FINAL DESIGN (100% SUBMITTAL)

Olean Well Field Superfund Site, Operable Unit 3

Prepared by:

CDM Smith
555 17th Street, Suite 500
Denver, Colorado 80202

Prepared for:

ARCONIC
Innovation, engineered.
www.arconic.com

Arconic
2300 North Wright Rd.
Alcoa TN, 37701

Attn: Mr. Robert Prezbindowski

September 2018

CDM Smith

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Acronyms

CDM Smith	CDM Smith Inc.
COC	chemical of concern
DCE	dichloroethene
DO	dissolved oxygen
DQOs	data quality objectives
EPA	Environmental Protection Agency
FFS	focused feasibility study
ft	feet
gal	gallons
GC/FID	gas chromatographic-flame ionization detector method
HDPE	high-density polyethylene
IDW	investigation derived waste
L	liter
lbs	pounds
mg/L	milligrams per liter
mL	milliliter
MS/MSD	matrix spike/ matrix spike duplicate
mV	millivolts
ORP	oxidation reduction potential
OU	operable unit
PCE	tetrachloroethene
ROD	record of decision
RPD	relative percent difference
Site	Alcas Cutlery Corporation Facility Site
TCE	trichloroethene
µg/L	micrograms per liter
UIC	underground injection control
UWBZ	upper water bearing zone
VC	vinyl chloride
VOC	volatile organic compound
vs	versus

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Section 1

Introduction and Background

This report presents the basis and design criteria for the remedial design (RD) of the selected remedy for the Olean Well Field Superfund Site, Operable Unit (OU) 3 (Site). The remedy was approved by the United States Environmental Protection Agency (EPA) to address impacted groundwater within OU3. The selected remedy was presented in the Record of Decision (ROD) for OU3 (EPA 2014). The activities described in this report will be conducted according to the Remedial Design/Remedial Action Statement of Work for OUs 2 and 3 at the Alcas Source Area at the Olean Well Field Superfund Site, hereafter referred to as the SOW. This report was prepared in general accordance with EPA guidance, the Remedial Design/Remedial Action Handbook (EPA 1995), and incorporates the remedial objectives and requirements presented in the ROD (EPA 2014) as design criteria. In general, the purpose of the remedial action (RA) at the Site is to mitigate trichloroethene (TCE) and its degradation products in groundwater within OU3. The RA was identified as necessary to protect human health and the environment from the presence of TCE and its degradation products in groundwater within OU3.

1.2 Introduction and Background

The Olean Well Field Superfund Site is located in the eastern portion of the City of Olean in Cattaraugus County, New York. The Site is characterized by impacted groundwater encompassing an area of approximately 800 acres within the City of Olean, the Town of Olean and the Town of Portville, and by contaminated soil at certain locations in the City and Town of Olean. The Site is approximately 65 miles southeast of Buffalo, New York, and seven miles north of the New York/Pennsylvania border. The Allegheny River, a principal tributary of the Ohio River, flows toward the west-northwest adjacent to the southern portion of the Site. A site location map is provided as **Figure 1**.

1.2 Site Description

The EPA has divided the Site into operable units (OUs) for remediation purposes. Operable Unit 1 (OU1) addresses the drinking water supply for the City and Town of Olean. The Allegheny River flows through the southwest and southern portions of the Site. OU2 addresses the sources of volatile organic compound (VOC) contamination to groundwater at four identified source areas: Alcas Cutlery Corporation (Alcas); Loohn's Dry Cleaners and Launderers (Loohn's); McGraw-Edison Company (McGraw); and AVX Corporation (AVX). The Alcas source area includes the real property at which Alcas formerly conducted manufacturing operations, located at 1116 East State Street, which is currently occupied by the Cutco Corporation (this facility is hereafter referred to as the Alcas Source Area).

The Alcas Source Area also includes several parcels of land to the south of the Alcas Facility that are impacted by contaminated groundwater including, but not necessarily limited to parcels identified on the City of Olean tax map as Block 2, Lots 23, 24 and a portion of Lot 44 (collectively, these parcels are hereafter referred to as Parcel B). OU3 has been developed to address groundwater contamination at Parcel B. The Alcas Facility and Parcel B hereafter constitute the Alcas Source Area. A map of the Alcas Source Area is provided as **Figure 2.**

This document presents the basis of the remedial design to address groundwater contamination at OU3, in accordance with the ROD for OU3 (EPA 2014).

1.3 Site History

A portion of the Alcas Source Area was formerly occupied by the Alcas Cutlery Corporation and is currently occupied by the Cutco Corporation. Cutlery and sporting knives have been manufactured at the facility since 1949. The facility formerly used trichloroethene (TCE) as part of the manufacturing process.

Following initial investigation activities, the U.S. Environmental Protection Agency (EPA) added the Site to the National Priorities List in September 1983. Between 1983 and 1985, the EPA conducted additional investigations at the Site and initiated early remedial actions including the supply of carbon adsorption filters to owners of impacted private wells. It was determined that soils and groundwater were impacted by several chemicals of concern (COCs) including TCE and its degradation products, with established pathways of migration to the Site's upper water-bearing zone (UWBZ) and upper aquitard, and the lower aquifer (City Aquifer). Targeted daughter, or degradation, products for TCE include cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC). Tetrachloroethene (PCE), a parent product for TCE, has also been detected at the Site at relatively low levels.

1.4 Summary of OU3 Pilot Test Activities

A pilot study to demonstrate the feasibility of enhanced anaerobic bioremediation (EAB) at the Site was implemented in 2011 and 2012. The results are summarized in the Final Enhanced Anaerobic Bioremediation Pilot Study Report (CDM Smith 2012). The primary objective of the pilot study was to determine whether bioremediation with bioaugmentation could be implemented as a cost-effective remedy for chlorinated solvent impacts in groundwater within OU3. During the pilot study, electron donor consisting of a mixture of fast-release and slow-release carbon substrates was injected into the UWBZ within OU3, near monitoring wells RU-10, RU-19, and RU-21. The donor was successfully distributed within the aquifer using low-pressure direct-push technology (DPT) injection techniques. Due to the relatively low, but highly variable, permeability of the aquifer formations at the Site, pressurized DPT injection using a "top-down" approach was determined to be an effective method for distributing electron donor both horizontally and vertically at the Site. A retractable-screen injection tool was used to facilitate top-down injection through the UWBZ.

The pilot study cell showed strongly reducing conditions following electron donor injection, and in general these favorable reducing conditions were maintained throughout the duration of the pilot study. Bioaugmentation in the cell was successful based on the results of groundwater samples indicating elevated populations of *Dehalococcoides spp.* (DHC) and functional genes, contributing to the development of an efficient dechlorinating culture in the pilot study cell. Methanogenesis occurred in the pilot study cell within 5 months of amendment injection, and ethene began to be detected at 6 months post-injection.

The pilot study results demonstrated that EAB can be stimulated for cost-effective treatment of TCE in groundwater, and in the presence of the bioaugmentation culture, reductive dechlorination occurred with a reduction in TCE concentration of approximately 95 percent, and a reduction in total chloroethenes of approximately 85 percent in areas where amendment was delivered. In addition to the observed VOC reduction, the results of the pilot study indicated that dissolved metals and TOC concentrations decline substantially outside of the area targeted during amendment injections, indicating that migration of these constituents during EAB is not expected to be a concern. The methods used during the pilot study serve as the basis for scaling up EAB to treat the portion of the VOC plume present within OU3.

1.5 Selected Remedial Alternative

The selected remedy for the Site was presented in the ROD for OU3 (EPA 2014). The major components of the selected remedy for TCE-impacted groundwater at Parcel B include the following:

- EAB to promote reductive dechlorination of detected constituents through a series of injection wells to degrade organic contaminants;
- Institutional controls for groundwater use restrictions until remedial action objectives (RAOs) are achieved to ensure the remedy remains protective. A plan will be developed which specifies institutional controls to restrict exposure to hazardous substances until RAOs are met, which are anticipated to include proprietary controls, such as deed restrictions for groundwater use, existing governmental controls, such as well permit requirements, and informational devices, such as publishing advisories in local newspapers and issuing advisory letters to local governmental agencies regarding groundwater use in the impacted area;
- Implementation of a long-term groundwater monitoring program to track and monitor changes in the groundwater to ensure the RAOs are attained. The sampling program will also monitor groundwater quality including degradation by-products generated by the treatment processes to ensure that drinking water quality standards are met at the nearby municipal water supply well 18M. The results from the long-term monitoring program will be used to evaluate the migration and changes in VOC contaminants over time; and
- Development of a site management plan (SMP) to provide for the proper management of the Site remedy post-construction, including through the use of institutional controls until RAOs are met, and will also include long-term groundwater monitoring, periodic reviews, and certifications. The SMP will also provide for the evaluation of the potential for soil vapor intrusion for any buildings developed on Parcel B.

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Section 2

Design Criteria

2.1 Regulatory Requirements and ARARs

Applicable or relevant and appropriate requirements (ARARs) for the Site were presented in the ROD (EPA 2014). ARARs are classified into three categories: (1) chemical-specific, (2) location-specific, and (3) action-specific, depending on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action. 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. Location-specific ARARs are restrictions on the concentration of constituents or the conduct of activities in environmentally sensitive areas. Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions or conditions taken with respect to specific constituents. Action-specific ARARs do not determine the remedial alternative; rather, they indicate how a selected alternative must be achieved. According to published EPA guidance (EPA540-R-98-020), ARARs may be waived under certain circumstances during on-site response actions. In other cases, the response might incorporate environmental policies or proposals that are not ARARs but do address site- specific concerns. Such to-be-considered (TBC) standards may be used in determining the cleanup levels necessary for protection of human health and the environment. These TBCs include nonpromulgated criteria, advisories, guidance, and proposed standards. ARARs and TBCs for OU3 are presented in **Appendix A**. The selected remedy described in this report is expected to be protective of human health and the environment, comply with ARARs, and be implemented in a cost-effective manner.

2.2 Remedial Action Objectives

Remedial action objectives (RAOs) are specific goals listed in the ROD to protect human health and the environment. These RAOs are based on available information and standards, including ARARs, TBCs, and site-specific risk-based levels. The RAOs for OU3 are designed to restore the upper and lower aquifers to their beneficial use as a drinking water source. The groundwater RAOs as stated in the ROD (EPA 2014) are as follows:

- Restore the City Aquifer beneath the Alcas Facility and Parcel B to its beneficial use as a source of drinking water by reducing contaminant levels to the more stringent of federal MCLs or New York State standards (**Table 2-1**);
- Minimize, contain and/or eliminate sources of VOC contaminants present in the shallow groundwater at the Alcas Facility and Parcel B;
- Minimize and/or eliminate the potential for human exposure to site contaminants via contact with impacted groundwater.

Table 2-1 Analytical Methods and Target Cleanup Levels

Analyte	Analytical Method	Cleanup Level (ppb)*
Trichloroethylene (TCE)	EPA 8260	5
cis-1,2-dichloroethene		5
trans-1,2-dichloroethene		5
Tetrachloroethylene (PCE)		5
Vinyl Chloride (VC)		2
Xylene		5

*Cleanup level values are presented in the ROD and are selected based on NYS Groundwater Quality Standards, or NYSDOH Drinking Water Standards when groundwater quality standards are not available.

2.3 Additional Design Criteria

This section provides a summary of additional criteria used during this phase of design, in addition to the RAOs described in the previous section.

2.3.1 EPA Underground Injection Control Permit Requirements

The injection activities to be completed at the Site are expected to fall under classification as Class V injection wells under the EPA Region 2 Underground Injection Control (UIC) program. Owners or operators of all Class V injection wells, existing and new, must submit inventory information to the UIC Program coordinator. Required information includes: facility name and location; name and address of legal contact; ownership of facility; nature and type of injection wells; and operating status of injection wells. Under EPA Region 2 UIC rules, injections used for remediation do not require a UIC permit since they are considered "rule-authorized". Although they do not require a UIC permit, an inventory form and information will be submitted to EPA and the New York State Department of Environmental Conservation (NYSDEC) at least one month prior to injection activities described in this design. No permits or fees are anticipated.

2.3.2 Avoid Impact to Municipal Well 18M

The RA for OU3 will be implemented in a manner that avoids adverse impacts to the operation of municipal water supply well 18M. All amendment injection activities will be completed in the interval above the Upper Aquitard to avoid delivering amendments to the upper portion of the City Aquifer. The results of the EAB pilot study (CDM Smith 2012) indicated that migration of metals or carbon outside of the EAB treatment area did not occur. If metals are temporarily mobilized within the treatment area, which has strongly reducing conditions, these metals would be expected to precipitate out of solution when they migrate outside of the treatment area where conditions are more oxidizing. Additionally, dissolved carbon compounds in groundwater are degraded and consumed by microbes outside of the treatment area and would not be expected to migrate a significant distance. Periodic monitoring will be conducted at wells within the UWBZ and City Aquifer, to evaluate whether dissolved carbon from injected amendments has migrated significantly away from the target treatment area. The frequency of sampling and proposed analytes are presented in Section 5 of this report. Given that the target treatment area in the UWBZ is in an area of relatively flat hydraulic gradient, it is not expected that injected amendments will migrate a significant distance away from the injection points as observed during the pilot study.

