March 26, 2020

New York State Department of Environmental Conservation
Division of Environmental Remediation – Region 7
615 Erie Boulevard West
Syracuse, New York 13204-2400
Attn: Mr. Michael Belveg

RE: Revised Alternatives Analysis Report
Former Coyne Textile Facility Vapor Intrusion Mitigation
CHA Project No.: 059294.001
NYSDEC Site No.: C734144

Dear Mr. Belveg,

On behalf of Ranalli/Taylor St., LLC (Ranalli/Taylor St.), please find an enclosed copy of the Revised Alternatives Analysis Report for the Former Coyne Textile Facility located at 140 Cortland Avenue in the City of Syracuse, New York. The document has been revised to reflect the comments provided in the New York State Department of Environmental Conservation's (NYSDEC's) comment letter dated March 6, 2020 which includes comments from the New York State Department of Health (NYSDOH). The NYSDEC/NYSDOH comments and CHA responses/report amendments are summarized below:

Comment 1: Section 1.0 Introduction – This section references that Ranalli/Taylor St., LLC is the previous site owner and that JMA Wireless purchased the Ranalli/Taylor St., LLC; If this is the case, then Ranalli/Taylor St., LLC is still the current owner of the site. Please reword this section to reflect that or submit to the Department a Change of Use notification form showing who the new owner(s) of the site are.

Response 1*: This comment has been addressed. Ranalli/Taylor St. LLC is still the owner, a Change of Use notification is not required.*

Comment 2: Section 2.4.1 Source Removal IRM – Please correct the NYSDEEC to NYSDEC.

Response 2: *Comment has been addressed.*

Comment 3: Section 3.1.1 Surface and Subsurface Soil, Second Bullet – This RAO has been modified from the standard language. Please use the full standard language "Prevent inhalation of or exposure from contaminants volatilizing from contaminants in soil" instead.

Response 3: *CHA had use the standard language included as part of the Generic Remedial Action Objectives listed on the NYSDEC web page: http://www.dec.ny.gov/regulations/67560.html. However, we have modified the language per your request to match the RAOs listed in the NYSDEC's August 2015 Site Management Plan Template.*

Comment 4: Section 3.1.2 Groundwater, RAOs for Environmental Protection – Please include the "Restore groundwater aquifer to pre-disposal/pre-release conditions, to the extent practicable" RAO.

Response 4: *Section 3.1.2 has been updated.*

One Park Place, 300 South State Street, Suite 600, Syracuse, NY 13202-2024
T 315.471.3920 • F 315.471.3569 • www.chacompanies.com

Comment 5: Several Locations Beginning in Section 3.3.2.1 Institutional and Administrative Controls – deed restrictions are listed as an institutional and administrative control for the site. BCP sites do not use deed restrictions but instead an environmental easement is placed on the site. Please update all sections of the AAR to reflect an easement being placed on the site instead of a deed restriction.

Response 5: *References to deed restrictions have been removed from the AAR.*

Comment 6: Several Locations Beginning in Section 4.0 Detailed Analysis of Alternatives – Please note that in order for a cleanup to be considered Track 2, all soil will need to be cleaned to a depth of 15 feet across the whole site. It is more likely that the alternatives proposed will reach Track 4 cleanups not Track 2. Please update all sections of the AAR to reference that a Track 4 cleanup will be utilized where applicable.

Response 6: *CHA agrees that contamination in exceedance of Unrestricted SCOs may still exist between the 0-15-ft interval, and therefore, has changed Track 2 to Track 4 for the proposed alternatives.*

If you have any questions, please do not hesitate to contact me at (315) 257-7145.

Sincerely,

Samantha J. Miller

Samantha J. Miller, EIT, CPESC-IT
Assistant Project Engineer III

ecc: Mr. Harry Warner, NYSDEC
Ms. Angela Martin, NYSDOH
Ms. Gail Cawley, JMA/GEC Consulting
Mr. James Trasher, CHA Consulting, Inc.

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Alternatives Analysis Report

Former Coyne Textile Facility
140 Cortland Avenue
Syracuse, New York 13202

Site No. C734144

CHA Project Number: 059294.001

Prepared for:

JMA Wireless d/b/a GEC Consulting
168 Brampton Road
Syracuse, New York 13205

Prepared by:

CHA

300 South State Street, Suite 600
Syracuse, New York 13202
Phone: (315) 471-3920

January 2020
Revised: March 2020

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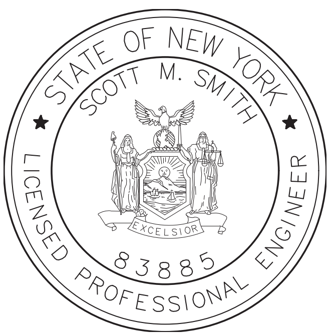
CERTIFICATION

I, Scott M. Smith, certify that I am currently a NYS registered professional engineer and that this Alternatives Analysis Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with DER Technical Guidance for Site Investigation and Remediation (DER-10).

I certify that all information and statements in this certification form are true. I understand that a false statement made herein is punishable as a Class "A" misdemeanor, pursuant to Section 210.45 of the Penal Law. I, the undersigned, of CHA Consulting, Inc. have been designated by the Site owner to sign this certification for the Site.

