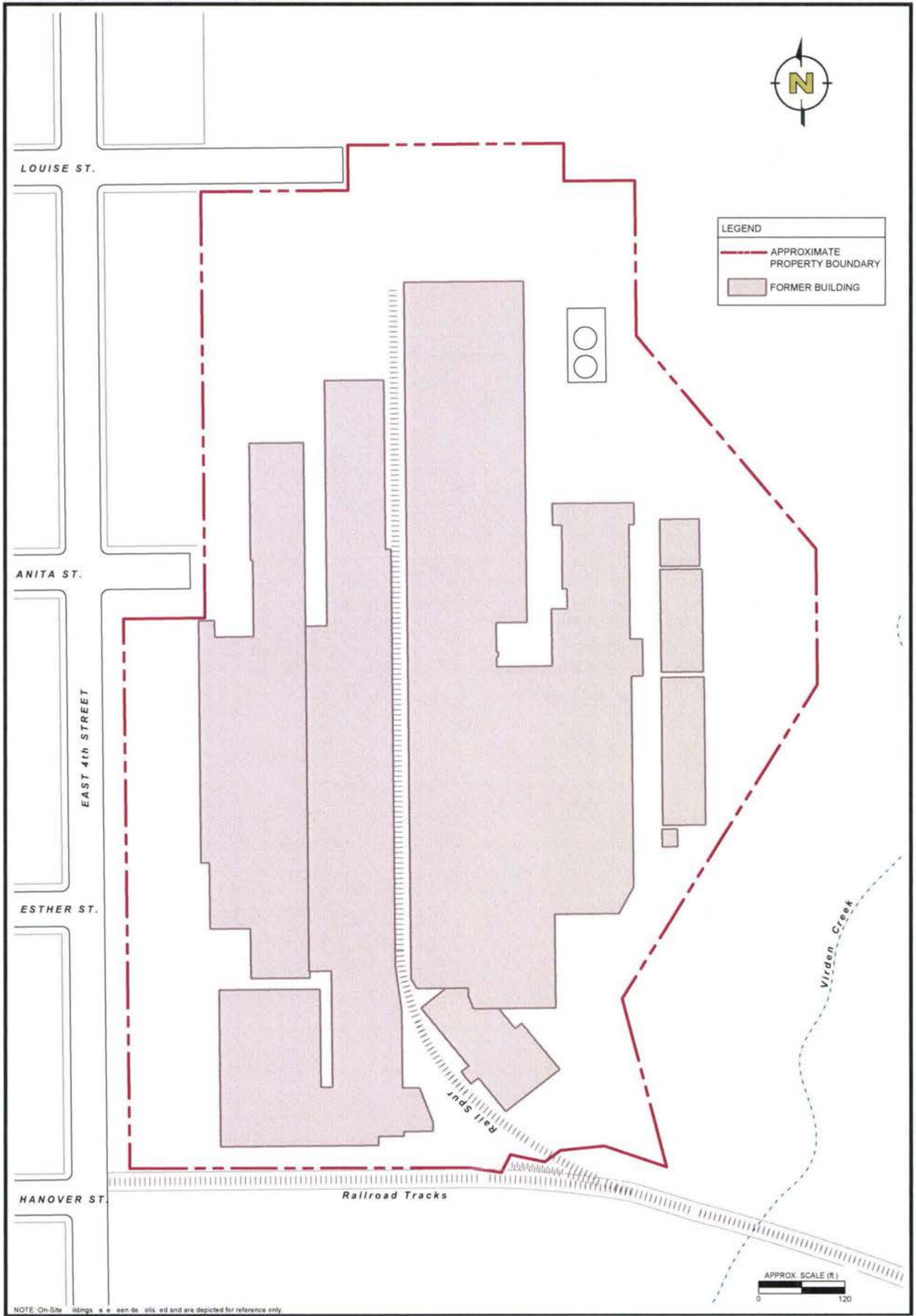
FIGURE
1-1

DRAFTED BY: ELS

DATE: 6/27/13

21-29014A

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-2_Site Layout.dwg



NOTE: On-Site buildings have been demolished and are depicted for reference only.