2.3.3 Sustainable/Green Remediation

Green remediation is the practice of considering all environmental effects of the implementation of a remedy and incorporating options to maximize the net environmental benefit of cleanup actions. EPA strives for cleanup programs that:

- Use natural resources and energy efficiently
- Reduce negative impacts on the environment
- Minimize or eliminate pollution at its source
- Reduce waste and reuse materials to the maximum extent possible

To the extent practical, Arconic will incorporate green remediation practices into the remedial design and construction in accordance with the EPA Region 2 "Clean & Green" Policy, issued on March 17, 2009 and updated on April 11, 2010. Green remediation strategies will be implemented to reduce direct and indirect greenhouse gas and other emissions, increase energy efficiency, conserve and efficiently manage resources and materials, reduce waste, and increase reuse of materials. To incorporate green remediation practices into the remedial action, an evaluation of potentially applicable best management practices (BMPs) was completed in general accordance with the ASTM Standard Guide for Greener Cleanups (ASTM E2893-16). The summary of the evaluation of BMPs included in the ASTM Standard Guide which could be potentially applicable for a bioremediation remedy, as well as identification of those retained for implementation during the remedy, is included as **Appendix B**. This evaluation identified several BMPs which will be implemented during the remedy, and these are described in further detail in the following subsections of the report along with other proposed sustainable practices.

Documentation and records supporting the green remediation practices incorporated into the remedy will be maintained during remedy implementation.

2.3.3.1 Vehicles and Fuel/Power

Most fuel that will be used during RA activities is associated with vehicles, equipment and drilling rigs that will be used during amendment injection and sampling activities. The following BMPs will be implemented:

- Subcontractors will be requested to use biodiesel (B-20) if locally available on the project, which will improve the quality of the vehicle exhaust.
- An idle reduction plan will be implemented for all field vehicles and machinery, to reduce unnecessary idling outside of active work activities and necessary equipment operation

2.3.3.2 Materials and Supplies

Material reuse, reduction, and recycling minimizes impacts on natural resources and reduces the production of waste. Waste reduction minimizes environmental impacts by limiting the amount of land required for waste disposal and minimizing consumption of fossil fuels and generation of air emissions associated with transport of the waste. Material reuse, reduction and recycling practices and BMPs at the Site will include the items detailed below.

- Copy papers, file folders, and paper office supplies will be sourced from recycled sources.
- Existing wells will be re-used to the extent practical for monitoring during remedy implementation.
- Dedicated sampling equipment will be re-used to the extent practical during the remedy
- Bio-based products, such as soybean oil derivatives, will be used to stimulate biodegradation
- Steam cleaning or non-phosphate detergents will be used for decontamination rather than solvents or acids.

2.3.3.3 Sustainable Practices/Project Planning and Management

Sustainable site practices minimize degradation of ecosystems and promote good stormwater management. The sustainable practices and project planning techniques listed below will be implemented during the remedy:

- Sequencing and scheduling shall be performed in such a manner to minimize transportation and/or shipping fuel consumption whenever possible. This shall include
  - Use of local laboratories when possible to reduce sample shipments,
  - Use of local suppliers for field equipment and supplies when possible
  - Use of local field staff and subcontractors when possible
- The number of field mobilizations shall be minimized when possible to reduce fuel consumption.
- Measures will be taken to reduce vehicle trips and impacts to the site, including planning multiple activities in a single trip to minimize number of trips.
- Clearing of vegetated areas and disturbance to vegetation will be minimized during RA implementation through limiting access to vegetated areas to essential vehicles only and using a single point/route of access for the work area. Equipment for drilling and injection will be of a type that minimizes disturbance to vegetation and care will be taken during mobilization to avoid sensitive vegetated areas at the site.
- Soil disturbance during RA implementation is expected to be limited to well drilling and injection activities with a small footprint; therefore, disturbance to the work area is expected to be minimal.
- Stormwater contact with soils generated during RA implementation will be minimized.

Section 3

Design Components

3.1 Site Controls

This section presents a summary of controls in place or planned for the OU3 site, including limitations on site access, security during remedy implementation, and controls to prevent damage to infrastructure at the site.

3.1.1 Site Access and Security

Access to all properties necessary to implement the OU3 selected remedy will be coordinated prior to implementation. The work is expected to occur entirely on private property. The majority of activities are expected to occur on Parcel B, located south of the Alcas source area. During implementation of the remedy, the work area will be secured in order to prevent access by unauthorized personnel and to protect equipment from vandalism and theft. Equipment and supplies at the EAB treatment area will be secured as necessary (i.e. materials and amendment will be stored in a locked building on site when necessary). Due to the short-term nature of the work, lack of above-grade infrastructure, and remote location of the work area away from public roads, fencing of the site for security is not expected to be necessary.

3.1.2 Utilities

At least three working days prior to any drilling activities, the public utility location service Dig Safely New York will be contacted to determine if utilities are present near the proposed well or injection locations. The drilling subcontractor shall be responsible for contacting Dig Safely New York to determine if any of the proposed drilling locations are near any underground water, electric, gas, cable, or other utilities. In the event that these utility location services do not identify buried utilities on a private property, then the drilling subcontractor will secure the services of a private utility location company to determine if any of the proposed well locations are near any underground utilities. The subcontractor will document all requests for utility location, utility location reference numbers, and results of the locating activities.

In terms of utilities needed for RA activities, potable water is needed to mix with the amendment prior to injection to dilute it to the proper concentration. The potable water is expected to be obtained from a fire hydrant near the Site and transported to the injection locations by truck or through use of fire hoses. If necessary, a generator will be used to supply power to the injection system.

3.2 Design Approach

The following section describes the approach to design for the major components of the OU3 remedy.

3.2.1 Target Treatment Area

The target EAB treatment area is located in the south-central portion of Parcel B. This area was determined to be an appropriate treatment area because it contains the core of the TCE plume (i.e. areas where TCE has historically been greater than 0.1 milligrams per liter [mg/L]) and targets the most down gradient portion of the known TCE plume. The treatment area is approximately 36,000 square feet and the assumed thickness of the aquifer to be targeted for treatment is 25 feet, with treatment generally targeted between 10 and 35 feet bgs. This thickness was based on the EAB pilot study, which indicated the presence of elevated VOC concentrations in the UWBZ and upper portion of a transition zone between the UWBZ and Upper Aquitard. In general, based on previous site investigations and the EAB pilot study completed at the site (CDM Smith 2012, ENI 2013), the top of the City Aquifer is anticipated to be located approximately 40 to 50 feet below ground surface (bgs) at Parcel B. The target vertical interval was selected to deliver amendment to the impacted vertical interval while avoiding potential for amendment delivery below the Upper Aquitard to the upper portion of the City Aquifer. The layout for the treatment area and approximate injection point locations are shown on **Figure 3**. The injection locations will be placed evenly throughout the treatment area and approximately forty (40) locations are anticipated to inject the amendment into the affected groundwater. Additional boreholes will be advanced as necessary in order to deliver the target mass of amendment into the treatment area as described in Section 3.2.3 of this report.

The groundwater flow direction in the treatment area is to the south-southeast, but relatively stagnant (has a relatively flat hydraulic gradient) within Parcel B. An anaerobic reactive zone will be created by the injections, facilitating anaerobic reductive dechlorination within the areas where amendment is injected. The flat gradient should help minimize the potential for amended, anaerobic groundwater from reaching well 18M, but the injection strategy will include precautions to avoid that.

Injection in the target treatment area is planned to be completed in up to three phases, progressing from the south to the north, as described in Section 3.2.4. The actual final number of injection boreholes and their locations might be modified based on the results observed during each phase of injections in order to optimize treatment.

3.2.2 Monitoring Well Installation

In order to adequately monitor the effectiveness of EAB within the target treatment area, additional monitoring wells will be necessary to collect data in areas where wells do not currently exist. This will provide information regarding progress of the remedy throughout the target treatment area. Proposed monitoring well locations are presented on **Figure 3**. Should the technical need arise, the existing monitoring well network may be modified or expanded in the future to support the site conceptual model and remedial strategy.

Monitoring wells will be installed in accordance with industry standards and are expected to be installed using hollow-stem auger or direct-push drilling techniques. During installation of the wells, soil will be logged continuously for field screening and to complete the boring log. Borings will be logged using the Unified Soil Classification System, describing lithology, mineralization, color, texture and other relevant features. Each monitoring well be a 2-inch diameter well, constructed with Schedule 40 polyvinyl chloride well screen and casing. A 10-foot length of machine slotted screen will be installed to monitor the upper water bearing unit. The sand pack surrounding the screen will be 20/40 silica sand to at least 1 foot above the top of the screen. A 2- to 3-foot bentonite plug will be placed on top of the sand pack. The remaining annulus will be grouted using 95% (by weight) cement and 5% bentonite powder, placed using a tremie pipe. The wells will be protected at the surface with flush-mounted protective covers. **Figure 4** presents a typical monitoring well construction diagram.

After construction, the wells will be developed by surging and pumping until turbidity (as measured by field measurement) is less than 50 nephelometric turbidity units (NTU) if aquifer conditions allow. If the aquifer formation contains significant silt and clay and the turbidity cannot be reduced to below 50 NTU, then the well will be developed until turbidity is stable. The wells will be left to recover for at least 24 hours. Once the wells have stabilized and equilibrium has been reached, water levels will be documented. Top of casing elevations will be surveyed to tie in the newly installed wells to the existing well network at the Site.

3.2.3 Amendment Selection and Dosing

Various types of electron donors were evaluated prior to the EAB pilot study completed at the site in 2011 and 2012. Electron donors come in two basic types: aqueous and "slow-release." Aqueous electron donors are generally miscible and of a viscosity similar to water and are therefore relatively easy to distribute in the subsurface and are very quickly used by the microbial community. They have the disadvantage that they typically last only a few months in the subsurface, and therefore must be reinjected more frequently. Slow-release donors are typically high-viscosity liquids or solids that last much longer than aqueous donors but are more difficult to distribute in subsurface soils. At this site, slow-release donors are generally appropriate for the more permeable soils for a couple reasons. First, the shallow depth of the target treatment zone and the unconsolidated soils allow emplacement of a large amount of electron donor using a grid of direct-push injection locations. Second, the residential land use in the area makes it desirable to minimize the number of injection events but provides relatively easy access to many injection locations. Therefore, the electron donor used for EAB implementation at OU3 will be a combination of aqueous donors, such as lactate, and slow-release donors, such as components derived from vegetable oil, to maximize the longevity of the amendment, but take advantage of better distribution and reduced lag time before onset of microbial activity (CDM Smith 2012). The amendment to be used includes a minimum of 10 percent by weight of an aqueous fast-release (lactate) amendment, which is a sufficient amount to quickly generate reducing conditions and stimulate microbial activity in the subsurface following amendment injections.

In order to estimate the required quantity of electron donor needed to support EAB in the target treatment area, two different methods were used. Calculations using these two methods are shown in **Appendix C**. The first method used to determine the amendment quantity based on the ability of the aquifer matrix to retain emulsified vegetable oil following injection. To generate this estimate, the mass of soil in the treatment area was calculated using the volume of the target treatment area multiplied by the porosity and an assumed dry density based on the soil type (clayey sand). It was assumed that the oil retention for the alluvium, clayey sand aquifer is 0.0013 grams of oil per gram of soil (ESTCP 2006). To find the total amount of oil that can be retained in the aquifer we multiplied the oil retention by the estimated mass of soil in the aquifer. Based on these assumptions, a total of 32,000 kilograms (8,500 gallons, assuming specific gravity of 1) of amendment can be retained in the aquifer matrix within the target treatment area.

The second method used to estimate donor requirements was to select a desired carbon concentration in the groundwater and to determine the necessary amendment quantity to achieve the desired carbon concentration throughout the treatment area volume. The same aquifer volume and porosity assumptions were used for this calculation. The desired carbon concentration of amendment in the groundwater is 2,000 milligrams per liter (mg/L), which has been sufficient to stimulate efficient reductive dechlorination in groundwater at similar sites where EAB has been implemented. The desired carbon concentration was multiplied by the volume of the groundwater in the aquifer to estimate the total amount of amendment required. This calculation resulted in an estimate of 18,000 kilograms (4,700 gallons assuming specific gravity of 1) of amendment required to reach the desired carbon concentration in the groundwater.

To ensure that sufficient amendment is delivered to the aquifer and to maximize the longevity of the amendment in the subsurface, CDM Smith assumes that the higher amendment quantity from the two calculations will be used during implementation of the remedy, resulting in a minimum amendment volume of approximately 32,000 kilograms (8,500 gallons assuming specific gravity of 1) during each injection event. Based on the pilot study at the Site and experience at similar sites where EAB has been implemented using this approach, injection events are anticipated to occur every 3 to 4 years.

3.2.4 Amendment Delivery Strategy

The pilot study (CDM Smith 2012) did not indicate that mobilization of metals or carbon compounds outside of the treatment area would be a concern during implementation of EAB, but a phased approach to implementation of the full-scale remedy, with a larger target treatment area and greater amendment volumes, will allow for adequate monitoring to ensure that impacts are not observed outside of the target treatment area which could have a detrimental impact on municipal well 18M. The phased approach would be implemented as follows:

- Injection of amendments into the target treatment area is planned to occur in two phases. The initial phase of injection is planned in the southern (most down gradient) half of the target treatment area, furthest away from well 18M. A total of 20 locations in the southern half of the target treatment area would be injected during the first phase of injection.

- The initial phase of injection will be monitored for approximately 6 months to ensure that no adverse impacts occur outside of the target treatment area. Adverse effects for which we would monitor include:

  - Increases in dissolved metals greater than one order of magnitude from baseline concentrations observed at wells CW-13A or CW-13B, located between the Phase 1 target treatment area and municipal well 18M.

  - Increases in total organic carbon or volatile fatty acid concentrations of greater than 1,000 mg/L at well CW-13A or 250 mg/L at CW-13B.

- As described in Section 2.3.2 of this report, significant migration of dissolved metals and carbon compounds outside of the treatment zone is not anticipated. If increases in metals are observed outside of the target treatment area as described above, and these increases are sustained for greater than 6 months after injection, then additional amendment injections will not be completed until concentrations decline. If increases in metals and carbon compounds are not observed outside of the target treatment zone, then the second phase of injection will be implemented, which is expected to address the remaining 20 proposed injection points in the northern half of the target treatment area presented on **Figure 3**.

Direct-push techniques will be used to inject amendments into the subsurface, using temporary injection points. As during the pilot study, a retractable screen injection tool will be advanced using direct push techniques, and a top-down approach will be used for injection throughout the vertical treatment interval to deliver amendment in the target vertical intervals. This top-down technique has the advantage of being able to target amendment injection in very specific vertical intervals, including intervals with less permeable soils, and reduces the likelihood of most of the amendment being delivered to high-permeability preferential pathways within the target vertical interval.

Amendment injections will be targeted within the UWBZ and the upper portion of the transition zone above the Upper Aquitard at the Site, which is the vertical interval impacted by VOCs. In general, based on previous site investigations and the EAB pilot study completed at the site (CDM Smith 2012, ENI 2013), the top of the City Aquifer is anticipated to be located approximately 40 to 50 feet below ground surface (bgs) at Parcel B. Therefore, the estimated vertical interval to be targeted for amendment injection in the UWBZ is between approximately 10 and 35 feet bgs. Injection points will be designed such that amendment is not injected into the Upper City Aquifer. Based on the observations during the EAB pilot study, an effective radius of influence (ROI) of approximately 10 feet should be achievable from a temporary injection point in the UWBZ, with injection points spaced at approximately 30 feet. It is expected that amendment will migrate to some extent within the treatment zone through dissolution and diffusion or advective transport in groundwater to treat areas located between the injection points. If performance monitoring after the first phase of injection indicates that distribution of amendment is inadequate to meet the objectives described in this section, then injection spacing may be modified during future amendment injection events.

The electron donor product, containing 100 percent fermentable carbon compounds, will be diluted 1:1 with potable water on site prior to injection. A direct-push rig will then pump the electron donor solution directly into the formation across the target thickness of aquifer (25 feet) in the areas shown on **Figure 3**. Injection locations may require adjustment in the field based on the locations of interferences such as utilities and/or surface obstructions. Based on observations from the pilot study, between 400 and 500 gallons of electron donor, distributed vertically, are adequate to achieve an approximate ROI of 10 feet from the injection location. Injection locations are expected to be spaced on a grid with approximately 30 foot spacing. Assuming 40 injection locations as presented on **Figure 3**, with an approximate injection volume of 450 gallons per location, a total of approximately 18,000 gallons of solution are planned to be injected during the two phases of the injection event as described above. The solution injected will contain approximately 8,500 gallons of electron donor. This value is equal to the estimated electron donor quantity to provide sufficient amendment in the aquifer to sustain reductive dechlorination based on the results of calculations presented in Section 3.2.3 and documented in **Appendix C**. A detailed description of the injection process is presented in the following paragraphs.

The electron donor will be injected in a "top-down" approach with a retractable-screen injection tool, such as the AMS retractable remediation injection tool used in the extended pilot test or other similar tooling. The direct-push rods will be advanced to about one foot below the top of target interval, then pulled back to expose the screen on the injection tool. The appropriate fraction of the electron donor solution will then be injected. Next, the direct-push rods will be pushed to close the retractable screen, the rods will be advanced to the next target depth (2-3-foot intervals) until the total target depth has been reached and target volume injected. For example, if the target interval for injection is between 10 and 35 feet bgs and the target injection volume at each location is approximately 450 gallons, then the injection will occur at depths of approximately 11, 14, 17, 20, 23, 26, 29, and 32 feet bgs, with approximately 56 gallons of electron donor solution injected at each depth. This strategy has the advantage of maximizing the probability of achieving the desired vertical distribution of electron donor solution. Injection rates for electron donor during the pilot study were generally observed to be between 1 and 4 gallons per minute (gpm), with the slower flow rates observed in the lower-permeability zones present at depths shallower than approximately 16 feet below ground surface. Planned electron donor injection rates during implementation will be between 1 and 4 gpm, with an average injection rate of 2 gpm assumed. This flow rate may be adjusted as necessary in the field based on the actual permeability of the specific injection interval. Based on observations during the pilot study, approximately 1,000 gallons of amendment solutions can be injected using a single direct-push drill rig during a working day.

One potential issue which can arise during pressurized direct-push amendment injections is the potential for the injected electron donor to surface through preferential pathways. These pathways include abandoned boreholes from previous sampling at the Site, soil disturbed due to previous construction activities, or other natural pathways. To minimize potential for surfacing, pressures will be maintained as low as possible while still maintaining flow. Injection pressures during the EAB pilot study were generally between 30 and 50 pounds per square inch, with no surfacing of amendment observed (CDM Smith 2012). Therefore, amendment pressures will be maintained below these levels to the extent practical. It should be noted that injections using direct push techniques are typically conducted at pressures slightly higher than the overburden pressure in the aquifer to initiate flow of amendment into lower-permeability lithologies. To the extent feasible, injections will not occur near previous borehole locations or other structures that might allow a preferential pathway to the surface. Finally, if electron donor is observed to surface at any specific location (including monitoring wells), then steps will be taken to reduce potential for surfacing, including reducing injection pressures or moving injection points further away from the location where surfacing is occurring. All electron donor observed to surface will be contained using spill-containment equipment as necessary, including granular oil absorbent material and absorbent booms. All materials used for spill cleanup will be containerized. At no point could more than a few gallons of electron donor reach the surface from an injection given the small volumes injected at each interval.

Following completion of the amendment injection as described above, temporary piezometers will be installed at select amendment injection points for delivery of bioaugmentation culture following completion of the amendment injections as described in Section 3.2.5. The temporary piezometers will consist of 1-inch diameter PVC with approximately 20 feet of factory-slotted screen installed within the targeted injection interval. Screen intervals may be modified in the field based on observations during injections and the actual vertical intervals targeted at each injection location. The boring annulus surrounding the piezometers will be backfilled with a sand filter pack to at least one foot above the screen interval, and hydrated bentonite will be used to seal the borehole annulus up to the ground surface. The temporary piezometers will be removed following completion of bioaugmentation.

In order to efficiently complete amendment injections and reduce the risk of logistical problems such as gelling or solidification of electron donor products or freezing of amendment solutions, amendment injections shall be completed during periods of warm weather, typically between May and September.

3.2.5 Bioaugmentation

Based on observations during the pilot study, bioaugmentation is expected to be necessary at OU3 to stimulate rapid reductive dechlorination in the EAB treatment area. Bioaugmentation is the process of adding a culture containing dechlorinating microorganisms that are not sufficiently present in the native community. Bioaugmentation was completed during the pilot study and determined to be beneficial at OU3. The dechlorinating bacteria, *Dehalococcoides spp*. (DHC), and the functional genes tceA and bvcA, or vcrA are necessary to achieve efficient dechlorination of PCE and TCE to non-toxic end products of ethene and ethane. Bioaugmentation can be completed using either a commercially-available dechlorinating culture or by transferring groundwater from other areas of the site that have been determined to have robust DHC populations. Bioaugmentation can be completed during amendment injection, or after amendment injection is complete and after sufficient time to allow groundwater conditions to become reducing, typically at least one month after amendment injection. Prior to completing bioaugmentation activities, reducing conditions in groundwater will be verified through measurement of field parameters at the piezometer locations (dissolved oxygen below 1 mg/L, negative ORP values, and/or detectable ferrous iron).

For the EAB remedy at OU3, bioaugmentation will be completed using one of two methods. If laboratory analysis shows that an adequate population of dechlorinating bacteria is present in the former pilot study area, then bioaugmentation will be completed through transferring groundwater from wells that were inoculated during the pilot study into additional locations within the treatment area. This technique leverages the fact that the culture used for augmentation during the pilot test has acclimated to the subsurface conditions at the Site. Implementation of bioaugmentation using this technique will commence following groundwater sampling to evaluate the effectiveness of bioaugmentation of source area wells using this technique. If analytical data do not indicate that substantial dechlorinating bacteria remain in the pilot study cell, then bioaugmentation of the larger EAB treatment area will be completed using a commercially-available culture.

Bioaugmentation will be completed by injecting inoculated groundwater or culture into temporary piezometers installed at selected locations where DPT injections were completed, as described in Section 3.2.4. This method is will ensure wider distribution of *Dehalococcoides* bacteria throughout the treatment zone. Bioaugmentation at these locations will be completed between 1 and 3 months after injection activities, to allow time for sufficiently reducing conditions to develop in the treatment area.

For bioaugmentation completed through transfer of groundwater, approximately 20 to 30 gallons of previously augmented groundwater will be transferred to each inoculation location using a submersible pump, bladder pump, or peristaltic pump. The pump tubing will be purged to remove all air from the line prior to injecting the augmented groundwater. The discharge tubing will be placed at least two feet below the static water level in the temporary piezometer during transfer.

If augmentation is completed using a commercially-available dechlorinating culture, approximately 5 liters of an actively dechlorinating culture (SDC-9® or equivalent) will be injected into each of the bioaugmentation locations. The culture will be obtained from a vendor that will provide specific instructions for the handling of the culture. Following injection of the culture, anaerobic chase water, created by mixing up to 1% ethyl lactate with water, will be injected to force the culture out into the formation. Following initial bioaugmentation using the commercial culture, additional bioaugmentation, if necessary, may be completed using transfer methods as described above.

3.2.6 Process Monitoring and Controls

Process monitoring during EAB implementation will consist of tracking of injection activities. Before injections begin, quality control information will be obtained from the amendment manufacturer and reviewed to ensure that the amendment meets project requirements. EAB amendment injections at individual locations will be monitored, and injection parameters (amendment quantities, injection depths, injection pressures, and flow rates) will be recorded at each location. Observations for surfacing of amendment will also be completed throughout injection to ensure that surfacing, if it occurs, is controlled. During bioaugmentation, quantities of extracted groundwater or commercial culture injected at each augmentation point will be measured and recorded. Monitoring of the effectiveness of the remedy after amendment injection and bioaugmentation are completed will be based on performance monitoring data from site monitoring wells, as described in Section 5.

During implementation of the remedy, air monitoring will be completed for health and safety purposes during onsite activities. Monitoring will include evaluation of ambient air within the breathing zone for onsite workers for VOCs using a photoionization detector, and for methane using a combustible gas indicator. Details for air monitoring during onsite activities, in compliance with Occupational Health and Safety Administration (OSHA) 40 CFR 1910.120 requirements, will be presented in the Final Health and Safety Plan prior to implementation of the remedy.

3.2.7 Investigation Derived Waste

Groundwater investigation-derived waste (IDW) generated during this investigation will be managed based upon the hazardous characteristics as defined in 40 CFR Subpart C. IDW will be generated during the drilling and development of the injection and performance monitoring wells, and during the groundwater sampling rounds. Analytical results specifically from waste characterization sampling as well as analytical results obtained for the investigations will be provided to the IDW disposal subcontractor for waste designation purposes. Samples will be analyzed for VOCs at a minimum.

Solid waste IDW will be containerized in 55-gallon drums and stored at the Alcas property pending waste characterization, and offsite transportation and disposal by the IDW disposal subcontractor. Well development and groundwater sampling purge water will be placed in 55-gallon drums and temporarily stored at the Alcas property. IDW water samples will be collected one sample per approximately 275 gallons, and soil samples one sample per drum. Upon receipt of the results, the waste materials will be shipped off-site for proper disposal, as either a characteristic hazardous waste or as non-hazardous waste material.

Transportation and offsite disposal of IDW will be completed in accordance with the transportation and offsite disposal plan.

Section 4

Operations and Maintenance Requirements

Depending on electron donor longevity, it is anticipated that it will be necessary to complete additional amendment injections in the treatment area approximately every 3 to 4 years until RAOs have been met. At least three amendment injections are anticipated to be necessary to substantially reduce VOC concentrations in groundwater. However, there is uncertainty in the timeframe required to reach RAOs during implementation of the selected remedy, and the timeframe will need to be re-evaluated following completion of the initial amendment injection event and a sufficient period of performance monitoring to evaluate VOC concentration trends in groundwater. The injection strategy may be modified based on the data collected during the RA.

The operations and maintenance requirements for the Site will include annual inspections of the monitoring wells for the first five years to ensure that the integrity of the wells is not compromised because of weather events, wear and tear, and corrosion. Inspections should be documented using a standard checklist/form and should be accompanied by photographs at the time of inspection.

Equipment used to complete the amendment injections will be provided by a drilling subcontractor and will only remain on site for the duration of the injections. Equipment will be inspected and tested prior to and during each amendment injection event. No operation and maintenance activities are anticipated associated with the amendment injection equipment.

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Section 5

Remedy Performance Monitoring

5.1 Data Quality Objectives

The Data Quality Objectives (DQO) process was used to help frame the "problem" to be addressed during implementation of the EAB remedy at OU3 at the Site, and to define the associated data needs. The DQO process is a series of planning steps that are designed to ensure that the type, quantity, and quality of environmental data used in decision-making are appropriate for the intended purpose. The DQO process specifies project decisions, the data required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality.