ENVIRON

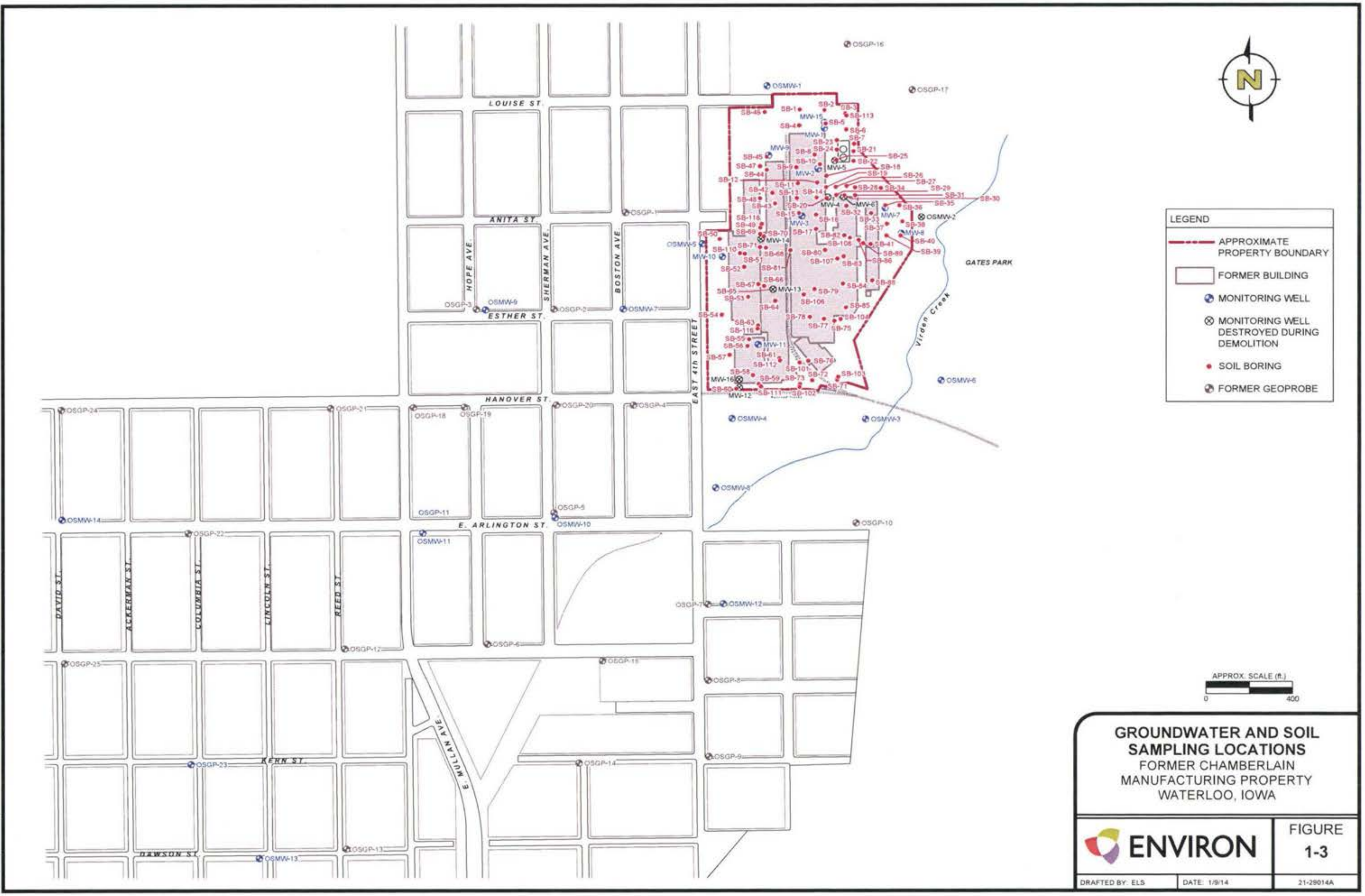
DRAFTED BY: ELS

DATE: 6/28/13

SITE LAYOUT
FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

FIGURE
1-2

21-29014A



GROUNDWATER AND SOIL SAMPLING LOCATIONS

FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

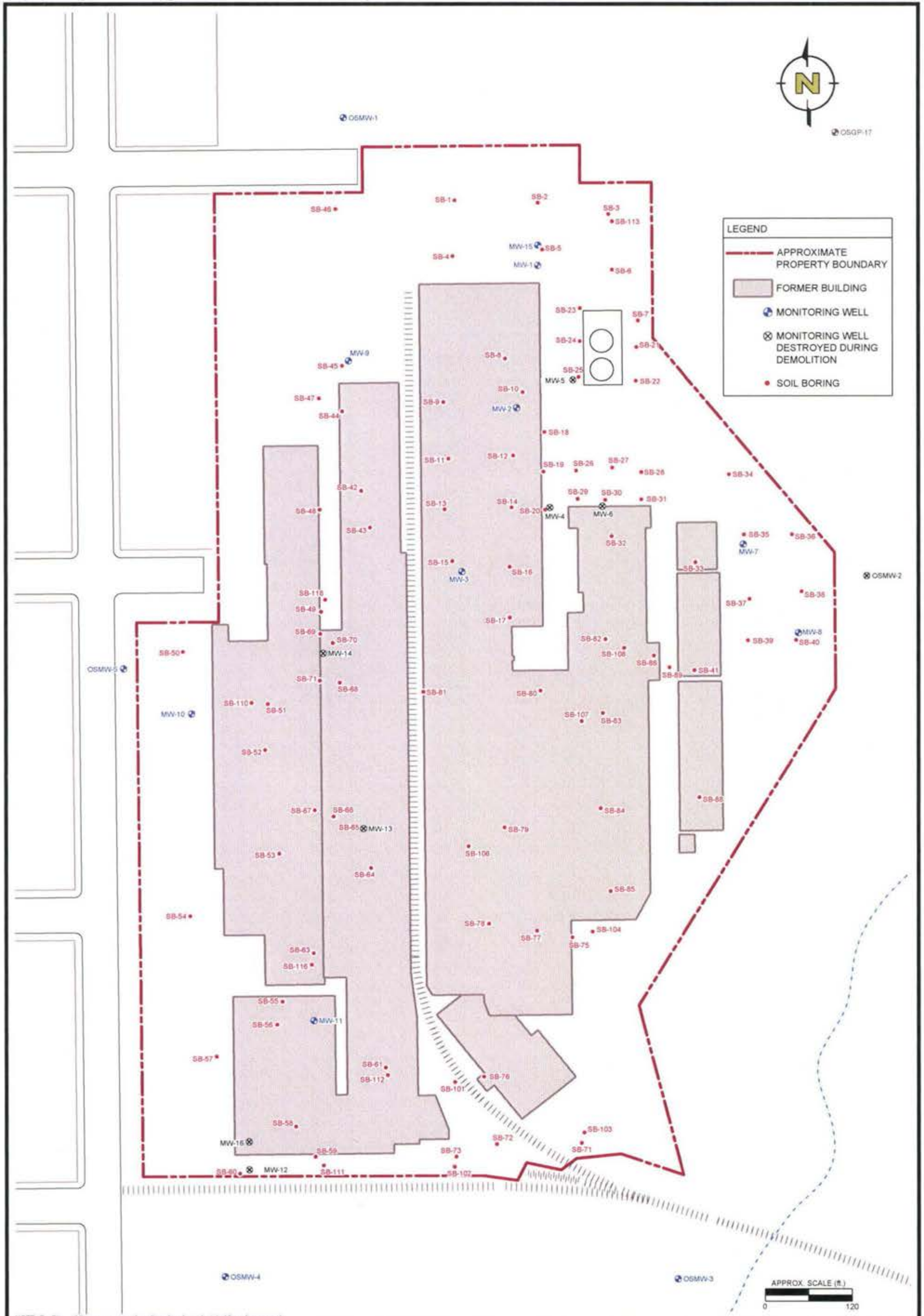
ENVIRON

FIGURE 1-3

DRAFTED BY: ELS
DATE: 1/9/14
21-29014A

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-3_GW SB Locations.dwg

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-4, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7.dwg



NOTE: On-Site ildings a e een de olis ed and are depicted for reference only.