5.1.1 Problem Statement

Historical operations at the Site have resulted in impacted soils and groundwater with TCE and other chlorinated products. EAB is the Selected Remedy for OU3 as described in the ROD (EPA 2014). Monitoring data are necessary to evaluate remedy progress and performance, troubleshoot any issues that arise during implementation, and evaluate progress toward the RAOs.

5.1.2 Decision Questions

The decisions to be made based on the EAB monitoring data pertain to the performance of the technology and its progress toward achieving RAOs. Specific decision questions include the following:

- Is electron donor effectively distributed at the Site to stimulate the reducing conditions necessary to support complete dechlorination?
- What is the longevity of the electron donor in the subsurface, and what electron donor injection frequency is necessary to support reductive dechlorination?
- Is bioaugmentation effective at providing the necessary microbial community to stimulate efficient reductive dechlorination?
- Is complete reductive dechlorination occurring within the EAB treatment zone?
- Does injection of electron donor within the UWBZ present any risk of undesired effects within the City Aquifer?

5.1.3 Inputs to the Decision

The data to be collected during EAB implementation are considered inputs to the decision questions. The data required are grouped here into categories roughly corresponding to the primary decision questions described above:

- Electron donor distribution and longevity – electron donor concentrations and trends over time (measured as dissolved organic carbon (DOC), and volatile fatty acids (VFAs)), biological activity indicators (measured as alkalinity and pH), and redox conditions (measured as ORP, DO, dissolved iron, sulfate, and methane). These parameters will also be used to evaluate migration of carbon compounds or other constituents outside of the EAB treatment area. Significant migration is not anticipated based on the EAB pilot study, and the need to collect data to evaluate impacts outside the EAB treatment area will be evaluated, and may be discontinued, during performance monitoring during full-scale EAB.

- Bioaugmentation effectiveness – chlorinated hydrocarbon and ethene trends over time (measured as PCE, TCE, DCE, VC, and ethene); and growth and proliferation of Dehalococcoides spp. bacteria over time (measured as increases in Dehalococcoides spp. in groundwater samples).

- Reductive dechlorination progress - chlorinated hydrocarbon and ethene trends over time (measured as PCE, TCE, DCE, VC, and ethene)

5.1.4 Boundaries of the Study

In this context, the term "boundaries" refers both to spatial and temporal boundaries for the EAB remedy. The target EAB treatment area is presented on **Figure 3.** Approximately 40 amendment injection points are planned within the target EAB treatment area, which encompasses approximately 36,000 square feet. Vertically, all injections and monitoring wells will target the UWBZ (up to 35 feet below ground surface). The vertical extent of injections will be confirmed during installation of monitoring wells at the Site.

The EAB remedy duration is expected to be up to 10 years during which amendments may be injected, and subsequent groundwater monitoring. The duration necessary to meet the objectives of the EAB remedy will be refined during implementation and as performance monitoring demonstrates progress of the remedy.

5.1.5 Decision Rules

Decision rules identify the actions to be taken for a given answer to each of the questions in Section 5.1.2. In some cases, the decision rules are qualitative in nature due to the multiple lines of evidence that must be considered to evaluate this technology.

- If the electron donor is not effectively distributed at the Site, then additional injection points may be necessary to adequately distribute amendment within the treatment area.

- If the electron donor in the treatment area is depleted/exhausted over time, then an additional amendment injection event may be required if objectives have not yet been achieved.

- If bioaugmentation is ineffective at providing the necessary microbes to support dechlorination in all areas, then additional augmentation using a different technique or using commercially-available culture may be necessary.

- If reductive dechlorination has not progressed to the point where objectives have been met, then the remedy should continue, or consideration may be given to modifications to the remedy approach.

Remedy performance monitoring and specific decisions to be made based on performance monitoring data are presented in Section 5.2 below.

5.1.6 Limits on Decision Errors

Limits on allowable errors for decision inputs ensure that data quality will be sufficient for the intended purpose. Total study error consists of two types of decision errors: sampling design errors and measurement errors. Because a judgmental sampling design is being followed during implementation of the EAB remedy, statistically derived limits on sampling design error are not quantifiable.

The judgmental sampling approach is designed to limit the probability of sampling design errors by:

- Collecting data from multiple lines of evidence (electron donor concentrations, biological activity indicators, redox conditions, TCE and degradation products, and microbial populations) to ensure an internally consistent data set.
- Collecting data at a sufficient frequency to demonstrate reproducibility of results.
- Locating monitoring wells to maximize the potential for influence by the electron donor injections.
- Designing the injection strategy based on successful EAB applications at other sites.

Measurement errors will be limited by selecting appropriate analytical procedures, detection limits, and quality control acceptance criteria (precision and accuracy). These are provided in **Table 5-2**.

5.2 EAB Performance Monitoring and Decision Criteria

Performance monitoring of the EAB remedy during implementation will include evaluation of electron donor distribution and longevity, redox conditions within the EAB treatment area, and dechlorination completeness and efficiency. **Table 5-1** presents a preliminary summary of the planned performance monitoring well locations and sampling frequency. The pre-injection baseline sampling event will be conducted within one month before the start of injections. The wells planned for sampling are located within and near the proposed EAB treatment zone. Wells proposed for monitoring are located at varying distances from proposed injection points (between 5 and 50 feet) to allow for evaluation of amendment distribution and remedy performance throughout and outside of the treatment area. The approximate distances between monitoring wells and proposed injection points are shown in **Table 5-1**. Wells within the EAB treatment zone are proposed for more frequent monitoring during the first year of EAB implementation to evaluate amendment distribution and to assess the need for bioaugmentation during the early phase of EAB implementation. The remaining wells are anticipated to be sampled on a semi-annual basis. All wells listed in **Table 5-1** will be sampled for all analytes during the first year, except for DHC analyses, which will only be completed on the wells located within the EAB treatment area.

Table 5-1: Performance Monitoring Locations and Sampling Frequency

Monitoring Well	Distance from Nearest Injection Point (feet)	Within Target Radius of Influence?	Pre-Injection	Year 1 Post-Injection				Subsequent Years
			Baseline	3-Month	6-Month	9-Month	12-Month	Semi-Annual
RU-8	40	No	X		X		X	X
RU-9	10	Maybe	X	X	X	X	X	X
RU-10	5	Yes	X	X	X	X	X	X
RU-11	50	No	X		X		X	X
RU-15	30	No	X	X	X	X	X	X
RU-16	40	No	X		X		X	X
RU-19	20	No	X	X	X	X	X	X
RU-20	10	Maybe	X	X	X	X	X	X
RU-21	15	No	X	X	X	X	X	X
RU-27 (New well)	20	No	X	X	X	X	X	X
RU-28 (New well)	5	Yes	X	X	X	X	X	X
UA-2	30	No	X	X	X	X	X	X
UA-3	30	No	X		X		X	X

In addition to the wells presented in **Table 5-1**, samples from sentinel monitoring wells CW-13A and CW-13B, as well as municipal well 18M, will be periodically analyzed for select analytes. The following samples are planned to evaluate groundwater conditions between the treatment zone and municipal well 18M:

- CW-13A (UWBZ) and CW-13B (City Aquifer) will be sampled prior to amendment injection and at 3 months and 6 months post-injection, then semi-annually, and analyzed for VOCs, dissolved metals (iron, manganese, and arsenic) and chemical oxygen demand (COD)

- Municipal well 18M will be sampled prior to amendment injection and then on a semi-annual basis, starting 6 months post-injection, and analyzed for dissolved metals (iron, manganese, and arsenic) and COD. VOCs are currently analyzed bimonthly by the City of Olean at well 18M

The sampling at these sentinel wells and 18M will coincide with the recommended remedy performance monitoring events described above. Sampling of well 18M will require coordination with the City of Olean.

Table 5-2 presents the analytical methods, required quantitation limits, and precision and accuracy criteria for the laboratory analyses used to evaluate EAB performance. **Table 5-3** presents the sample collection and handling requirements for performance monitoring analytes. **Table 5-4** indicates the significance of each of the analytes with respect to EAB performance, and how the data will be evaluated. Further discussion specifically related to electron donor distribution and dechlorination performance is provided in the subsections below. The EAB pilot study at the Site evaluated target analyte list (TAL) metals concentrations within the EAB treatment area following amendment injection. The results of that evaluation indicated that arsenic, iron, and manganese were the only metals to exhibit a notable increase in concentration within the treatment zone, where strongly reducing conditions were established, and these elevated concentrations of arsenic, iron, and manganese were not observed to migrate outside of the active treatment area (CDM Smith 2012). Therefore, it is not expected that other metals would be mobilized during the full-scale EAB implementations, and analysis of the full suite of TAL metals is not necessary.

In addition to these issues, the topic of mass balance is briefly discussed below. Decisions to be made during EAB generally use a multiple lines of evidence approach and professional judgment to evaluate the performance of the remedy, and to decide the appropriate actions to be taken to address performance problems. The general decision framework for potential actions based on performance monitoring data are presented in the following subsections.

Table 5-2: Analytical Methods for EAB Implementation

Analyte	Required Quantitation Limit	Precision	Accuracy[a] (recovery)	Method
VOCs				
PCE	5 µg/L	14% RPD[b]	70-130%	EPA 8260B
TCE	5 µg/L	14% RPD	70-130%	EPA 8260B
cis-DCE	5 µg/L	14% RPD	70-130%	EPA 8260B
VC	2 µg/L	14% RPD	70-130%	EPA 8260B
Electron donor				
Acetate	5 mg/L	25% RPD	50-150%	GC/FID[c]
Propionate	5 mg/L	25% RPD	50-150%	GC/FID[c]
Butyrate	5 mg/L	25% RPD	50-150%	GC/FID[c]
COD	5 mg/L	25% RPD	50-150%	EPA 410
Specific conductivity	0.001 mS/cm	25% RPD	50-150%	Flow Cell
Dissolved gases				
Ethene	5 µg/L	25% RPD	50-150%	RSK 175
Ethane	5 µg/L	25% RPD	50-150%	RSK 175
Methane	5 µg/L	25% RPD	50-150%	RSK 175
Redox parameters				
Sulfate	1 mg/L	25% RPD	50-150%	EPA 300.0
DO	0.1 mg/L	25% RPD	50-150%	Flow Cell
ORP	1 mV	25% RPD	50-150%	Flow Cell
Ferrous Iron	0.1 mg/L	25% RPD	50-150%	Test Kit
Dissolved Metals (arsenic, iron, and manganese)	5 ug/L	25% RPD	50-150%	EPA 6020
Biological parameters				
Alkalinity	5 mg/L	25% RPD	50-150%	Test Kit
pH	0.1 units	25% RPD	N/A[d]	Flow Cell
DNA	1 copy/mL	25% RPD	50-150%	Q-PCR

a For analytical methods that do not measure matrix spike recovery, the percentage range indicated represents the acceptable range for check standards
b RPD = relative percent difference for duplicate sample analysis
c GC/FID = gas chromatography with a flame ionization detector
d Check standards should be within 0.2 pH units
Q-PCR – Quantitative Polymerase-Chain Reaction

Table 5-3. Sampling Requirements for EAB Implementation

Analyte	Sample container size and type	Preservative	Holding time	Comments
VOCs	Three glass 40-mL VOA vials	4ºC	7 days	No headspace
Acetate/propionate/ butyrate	Two glass 40-mL VOA vial	4ºC	7 days	
COD	One 125-mL HDPE	4ºC, pH<2 with H2SO4	14 days	
Ethene/ethane/ methane	Three glass 40-mL VOA vials	4ºC	7 days	No headspace
Sulfate	250-mL HDPE	4ºC	14 days	
Ferrous Iron	250-mL HDPE	4ºC	4 hours	Analyze immediately in the field
Alkalinity	250-mL HDPE	4ºC	4 hours	Analyze immediately in the field
DNA	Two 1-L HDPE bottles	4ºC	48 hours	No headspace
Arsenic, iron, and manganese	250-mL HDPE	pH<2 with HNO3; 4ºC	6-months,	Filter in field

Table 5-4. EAB Performance Assessment

Performance Data	Significance	Performance Confirmation Method	Expected Performance
VOCs			
TCE	Primary indicator of dechlorination	Trend charts for VOCs vs. time and area charts of molar concentrations vs. time	TCE might increase initially due to release of sorbed mass; concentrations should decrease within 2 to 3 months with subsequent increase in DCE
PCE	Sometimes present as co-constituent with TCE	Trend charts for VOCs vs. time and area charts of molar concentrations vs. time	PCE might increase initially due to release of sorbed mass; concentrations should decrease within 2 to 3 months with subsequent increase in DCE
cis-DCE	Primary indicator of dechlorination	Trend charts for VOCs vs. time and area charts of molar concentrations vs. time	DCE might increase initially due to release of sorbed mass; concentrations not likely to decrease until methanogenic conditions are achieved, at which point they should decline with subsequent increase in VC and ethene
VC	Primary indicator of dechlorination	Trend charts for VOCs vs. time and area charts of molar concentrations vs. time	VC will likely remain relatively stable until methanogenesis is significant; will likely increase as DCE is dechlorinated, but should reach a peak within months and then decline with increasing ethene
Ethene	Primary indicator of dechlorination	Trend charts for VOCs vs. time and area charts of molar concentrations vs. time	Ethene will likely remain stable until methanogenesis is significant; should increase as DCE and VC are dechlorinated

Electron donor			
Acetate	Indicator of electron donor distribution; indicator of rate and extent of fermentation	Trend charts for electron donor vs. time	Should be present in down gradient wells within a couple months if electron donor distribution is adequate and longevity is desirable
Propionate	Indicator of electron donor distribution; indicator of rate and extent of fermentation	Trend charts for electron donor vs. time	Likely to be present at least in the nearest down gradient wells for some electron donors.
Butyrate	Indicator of electron donor distribution; indicator of rate and extent of fermentation	Trend charts for electron donor vs. time	Might be present in the nearest down gradient wells for some electron donors
COD	Indicator of electron donor distribution and longevity	Trend charts for electron donor vs. time	Should increase first in nearest wells, then in down gradient wells if distribution is favorable; concentrations above 50-100 mg/L are desirable for dechlorination
Specific conductivity	Indicator of electron donor distribution for some electron donors	Trend charts for electron donor vs. time	Should increase over time depending on electron donor
Dissolved gases			
Ethane	Indicator of extremely reducing conditions (ethene reduction)	Trend charts vs time if detected	Not expected to be present at significant concentrations
Methane	Indicator of methanogenesis and thus favorability for dechlorination	Trend charts for vs. time with other redox indicators	Should increase over time once sulfate is depleted; might reach 10 to 20 mg/L during full-scale implementation
Redox indicators			
Dissolved oxygen	Indicator of redox conditions	Trend charts for redox conditions vs. time	Should decrease to zero quickly at monitoring wells over time
Sulfate	Indicator of redox conditions	Trend charts for redox conditions vs. time	Should decrease to less than 10 mg/L within about 2 to 3 months
Iron	Indicator of redox conditions	Trend charts for redox conditions vs. time	Should increase within the first 4 to 6 weeks; concentrations of a few mg/L are typical
ORP	Indicator of redox conditions	Trend charts for redox conditions vs. time	Should decrease over time, becoming negative within the first 1 to 2 months, and reaching -100 to -300 mV or lower by 2 to 3 months
Biological Parameters			
Alkalinity	Indicator of biological activity	Trend charts vs. time	Should increase over time
pH	Indicator of biological activity	Trend charts vs. time	Might decrease by up to a point during the first 2 months, but will likely stabilize and recover later during implementation
DNA	Indicator of the presence and growth of *Dehalococcoides* bacteria	Trend charts for cell numbers vs. time	Should increase over time (except in inoculation point)

5.2.1 Electron Donor Distribution

Electron donor distribution can be measured directly through the electron donor analytes, including COD, acetate, propionate, and butyrate. COD will be used during EAB implementation in OU3 as the direct measure of electron donor distribution. Evaluation of whether conditions are appropriate to support reductive dechlorination, and an indirect evaluation of distribution, can also be measured through the redox-sensitive parameters. An even more basic consideration is the ability to inject the desired volumes of electron donor material into the ground in a timely fashion. Concentrations of electron donors generally need to exceed about 50-100 mg/L over time to stimulate sufficient biological activity to maintain strongly reducing conditions that are conducive to complete dechlorination. Of interest during EAB implementation will be comparing the distribution of electron donors and associated reducing conditions in space, and their longevity over the course of implementation.

Decisions related to monitoring of the electron donor distribution within the treatment zone include the following:

- If COD is low (below 50 mg/L) within the target treatment zone, and redox conditions and biological indicators are not conducive to reductive dechlorination and dechlorination is not occurring as described below, then additional electron donor injection will be completed.

5.2.2 Redox Conditions

DO, ORP, sulfate, ferrous iron, and methane are redox parameters used to evaluate the degree to which reducing conditions are established following amendment injection. Chlorinated hydrocarbons serve as electron acceptors in microbially-mediated redox reactions during reductive dechlorination. Therefore, they must compete with naturally occurring electron acceptors in groundwater. During bioremediation, injection of nutrients in sufficient quantities drives redox conditions from aerobic to nitrate-reducing, to iron-reducing, to sulfate-reducing, and finally to methanogenic. Reductive dechlorination of TCE to cis-1,2-DCE generally occurs under iron-reducing to sulfate-reducing conditions. Complete dechlorination to ethene and ethane typically occurs under sulfate-reducing to methanogenic conditions. Thus, understanding redox conditions provides key insight into the potential for reductive dechlorination to occur at a site. The concentrations of various electron acceptors are discussed below to assess the accurate redox conditions within the EAB treatment zone. Methanogenic conditions, typically ideal for complete reductive dechlorination of chlorinated compounds to ethene or ethane, are indicated by the absence of oxygen, sulfate and nitrate and the presence of methane and dissolved iron. In addition, methane production is also used as a surrogate for ideal conditions for reductive dechlorination because methanogens and DHC generally require the same conditions (presence of hydrogen and carbon, reducing conditions and pH greater than 5.5 to 6) for growth and activity. Therefore, production of methane often coincides with production of ethene/ethane from reductive dechlorination.

Decisions related to monitoring of redox conditions within the treatment zone include the following:

- If redox conditions within the target treatment zone are not sulfate-reducing or methanogenic within approximately 6-9 months after amendment injection, then evaluation of the need for additional electron donor injection will be completed.

5.2.3 Biological Indicators

pH is a key factor influencing the effectiveness of the biodegradation process. A pH below 6.0 will inhibit the bacteria capable of complete reductive dechlorination to ethene, primarily the DHC population, with complete inhibition at pH of 5.5 or less. Monitoring during the pilot study at the Site (CDM Smith 2012) did not indicate significant pH declines in groundwater during performance monitoring of the areas where amendment was delivered.

Periodic analysis for *Dehalococcoides spp*. using quantitative polymerase chain reaction (qPCR) is necessary determine the presence/absence and concentration of DHC populations known to promote the reductive dechlorination of VOCs. Using qPCR methods, techniques have been developed to identify four genes associated with DHC. First is the 16S rRNA gene, which is used as the general marker for evaluating all strains of DHC present in a sample. Three functional genes, tceA, vcrA, and bvcA, associated with differing reductive dechlorinating capacities were also evaluated. Reductase gene tceA was isolated from DHC ethenogenes strain 195, which reduces PCE or TCE to cis-1,2-DCE and VC in energy yielding reactions, but only reduces VC to ethene in a cometabolic reaction, which may result in VC accumulation in the field. Reductase gene vcrA was isolated from DHC Strain VS and degrades PCE and TCE energetically all the way to ethene. Reductase gene bvcA was isolated from DHC Strain BAV1 and degrades PCE or TCE only cometabolically and energetically degrades DCE and VC to ethene.

Typically, DHC concentrations greater than 10^4 gene copies per milliliter (gene copies/mL) are associated with efficient dechlorination of DCE and VC to occur. Similarly, high concentrations of functional genes (specifically bvcA and/or vcrA) are associated with dechlorination of DCE and VC.

Decisions related to monitoring of the biological indicators within the treatment zone include the following:

- If pH of the aquifer remains below 6 for an extended period (greater than 6 months) after amendment injection, then an evaluation of the need for buffer injection will be completed.

- If DHC populations do not increase at monitoring locations following amendment injection or bioaugmentation, and reductive dechlorination performance is not adequate as described in the following subsection, then evaluation of additional bioaugmentation will be completed.

5.2.4 Dechlorination

Assessment of dechlorination is straightforward; however, it is important to evaluate both mass concentrations over time as well as molar concentrations over time. The former has regulatory implications, while the latter illustrates mass balance. It is worthwhile to note that increases in total constituent mass are common immediately after electron donor injection, especially for high concentration electron donors. This increase occurs due to enhanced mass transfer of sorbed and non-aqueous constituents into the aqueous phase where they are subsequently degraded. DCE typically reaches the highest molar concentrations of any of the chlorinated ethenes. Conversion to DCE typically coincides with sulfate-reducing conditions, while its transformation to VC and ethene typically occurs under methanogenic conditions. Once DCE is further dechlorinated, VC will increase, but typically does not reach the same molar concentrations because ethene production soon outpaces VC production, and ethene becomes the primary compound remaining in groundwater.

Decisions related to monitoring of dechlorination performance within the treatment zone include the following:

- If reductive dechlorination (degradation of TCE and increases in degradation compounds cis-1,2-DCE, VC, and ethene) is not observed within the treatment zone within 6-12 months after amendment injection, then evaluation of the need for electron donor injection will be completed based on evaluation of donor distribution, redox conditions, and biological parameters described above.

- If reductive dechlorination to cis-1,2-DCE is observed, but formation of VC and ethene is not observed within 6-12 months of amendment injection, then evaluation of the need for additional bioaugmentation will be completed.

- If concentrations of VOCs, specifically TCE, begin to increase, and electron donor appears to be exhausted based on evaluation of COD and redox conditions, then additional electron donor injection will be evaluated. If TCE concentrations remain low following exhaustion of the electron donor in the treatment area, then evaluation of natural attenuation for continued degradation of remaining COCs in order to meet the RAOs will be completed.

5.2.5 Mass Balance

Achieving a true mass balance can be difficult during EAB, largely because of the increasing volatility of the degradation products, which ultimately are no longer volatile liquids, but dissolved gases. This causes losses from the groundwater as the degradation products partition into the unsaturated zone above the water table and causes losses during sampling. To complicate matters, abiotic degradation of both DCE and VC can occur in the presence of reduced iron minerals, and VC might also be subject to oxidation reactions that can occur even under anaerobic or very low oxygen conditions, thereby potentially further compromising a mass balance. In any case, it is important to use molar concentrations of chlorinated VOCs to evaluate mass balance because one mole of TCE produces one mole of DCE, which produces one mole of VC, which produces one mole of ethene. Mass concentrations, on the other hand, decrease dramatically with each transformation step because the molecular weight of each subsequent compound decreases as chlorine atoms are replaced with hydrogen atoms.

As noted above, it is expected that concentrations will not decrease immediately after electron donor injection, which will confirm that dilution is not occurring. Once dilution is ruled out, any loss of constituent mass can be attributed to EAB, partitioning of degradation products into the unsaturated zone, abiotic reduction of constituents, or oxidation of degradation products such as VC and ethene. In shallow, thin aquifers (such as the surficial zone and UWBZ at the Site) it is typical for mass balance to be lost quickly once DCE is transformed to VC and ethene.

5.3 EAB Performance Monitoring Timeframe

It is anticipated that performance monitoring at wells indicated in **Table 5-1** will continue throughout the course of active remediation activities at the Site. Monitoring at a particular location may be discontinued when two consecutive monitoring events indicate that groundwater VOC concentrations have met the RAOs as described in Section 2.2 of this report. Additional details regarding timeframe for cessation of performance monitoring activities will be presented in the Remedial Action Work Plan.

Section 6

References

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ENI Engineering, Inc. 2013. Focused Feasibility Study. Alcas Cutlery Corporation Facility Site. July.

EPA. 2014a. Record of Decision. Operable Unit Three Record of Decision for the Olean Well Field Superfund Site Related to the Alcas Source Area. September.

EPA. 2014b. Remedial Design/Remedial Action Statement of Work Operable Units Two and Three, Alcas Source Area at the Olean Well Field Superfund Site.

EPA. 1995. The Remedial Design/Remedial Action Handbook. June

ESTCP. 2006. Protocol for Enhanced In Situ Bioremediation Using Emulsified Edible Oil. May.

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Figures

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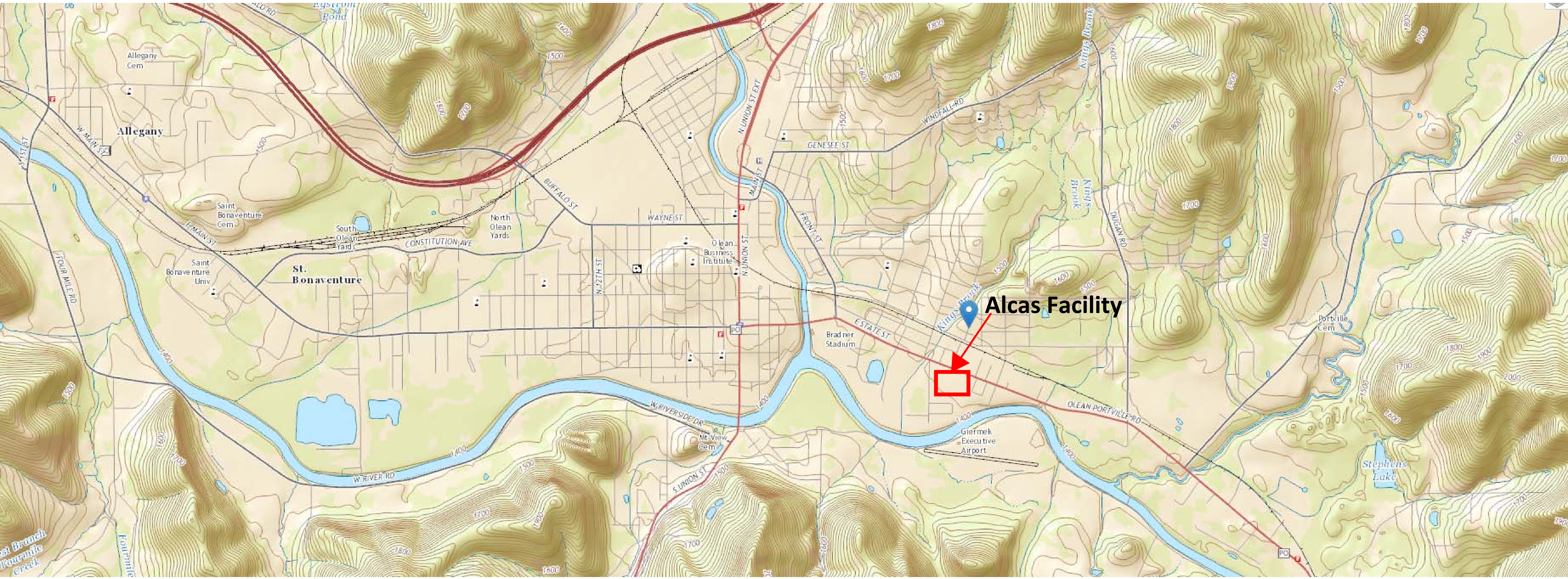