ENVIRON

DRAFTED BY: ELS

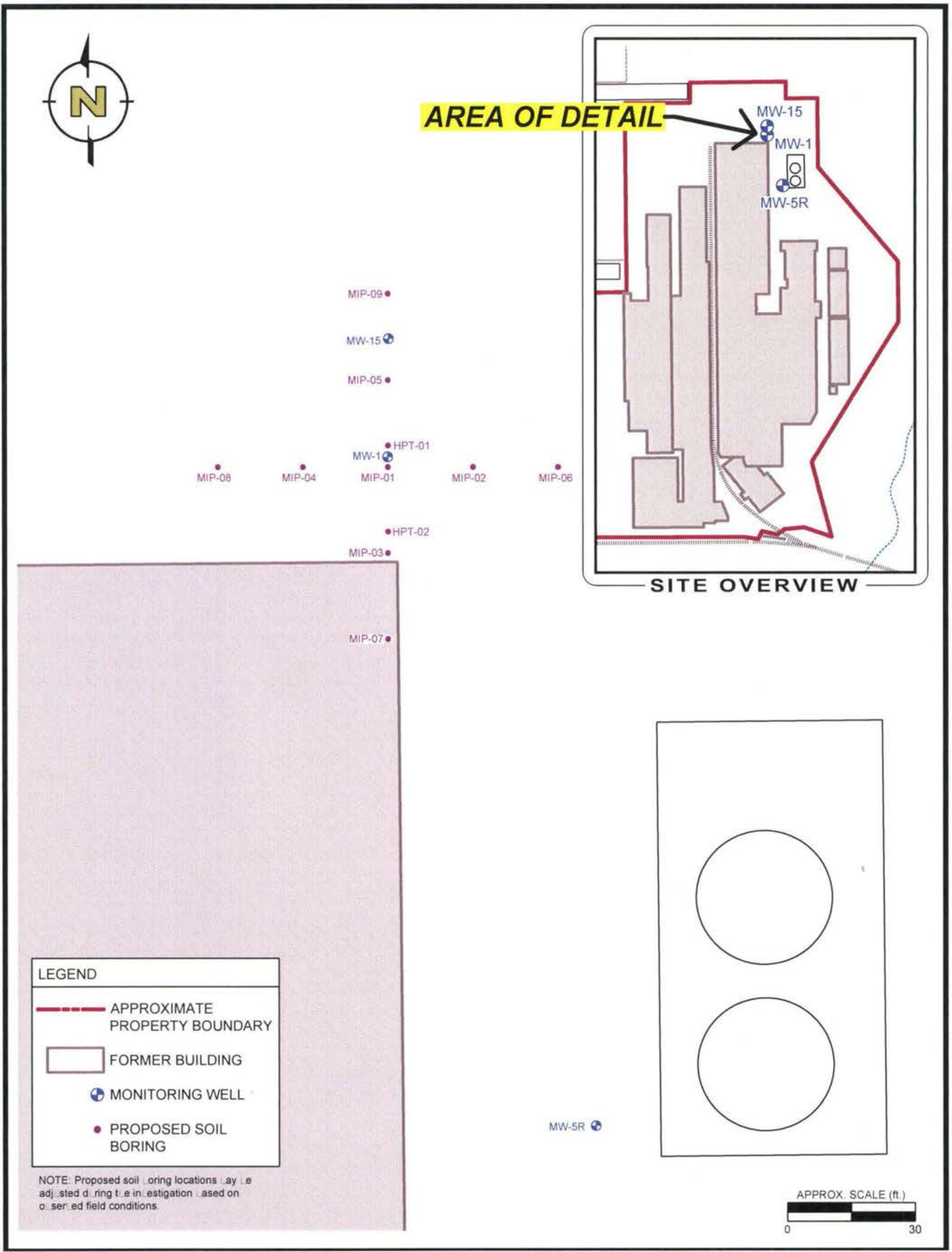
DATE: 1/9/14

SITE GROUNDWATER AND SOIL SAMPLING LOCATIONS

FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

FIGURE
1-4

21-29014A



ENVIRON

DRAFTED BY: ELS

DATE: 1/9/14

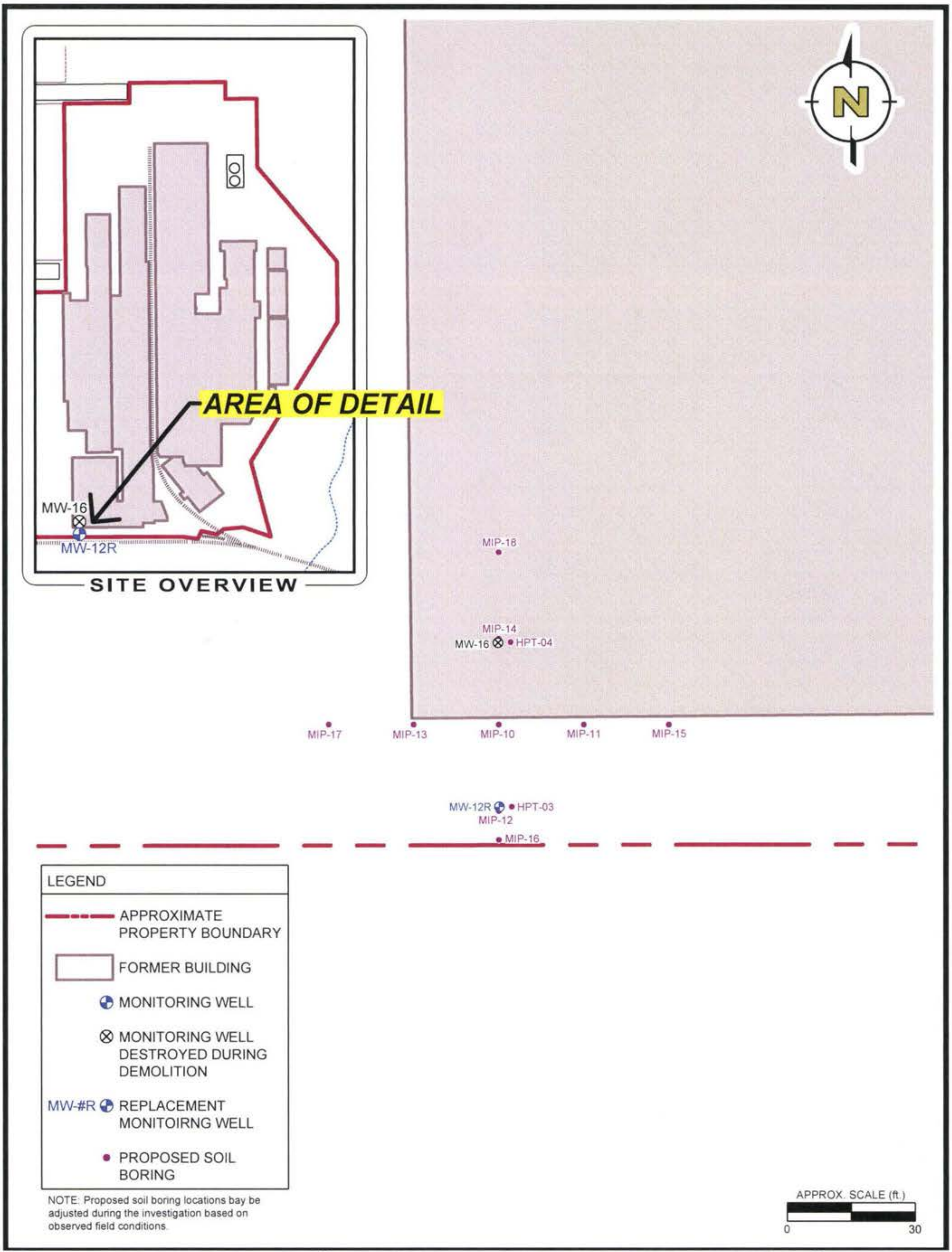
PROPOSED INVESTIGATION LOCATIONS FOR THE MW-1/MW-5 GROUNDWATER AREA

FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

FIGURE
2-1

21-29014A

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-4, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7.dwg



NOTE: Proposed soil boring locations bay be adjusted during the investigation based on observed field conditions.