Figure 1: Alcas Facility Location

Olean, New York

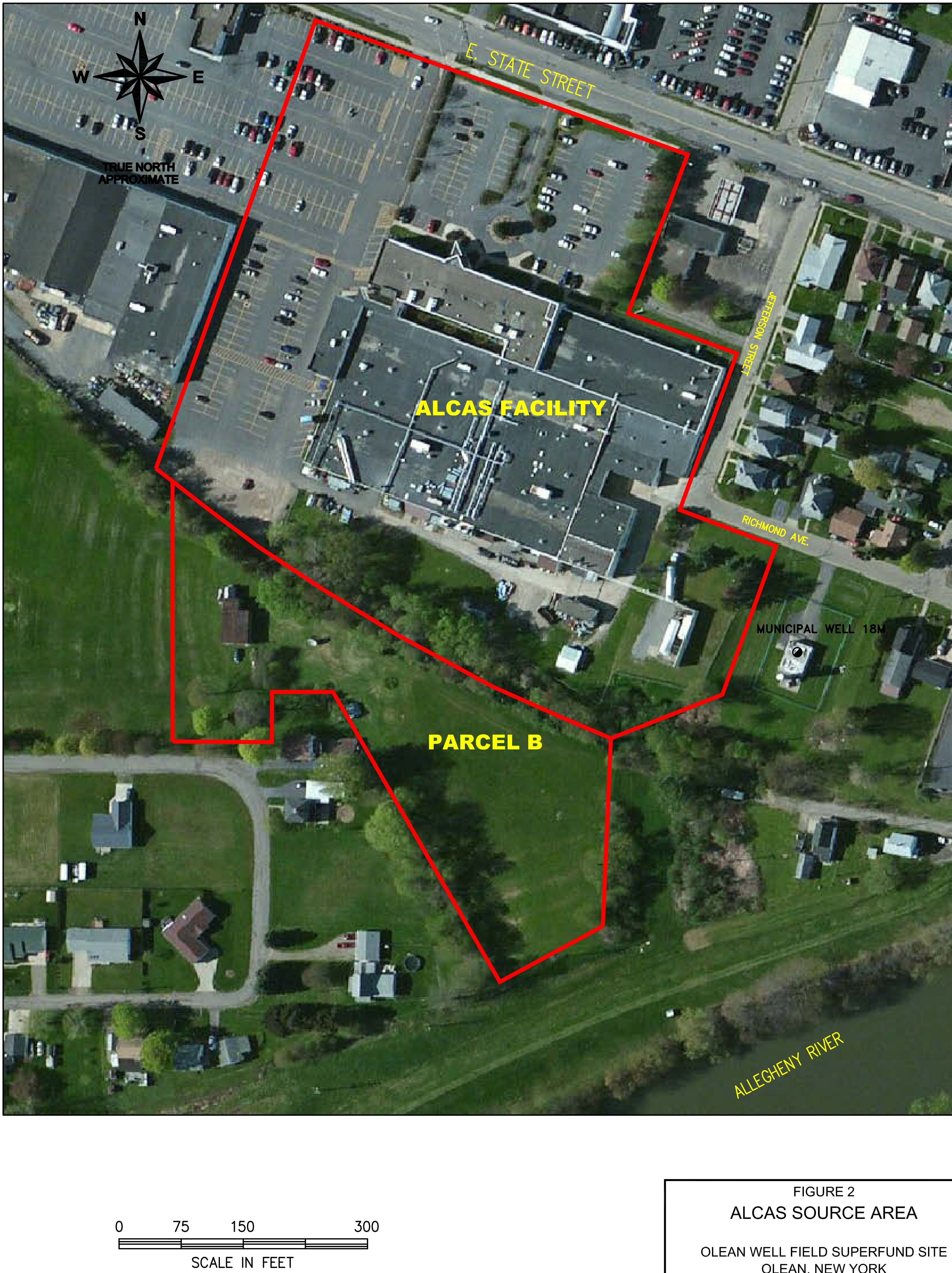
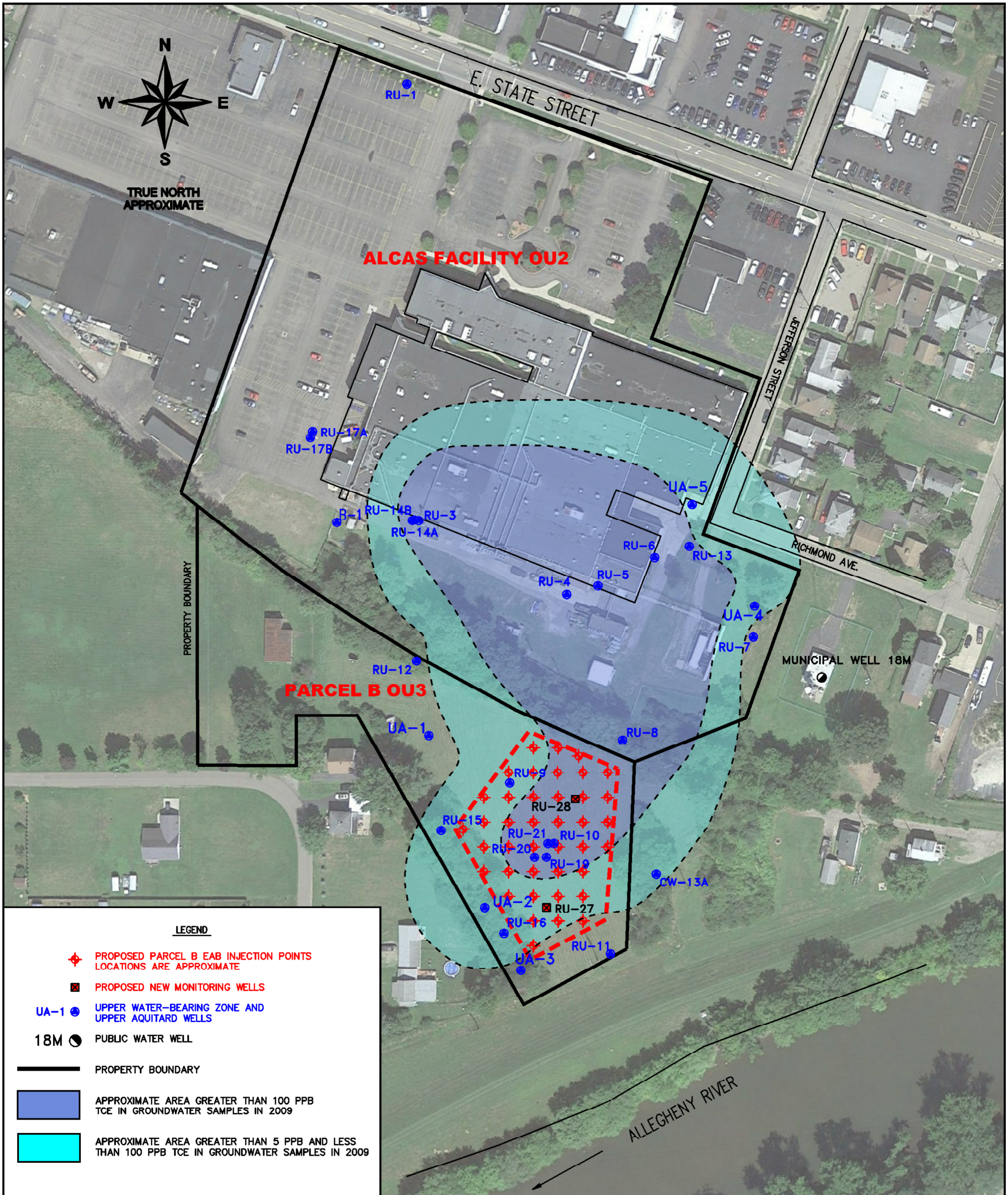


FIGURE 2
ALCAS SOURCE AREA

OLEAN WELL FIELD SUPERFUND SITE
OLEAN, NEW YORK

DRAWN BY:	DATE:	PROJ. NO.
MWW	09/24/2014	137-196



0 75 150 300

SCALE IN FEET

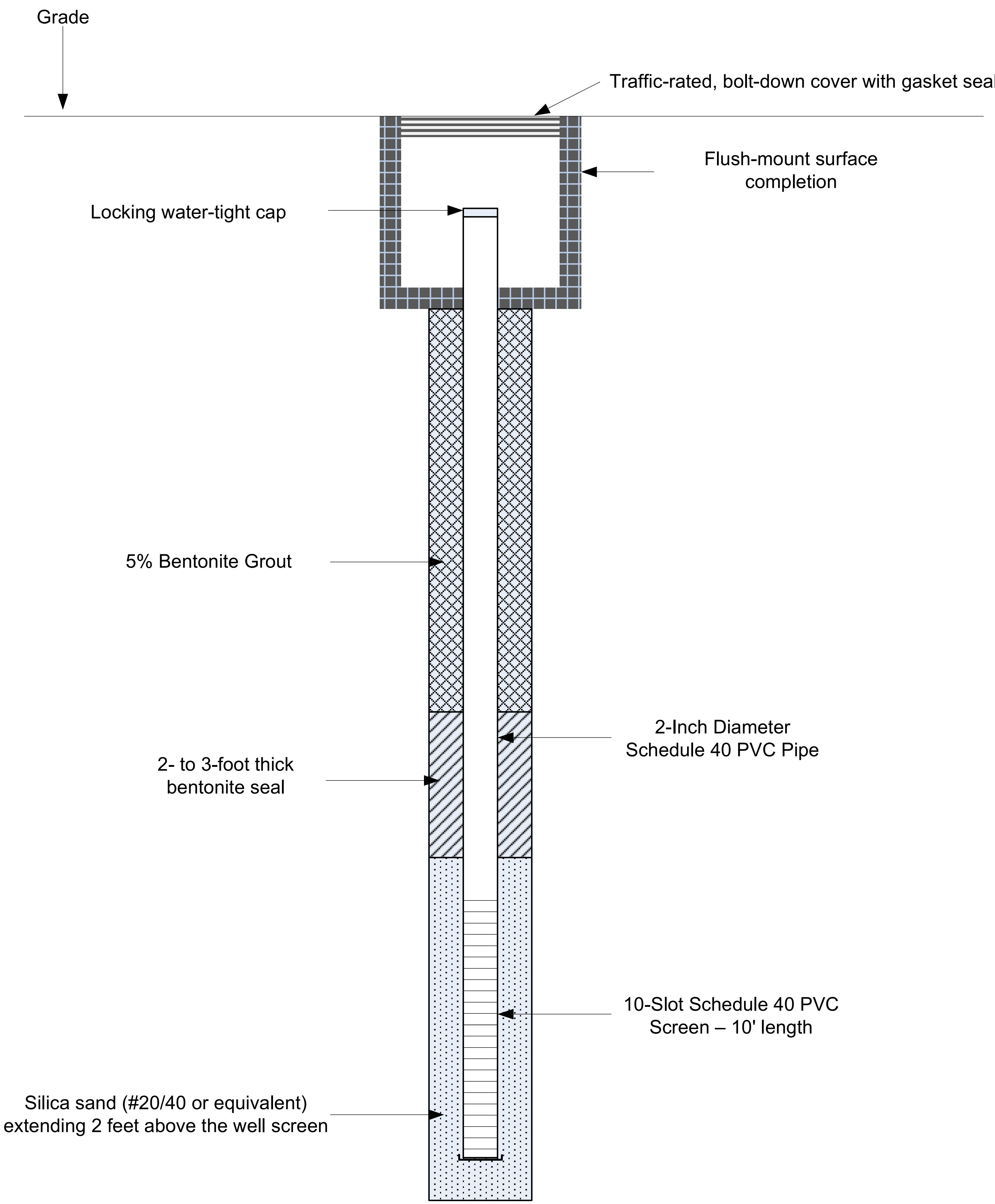
NOTES:
1. FIGURE BASED ON 2009 DATA AND DOES NOT REFLECT RECENT INFORMATION INDICATING THAT THE >5 PPM AND >100 PPM PLUME AREAS MAY BE SMALLER.
2. LOCATIONS APPROXIMATED FROM FIGURES 6-9, 6-10, AND 6-11 PROVIDED IN JULY 2014 FFS REPORT.