ENVIRON

PROPOSED INVESTIGATION LOCATIONS FOR THE MW-12/MW-16 GROUNDWATER AREA

FORMER CHAMBERLAIN MANUFACTURING PROPERTY
WATERLOO, IOWA

FIGURE
2-2

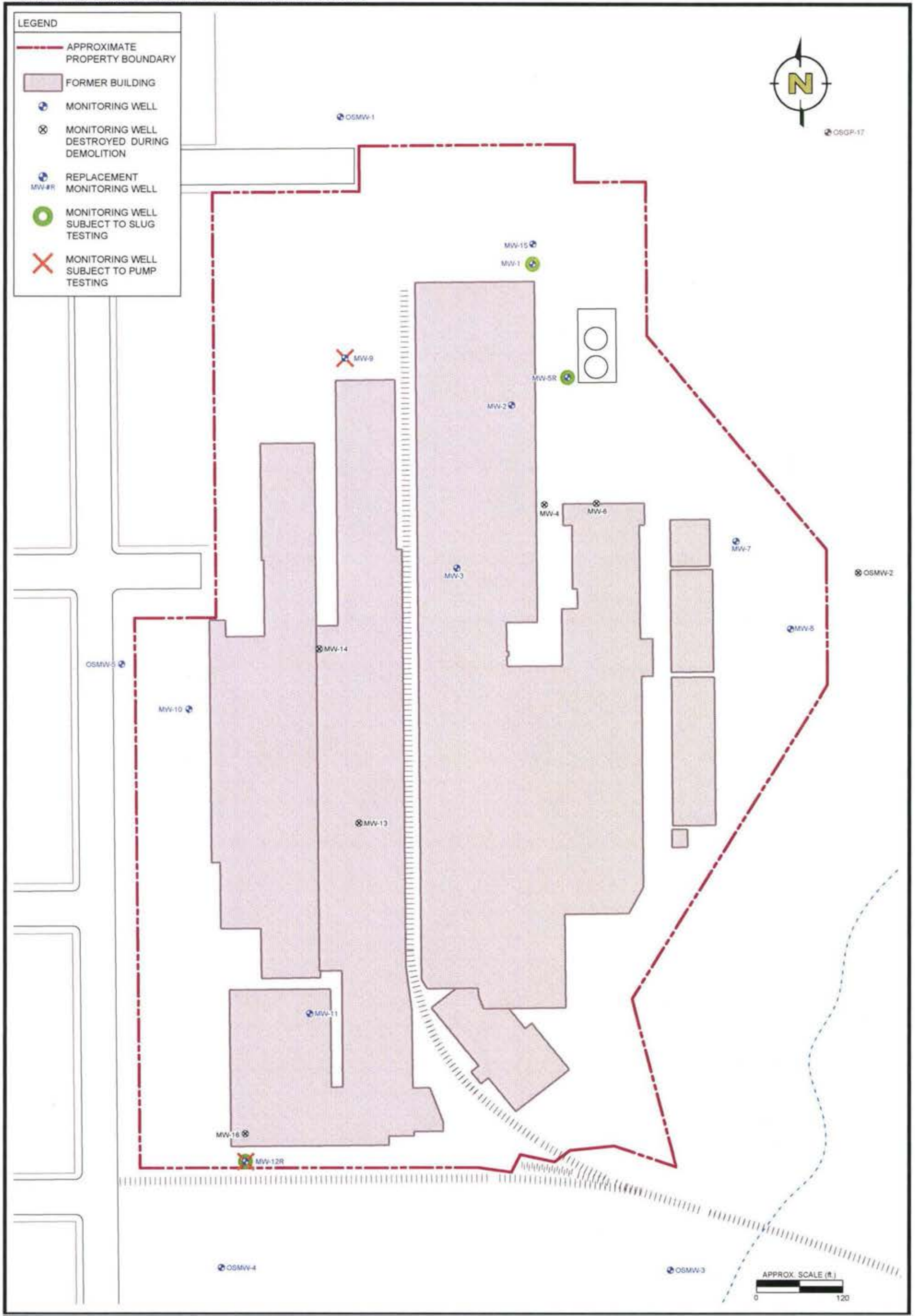
DRAFTED BY: ELS

DATE: 1/16/14

21-29014A

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-4, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7.dwg

L:\Loop Project Files\00_CAD FILES\21\Jones Day_Waterloo 21-29014A\1-4, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7.dwg



ENVIRON

DRAFTED BY: ELS

DATE: 1/9/14

PROPOSED LOCATIONS FOR HYDRAULIC CONDUCTIVITY AND PUMP TESTS

FORMER CHAMBERLAIN MANUFACTURING PROPERTY

WATERLOO, IOWA

FIGURE

2-3

21-29014A