*OVERLAY IMAGERY OBTAINED VIA GOOGLE EARTH PRO (APRIL 2018)

FIGURE 3
PROPOSED INJECTION LOCATIONS AND MONITORING WELLS

ALCAS SOURCE AREA
OLEAN, NEW YORK

DRAWN BY:	DATE:	PROJ. NO.
TJT	04/24/2018	218435



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Remedial Design – Operable Unit 3
Alcas Source Area
Olean Well Field Superfund Site

Figure 4
Monitoring Well Construction Diagram
(not to scale)

Appendix A

Applicable or Relevant and Appropriate Requirements (ARARs)

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Table A-1 Chemical-specific ARARs, TBCs, and other Guidance, Alcas Property, Olean, Cattaraugus County, New York

Regulatory Level	Regulatory Authority and Citation	Requirement Synopsis
Federal	National Primary Drinking Water Standards-Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) (42 U.S.C. § 300f et seq and 40 CFR Part 141, Subpart F)	Establishes health-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety.
State	New York State Department of Health Drinking Water Standards (10 NYCRR Part 5)	Sets MCLs for public drinking water supplies.
State	New York Remedial Program Soil Cleanup Objectives (6 NYCRR Part 375.6)	Establish standards for soil cleanups.
State	New York DEC Commissioner Policy 51 (CP-51 /Soil Cleanup Guidance)	Provides the framework and procedures for the selection of soil cleanup levels appropriate for each of the remedial programs
State	New York Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 NYCRR Part 703)	Establish numerical standards for groundwater and surface water cleanups.

Table A-2 Action-specific ARARs, TBCs, and other Guidance, Alcas Property, Olean, Cattaraugus County, New York

Regulatory Level	Regulatory Authority and Citation	Requirement Synopsis
General Requirement for Site Remediation		
Federal	OSHA—Record keeping, Reporting, and Related Regulations (29 CFR 1904)	This regulation outlines the record keeping and reporting requirements for an employer under OSHA.
Federal	OSHA—General Industry Standards (29 CFR 1910)	These regulations specify an 8-hour time-weighted average concentration for worker exposure to various organic compounds
Federal	OSHA—Construction Industry Standards (29 CFR 1926)	This regulation specifies the type of safety equipment and procedures to be followed during site remediation.
Federal	RCRA Identification and Listing of Hazardous Wastes (40 CFR 261)	Describes methods for identifying hazardous wastes and lists known hazardous wastes.
Federal	RCRA Standards Applicable to Generators of Hazardous Wastes (40 CFR 262)	Describes standards applicable to generators of hazardous wastes.
Federal	RCRA—Preparedness and Prevention (40 CFR 264.30-264.31)	This regulation outlines the requirements for safety equipment and spill control.
Federal	RCRA—Contingency Plan and Emergency Procedures (40 CFR 264.50–264.56)	This regulation outlines the requirements for emergency procedures to be used following explosions, fires, etc.
State	New York Hazardous Waste Management System - General (6 NYCRR Part 370)	This regulation provides definition of terms and general standards applicable to hazardous wastes management system.
State	New York Identification and Listing of Hazardous Waste (6 NYCRR Part 371)	Describes methods for identifying hazardous wastes and lists known hazardous wastes.
State	New York Hazardous Waste Management Facilities (6 NYCRR Part 373)	Regulates treatment, storage, and disposal of hazardous waste.
State	New York Management of Specific Hazardous Waste (6 NYCRR Part 374)	Establishes standards for the management of specific hazardous wastes.
State	New York Environmental Remediation Programs (6 NYCRR Part 375)	Identifies process for investigation and remedial action at state funded Registry site; provides exception from NYSDEC permits.
State	New York DEC Commissioner Policy 51 (CP-51 /Soil Cleanup Guidance)	Provides the framework and procedures for the selection of soil cleanup levels appropriate for each of the remedial programs
State	New York Solid Waste Management Regulations (6 NYCRR 360)	Sets standards and criteria for all solid waste management facilities, including design, construction, operation, and closure requirements for the municipal solid waste landfills.
Waste Transportation		
Federal	Department of Transportation (DOT) Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171, 172, 177 to 179)	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting hazardous materials.
Federal	RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)	Establishes standards for hazardous waste transporters.
State	New York Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities (6 NYCRR Part 372)	Establishes record keeping requirements and standards related to the manifest system for hazardous wastes.
State	New York Waste Transporter Permit Program (6 NYCRR Part 364)	Establishes permit requirements for transportations of regulated waste.
Disposal		
Federal	RCRA Land Disposal Restrictions (40 CFR 268)	Identifies hazardous wastes restricted from land disposal and provides treatment standards under which an otherwise prohibited waste may be land disposed.
State	New York Standards for Universal Waste (6 NYCRR Part 374-3) and Land Disposal Restrictions (6 NYCRR Part 376)	These regulations establish standards for treatment and disposal of hazardous wastes.
Groundwater Discharge		
Federal	Clean Water Act (CWA [40 CFR 122, 125)	National Pollutant Discharge Elimination System (NPDES) permit requirements for point source discharges must be met, including the NPDES Best Management Practice (BMP) Program. These regulations include, but are not limited to, requirements for compliance with water quality standards, a discharge monitoring system, and records maintenance.
Federal	Clean Water Act (Federal Ambient Water Quality Criteria [FAWQC] and Guidance Values [40 CFR 131.36])	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.

Appendix A

Applicable or Relevant and Appropriate Requirements (ARARs)

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State	New York DEC Commissioner Policy 51 (CP-51 /Soil Cleanup Guidance)	Provides the framework and procedures for the selection of soil cleanup levels appropriate for each of the remedial programs
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Federal	Clean Water Act (Federal Ambient Water Quality Criteria [FAWQC] and Guidance Values [40 CFR 131.36])	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.

Regulatory Level	Regulatory Authority and Citation	Requirement Synopsis
Federal	Safe Drinking Water Act - Underground Injection Control Program (40 CFR 144, 146)	Establish performance standards, well requirements, and permitting requirements for groundwater re-injection wells.
State	New York Regulations on State Pollution Discharge Elimination System (SPDES) (6 NYCRR parts 750-757)	This permit governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of State waters, except as authorized pursuant to a NPDES or State permit.
State	New York Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 NYCRR Part 703)	Establish numerical criteria for groundwater treatment before discharge.
State	New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1)	Provides groundwater effluent limitations for use where there are no standards.
Off-Gas Management		
Federal	Clean Air Act (CAA)—National Ambient Air Quality Standards (NAAQs) (40 CFR 50)	These provide air quality standards for particulate matter, lead, NO_2, SO_2, CO, and volatile organic matter.
Federal	Federal Directive – Control of Air Emissions from Superfund Air Strippers (OSWER Directive 9355.0-28)	These provide guidance on the use of controls for superfund site air strippers as well as other vapor extraction techniques in attainment and non-attainment areas for ozone.
State	New York Air Quality Standards/ DER-10 (6 NYCRR Part 257)	This regulation requires that maximum 24-hour concentrations for particulate matter not be exceeded more than once per year. Fugitive dust emissions from site excavation activities must be maintained below 250 micrograms per cubic meter (µg/m3).
State	New York State Department of Environmental Conservation (DAR-1) Air Guide 1, Guidelines for the Control of Toxic Ambient Contaminants	This policy provides guidance for the control of toxic ambient air contaminants and outlines the procedures for evaluating sources.
State	New York Permits and Certificates (6 NYCRR Part 201)	Permits may be exempted for listed trivial activities.
State	New York Emissions Verification (6 NYCRR Part 202)	Specifies the sampling and documentation requirements for off-gas emissions.
State	New York General Prohibitions (6 NYCRR Part 211)	Prohibition applies to any particulate, fume, gas, mist, odor, smoke, vapor, pollen, toxic or deleterious emissions.
State	New York General Process Emission Sources (6 NYCRR Part 212)	Sets the treatment requirements for certain emission rates.

Table A-3 Location-specific ARARs, TBCs, and other Guidance, Alcas Property, Olean, Cattaraugus County, New York

Regulatory Level	Regulatory Authority and Citation	Requirement Synopsis
Federal	National Historic Preservation Act (16 U.S.C. §470 et seq. and 36 CFR Part 800)	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.
Federal	Endangered Species Act (16 U.S.C.§ 1531 et seq.,50 CFR Part 200)	Requires that the continued existence of any endangered or threatened species and/or its habitat not be impacted by a federal activity
Federal	Clean Water Act Section 404; 40 CFR Parts 230; 33 CFR Parts 320-330	Prohibits discharge into wetlands.
Federal	Clean Water Act ; 40 CFR Part 6 Appendix A, section 4	Avoids adverse effects, minimize potential harm, preserve, and enhance wetlands.
Federal	Floodplain Management; 40 CFR 6.302 (b) (2005)	Regulates activities in a floodplain.
State	Endangered and Threatened Species of Fish and Wildlife (6 NYCRR Part 182)	Standards for the protection of threatened and endangered species
State	Freshwater Wetlands; 6 NYCRR 663-665	Establishes permit requirement regulations, wetland maps, and classifications.
State	Floodplain Management; 6 NYCRR 500	Describes development permitting requirements for areas in floodplains
State	Use and Protection of Waters; 6 NYCRR 608	Regulates the modification or disturbance of streams
State	Wild, Scenic, and Recreational Rivers; 6 NYCRR 666	Regulations for administration and management
State	Floodplains; 6 NYCRR 502	Contains floodplain management criteria for state projects.

Appendix B

Green Remediation Best Management Practices Screening Evaluation

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Appendix B. Green Remediation Best Management Practices Screening Evaluation

ASTM International Greener Cleanups Standard Category	ASTM Best Management Practice Description	Retained	Implementation and Documentation
Buildings	Use graywater collection systems at on-site buildings for water during cleanup activities, to minimize freshwater use	N	Not Applicable
Materials	Implement a flexible network of piping (under and/or aboveground) to allow for shorter piping runs and future modular increases or decreases in the extraction or injection rates and treatment modifications	N	Not Applicable
Materials	Insulate all applicable pipes and equipment to improve energy efficiency with greener insulation material	N	Not Applicable
Materials	Link a deconstruction project with a replacement construction project (for example, the same site of the deconstruction project or a local current construction or renovation project) to facilitate reuse of clean salvaged materials	N	Not Applicable
Materials	**Maximize the reuse of existing wells for sampling, injections, or extractions, where appropriate, and/or design wells for future reuse**	**Y**	**The remedial design currently utilizes existing monitoring wells to the extent practical. Use of existing wells for sampling will be documented in the RA report.**
Materials	Select oxidants/reagents with a smaller environmental footprint	N	Limited options available for amendments
Materials	Select piping materials and treatment equipment to facilitate their reuse. For example, carbon steel piping may resist chlorine stress corrosion better than stainless steel	N	Not Applicable
Materials	Select products that are environmentally preferable (when compared to other products serving the same purpose) with respect to raw materials consumption, manufacturing processes and locations, packaging, distribution, recycled content and recycling capability, maintenance needs, and disposal procedures. Explore the GSA Sustainable Facilities tool at https://sftool.gov/ for a list of greener options	N	Not Applicable
Materials	**Steam-clean or use phosphate-free detergents or biodegradable cleaning products instead of organic solvents or acids to decontaminate sampling and other equipment**	**Y**	**Steam cleaning and/or decontamination using phosphate-free detergent will be documented in field notes and a BMP checklist.**
Materials	**Use biobased products to reduce petroleum use or enhance degradation of material. For example, use biodegradable seed matting, or erosion control fabrics containing agricultural by-products; use algae-based oils, soybean oil, or waste/by-products from forestries, plant nurseries, or food processing/retail industries as a substrate for bioremediation**	**Y**	**Amendments as specified in the remedial design consist of biobased products (soybean oil derivatives).**
Materials	Use by-products, waste, or less refined materials in place of refined chemicals or materials (for example, cheese whey, molasses, compost, or off-spec food products for inducing anaerobic conditions; limestone in place of concentrated sodium hydroxide for neutralization; fly ash or slag as a component in concrete)	N	Not Applicable
Materials	Use materials with recycled content (for example, concrete and/or asphalt from recycled crushed concrete and/or asphalt; plastic made from recycled plastic; geotextile fabrics/tarps made with recycled contents)	N	Not Applicable
Power and Fuel	Install amp meters to evaluate electricity consumption rates on a real-time basis and options for off-peak energy usage	N	Not Applicable
Power and Fuel	Purchase renewable energy via local utility and Green Energy Programs or renewable energy credits/certificates (RECs or Green Tags) to power cleanup activities	N	Not Applicable
Power and Fuel	Use a flexible on-site renewable energy system to meet energy demands of multiple activities or consumption needs beyond the lifespan of the cleanup	N	Not Applicable
Power and Fuel	**Use biodiesel produced from waste or cellulose-based products to power equipment**	**Y**	**Biodiesel will be used for equipment if it is available for use in the area. Use of biodiesel will be documented in field notes and a BMP cehcklist.**
Power and Fuel	Use gravity flow to introduce amendments or chemical oxidants to the subsurface when high-pressure injection is unnecessary	N	Not Applicable
Power and Fuel	Use on-site generated renewable energy such as solar photovoltaic, wind turbines, landfill gas, geothermal, and biomass combustion to fully or partially provide power otherwise generated through on-site fuel consumption or use of grid electricity	N	Not Applicable

Appendix B. Green Remediation Best Management Practices Screening Evaluation

ASTM International Greener Cleanups Standard Category	ASTM Best Management Practice Description	Retained	Implementation and Documentation
Power and Fuel	Use solar power pack system for low-power system demands (for example, security lighting, system telemetry)	N	Not Applicable
Power and Fuel	When possible, operate remediation system during off-peak hours of electrical demand without compromising cleanup progress	N	Not Applicable
Project Planning and Team Management	Buy carbon offset credits (for example, for airline flights) when in person meetings are required	N	Not Applicable
Project Planning and Team Management	**Choose equipment and product vendors with production and distribution centers near the site to minimize fuel consumption associated with delivery**	**Y**	**Local vendors and suppliers will be used to the extent practical. Use of local suppliers and subcontractors will be documented in field notes and a BMP checklist.**
Project Planning and Team Management	Choose suppliers that will take back scraps or unused materials	N	Not Applicable
Project Planning and Team Management	Contract a laboratory that uses green practices and/or chemicals	N	Not Applicable
Project Planning and Team Management	Designate collection points for compostable materials and routine recycling of single-use items such as metal, plastic, and glass containers; paper and cardboard; and other items that may be recycled locally	N	Not Applicable
Project Planning and Team Management	Establish green requirements (for example, greener cleanup BMPs) as evaluation criteria in the selection of contractors and include language in RFPs, RFQs, subcontracts, contracts, etc. For example, procure remediation reagents from vendors with sustainable policies	N	Not Applicable
Project Planning and Team Management	Select facilities with green policies for worker accommodations and periodic meetings	N	Not Applicable
Project Planning and Team Management	Select local waste disposal and recycling facilities to minimize transportation impacts	N	Not Applicable
Project Planning and Team Management	**Use a local laboratory to minimize transportation impacts**	**Y**	**A local laboratory will be used if practical for the analyses required. Use of local laboratories will be documented in field notes and a BMP checklist.**
Project Planning and Team Management	**Use local staff (including subcontractors) when possible to minimize transportation impacts**	**Y**	**Local subcontractor staff will be used to the extent practical. Use of local subcontractors will be documented in field notes and a BMP checklist.**
Residual Solid and Liquid Waste	Reuse or recycle recovered product (such as resale of captured petroleum products, precipitated metals) and materials (for example, cardboard, plastics, asphalt, concrete)	N	Not Applicable
Residual Solid and Liquid Waste	Salvage uncontaminated objects/infrastructure with potential to recycle, re-sell, donate, or re-use	N	Not Applicable
Residual Solid and Liquid Waste	Employ closed-loop graywater washing system for decontamination of trucks	N	Not Applicable
Residual Solid and Liquid Waste	Segregate drilling or excavation waste based on location and composition to reduce the volume of drilling waste disposed off-site; collect needed analytical data to make on-site reuse decisions	N	Not Applicable
Sampling and Analysis	Use a multi-port sampling system in monitoring wells to minimize the number of wells needing to be installed	N	Not Applicable
Sampling and Analysis	Use a passive/no purge groundwater sampling system	N	Not Applicable
Sampling and Analysis	**Use dedicated materials (that is, re-use of sampling equipment and non-use of disposable materials/equipment) when performing multiple rounds of sampling**	**Y**	**Dedicated sampling supplies are planned for use during the remedy. Use of dedicated sampling equipment will be documented in field notes and a BMP checklist.**
Sampling and Analysis	Use direct sensing non-invasive technology such as a MIP, X-ray fluorescence, LIF sensor, CPT, ROST, FFD, and/or seismic refraction/reflection	N	Not Applicable
Sampling and Analysis	Use drilling methods which minimize the generation and disposal of cuttings (for example, sonic technology)	N	Not Applicable
Sampling and Analysis	Use field test kits for screening analysis of soil and groundwater contaminants such as petroleum, polychlorinated biphenyls, pesticides, explosives, and inorganics to minimize the need for offsite laboratory analysis and associated sample packing and shipping	N	Not Applicable

Appendix B. Green Remediation Best Management Practices Screening Evaluation

ASTM International Greener Cleanups Standard Category	ASTM Best Management Practice Description	Retained	Implementation and Documentation
Sampling and Analysis	Use on-site mobile lab or other field analysis (for example, portable gas chromatography/mass spectrometry for fuel-related compounds and VOCs) to minimize the need for offsite laboratory analysis and associated sample packing and shipping	N	Not Applicable
Site Preparation and Land Restoration	For restoration use a suitable mix of trees, shrubs, grasses, and forbs to preserve or improve biodiversity and related ecosystem services	N	Not Applicable
Site Preparation and Land Restoration	**Minimize clearing of trees and other vegetation throughout investigation and cleanup**	**Y**	**Vegetation disturbance will be minimized during the work, and approximate quantity of vegetation disturbed, as well as restoration will be documented in field notes and a BMP checklist.**
Site Preparation and Land Restoration	**Restrict traffic to confined corridors to minimize soil compaction and land disturbance during site activities**	**Y**	**Traffic to the work area will be limited to confined areas, and will be documented in field notes and a BMP checklist.**
Site Preparation and Land	Use biodegradable covers to protect and preserve healthy plants from land disturbing activities	N	Not Applicable
Site Preparation and Land	Use crushed concrete as a construction aggregate for road base, pipe bedding, or landscaping	N	Not Applicable
Site Preparation and Land	Use excavated areas to serve as retention basins in final storm water control plans	N	Not Applicable
Site Preparation and Land Restoration	Use pervious surface material such as porous pavement or gravel and separated pervious surfaces, rather than impermeable materials, when installing hardscape (for example, roadway, parking area) to maximize infiltration	N	Not Applicable
Site Preparation and Land	Use reclaimed asphalt pavement as a granular base for new roads	N	Not Applicable
Site Preparation and Land Restoration	Use silica-based spent foundry sands from iron, steel, and aluminum foundries in soil-related applications such as manufactured soils and roadway sub-base	N	Not Applicable
Surface and Storm Water	Capture rainwater for tasks such as wash water, irrigation, dust control, constructed wetlands, or other uses	N	Not Applicable
Vehicles and Equipment	**Implement an idle reduction plan**	**Y**	**An idle reduction plan will be implemented during the remedy, and compliance will be documented in the field notes and a BMP checklist.**
Vehicles and Equipment	Use biodegradable hydraulic fluids on hydraulic equipment such as drill rigs	N	Not Applicable
Vehicles and Equipment	Use electric, hybrid, ethanol, or compressed natural gas vehicles instead of conventional vehicles	N	Not Applicable
Vehicles and Equipment	Use equipment to increase automation such as electronic pressure transducers, thermo-couples, and water quality monitoring devices coupled with an automatic data logger to optimize operation and minimize transportation of staff to the site	N	Not Applicable
Vehicles and Equipment	Use retrofitted engines that use ultra-low, low sulfur diesel, or alternative fuels; or filter/treatment devices to achieve BACT or MACT	N	Not Applicable
Vehicles and Equipment	Use SmartWay transportation retrofits (for example skirts, air tabs) on tractor-trailers whenever possible	N	Not Applicable
Vehicles and Equipment	Use timers or feedback loops and process controls for dosing chemical injections to minimize transportation of staff to the site	N	Not Applicable

Note: **Bolded** BMPs were retained and planned for implementation during the remedy.

Appendix C

Calculations

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CDM Smith

		Job #: 218435		**Calc By:**	E. Ehret
Client:	**Arconic**	**Checked By:**	**N. Smith**	**Date:**	**4/23/18**
Project:	**Olean**	**Date:**	**5/7/18**	**Calc. No.**	1
Detail:	**Amendment Quantity Based on Oil Retention**			**Revision#**	
				Date:	___/___/___

Calculation Brief Title: Calculation for Total Volume of Amendment

1.0 Purpose/Objective

- This calculation was completed to find the total amount of amendment based on the quantity of emulsified oil that can be retained the in aquifer.

2.0 Procedure

- Calculate the volume of the aquifer unit using the known area and thickness.
- Calculate the mass of soil within the aquifer unit using the porosity and dry density.
- Calculate the effective retention of emulsified oil in the aquifer matrix by multiplying the density of soil by the effective retention rate
- Calculate the total mass of oil retained in the aquifer matrix by multiplying the mass of soil by the effective retention of the aquifer.
- Convert the mass of amendment to volume of amendment to be injected using the density of the amendment.

3.0 References/Data Sources

- Soil within the aquifer unit consists of has an average bulk density of approximately 1.5 (g/cm^3), based on the assumed soil type of clayey sand (Argonne National Laboratory: http://web.ead.anl.gov/resrad/datacoll/soildens.htm).
- The effective retention is for alluvium (clayey sand) is 0.0013 g of oil/g of soil (Protocol for Enhanced In Situ Bioremediation Using Emulsified Edible Oil, ESTCP 2006).
- The porosity of clayey sand soil is 35% (Argonne National Laboratory - http://web.ead.anl.gov/resrad/datacoll/porosity.htm).
- The target bioremediation treatment area is approximately 36,000 square feet.

Equations:

- Convert soil density g/cm^3 to g/ft^3 : 1 ft^3 = 28,316.8 cm^3

- Convert mL to gallons : 1 mL = 0.0002641 gallon

4.0 Assumptions

- Assumed the aquifer porosity during injection is 35%
- Assumed that the effective retention is for alluvium (clayey sand)
- Assumed that the thickness of the saturated interval of the aquifer targeted for treatment is 25 feet
- Assumed the specific gravity of the amendment is approximately 1
- These calculations are limited by the heterogeneous nature of the soil overlying the aquifer unit

CDM Smith

	Job #:	218435		Calc By:	E. Ehret
Client:	Arconic	Checked By:	N. Smith	Date:	4/23/18
Project:	Olean	Date:	5/7/18	Calc. No.	1
Detail:	Amendment Quantity Based on Oil Retention			Revision#	
				Date:	___/__/___

5.0 Calculations

- Calculate aquifer volume:
  $=36{,}000\ ft^2 * 25\ ft$ — 900,000 ft^3

- Calculate volume of soil in aquifer matrix:
  $= 900{,}000\ ft^3 * (1-0.35)$ — 585,000 ft^3

- Calculate effective retention for aquifer:
  $= 1.5$ g of soil/cm^3 * 28,316.8 cm^3/ft^3 * 0.0013 g of oil/g of soil — 55 g/ft^3

- Calculate mass of oil retained:
  $= 585{,}000\ ft^3 * 55\ g/ft^3$ — 32,175,000 g
  32,000 kg

- Calculate volume of amendment required:
  = 32,175,000 g * 1 mL/g * 0.0002641 gallons/mL — **8,500 gallons**

6.0 Conclusions/Results

- The total amount of oil that can be retained the in aquifer target treatment volume is 8,500 gallons.
- This calculation is limited by the heterogenous nature of the soil and lithology overlying the aquifer unit.

CDM Smith

	Job #:		Calc By: E. Ehret
Client: Arconic	Checked By: N. Smith		Date: 4/23/18
Project: Olean	Date: 5/7/18		Calc. No. 2
Detail: Required Amendment Using Target Carbon Concentration In Aquifer			Revision#
			Date: ___/___/___

Calculation Brief Title: Calculation for Amendment Required Using Target Carbon Concentration in the Groundwater

1.0 Purpose/Objective

- This calculation was completed to estimate the amendment required to reach a desired carbon concentration in the groundwater within the target bioremediation treatment area.

2.0 Procedure

- Calculate the volume of the aquifer unit in the target treatment area using the known area and thickness.
- Multiply the volume of the aquifer unit by the porosity to calculate volume of water in the aquifer.
- Calculate themass of amendment required to reach desired carbon concentration in the groundwater by multiplying the groundwater volume by the desired carbon concentration.
    - Convert the mass of amendment to volume of amendment to be injected using the density of the amendment.

3.0 References/Data Sources

- The porosity of clayey sand soil is 35% (Argonne National Laboratory - http://web.ead.anl.gov/resrad/datacoll/porosity.htm).
- Desired carbon concentration is 2,000 mg/L in the groundwater.
- The target bioremediation treatment area is approximately 36,000 square feet.

Equations:

- *Convert ft³ to L :* 1 ft^3 = 28.317 L
- *Convert mL to gallons :* 1 mL = 0.0002641 gallon

4.0 Assumptions

- Assumed the aquifer porosity during injection is 35%
- Assumed that the thickness of the saturated interval of the aquifer is 25 feet bgs
- Assumed that the injected amendment contains approximately 100 percent fermentable compounds (carbon compounds)
- Assumed the specific gravity of the amendment is approximately 1
- These calculations are limited by the heterogeneous nature of the soil overlying the aquifer unit.

CDM Smith	Job #:			Calc By:	E. Ehret
Client:	Arconic	Checked By:	N. Smith	Date:	4/23/18
Project:	Olean	Date:	5/7/18	Calc. No.	2
Detail:	Required Amendment Using Target Carbon Concentration In Aquifer			Revision#	
				Date:	___/___/___

5.0 Calculations

- Calculate aquifer volume:

  $=36,000\ ft^2 * 25\ ft$ — 900,000 ft^3

- Calculate volume of water in aquifer:

  $= 900,000\ ft^3 * (0.35)$ — 315,000 ft^3

- Calculate mass of amendment (as carbon) to reach target concentration in groundwater:

  $= 2,000\ mg/L * (315,000\ ft^3 * 28.317\ L/ft^3) * 0.001\ g/mg$ — 17,840,000 g; 18,000 kg

- Calculate the volume of amendment required:

  $= 17,840,000\ g * 1\ mL/g * (0.0002641\ gallon/mL)$ — **4,700 gallons**

6.0 Conclusions/Results

- The total amount of oil required to reach desired carbon concentration of 2,000 mg/L in the groundwater is 4,700 gallons, assuming the amendment contains 100 percent carbon compounds.
- This calculation is limited by the heterogenous nature of the soil and lithology overlying the aquifer unit.

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cdmsmith.com