For CHA Consulting, Inc.:

(Professional Seal)



Scott M. Smith, P.E.
Printed Name of Certifying Engineer

Signature of Certifying Engineer

March 26, 2020
Date of Certification

083885
NYS Professional Engineer Registration Number

CHA Consulting, Inc.
Company

Associate Vice President
Title

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Appendix A XDD Environmental Summary Memo and Table

LIST OF ACRONYMS & ABBREVIATIONS

AAR	Alternatives Analysis Report
AMSL	Above Mean Sea Level
AOC	Area of Concern
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
BCA	Brownfield Cleanup Agreement
BCP	Brownfield Cleanup Program
BGS	Below Ground Surface
CCR	Construction Completion Report
CHA	CHA Consulting, Inc.
COC	Contaminants of Concern
DCE	1,2 - Dichloroethane
DER-10	Division of Remediation Program Policy 10
EISB	Enhanced In-Situ Bioremediation
ESA	Environmental Site Assessment
ft^2	Square Feet
GAC	Granular Activated Carbon
GEC	GEC Consulting, LLC
GPR	Ground Penetrating Radar
GZA	GZA GeoEnvironmental
IC	Institutional control
IRMWP	Interim Remedial Measure Work Plan
ISCO	In-Situ Chemical Oxidation
ISCR	In-Situ Chemical Reduction
JMA	JMA Wireless
LDR	Land Disposal Restriction
MIHPT	Membrane Interface Hydraulic Profiling Tool
MNA	Monitored Natural Attenuation
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PFAS	Per-and Polyfluoroalkyl Substances
PID	Photoionization Detector
PRB	Permeable Reactive Barrier
PVC	Polyvinyl Chloride
RAOs	Remedial Action Objectives
REC	Recognized Environmental Condition
RI	Remedial Investigation
RIR	Remedial Investigation Report

SCGs	Standards, Criteria and Guidance
SCOs	Soil Cleanup Objectives
SMP	Site Management Plan
SPDES	State Pollution Discharge Elimination System
SSDS	Sub-Slab Depressurization System
SVE	Soil Vapor Extraction
SVOC	Semi-volatile Organic Compound
TCE	Trichloroethylene
TMP	Tax Map Parcel
TO-15	Toxic Organics Method 15
TOD	Total Oxygen Demand
TOGS	Technical and Operational Guidance Series
µg/L	Microgram per Liter
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound
XDD	XDD Environmental
ZVI	Zero-Valent Iron

1.0 INTRODUCTION

The Former Coyne Textile Facility (Site) is located at 140 Cortland Avenue in Syracuse, New York (Figure 1). The Site owner, Ranalli/Taylor St., LLC (Ranalli/Taylor St.), entered into a Brownfield Cleanup Agreement (BCA) in September 2017 through the New York State Department of Environmental Conservation's (NYSDEC's) Brownfield Cleanup Program (BCP). The Site consists of three tax map parcels (TMP's) as shown on Figure 2 and is registered as BCP Site No. C734144. In December 2019 JMA Wireless (JMA) doing business as GEC Consulting, LLC (GEC), purchased Ranalli/Taylor St. LLC. The remainder of the BCP work will still be completed under the Ranalli/Taylor St. LLC entity, as a volunteer (defined in Title 6 of the New York Codes, Rules, and Regulations (6 NYCRR) Part 375). New owner contact information has been provided to the NYSDEC following the transfer of the corporation ownership.

CHA Consulting, Inc. (CHA) was retained by GEC to prepare an Alternatives Analysis Report (AAR) to evaluate potential strategies for the remediation of the contamination identified during the Remedial Investigation (RI) conducted in 2018, summarized in a Remedial Investigation Report (RIR) (CHA, February 2019), and approved by NYSDEC March 6, 2019.

1.1 PURPOSE OF THE REPORT

The purpose of the AAR is to develop and evaluate the remedial alternative(s) which will best address the Site-specific environmental conditions and Areas of Concern (AOCs) at the Site. Based on the results of the RI, the following four AOCs were identified and are shown on Figure 3:

- The Former underground storage tank (UST) Area, also referred to as the Source Area;
- Site-Wide Groundwater;
- Office Vapor; and
- Warehouse Vapor.

This report establishes remedial goals and action objectives for the Site, screens several remedial alternatives for the treatment of the four AOCs and provides an in-depth analysis of a select number of alternatives based on the following nine criteria, as defined in NYSDEC Division of Environmental Remediation Program Policy 10 (DER-10):

1. Protection of Human Health and the Environment
2. Compliance with Standards, Criteria and Guidance (SCGs)
3. Long-term Effectiveness and Permanence
4. Reduction in Toxicity, Mobility and Volume
5. Short-Term Effectiveness
6. Implementability
7. Cost
8. Land Use
9. Green Remediation and Sustainability

1.2 REPORT ORGANIZATION

This AAR is divided into six (6) major sections, including:

Section 1:	Provides an introduction of the project along and the purpose of the report.
Section 2:	Provides the Site background and summary of previous investigations.
Section 3:	Identifies the remedial goals and objectives for this project.
Section 4:	Identifies each remedial alternative and provides a description and analysis of each.
Section 5:	Identifies the recommended remedial alternative.
Section 6:	Provides an estimated schedule for the completion of the project.

2.0 SITE BACKGROUND

2.1 SITE DESCRIPTION

The Former Coyne Textile Facility is located in an urban area at 140 Cortland Avenue in the City of Syracuse, Onondaga County, New York. The Site is currently unoccupied, contains one building with an approximately 52,000-square foot (ft^2) footprint, and is zoned for commercial use. The Site is identified as two non-contiguous areas (Figure 2) as described below:

- The former main laundry facility and offices are known as 140 Cortland Avenue (Tax Map No. 094.-05-06.0) and consist of one parcel of land totaling approximately 1.75 acres in size. This parcel will be referred to as the main parcel. The parcel consists of the currently vacant former laundering facility and offices, and concrete sidewalks. The building is a concrete block building with a slab-on-grade foundation.
- The park area and employee parking area are known as 1002-1022 South Salina Street/Cortland Avenue (Tax Map No. 094.-20-01.0) and 10247-1040 South Salina Street/Tallman Street (Tax Map No. 094.-20-02.0) and consist of two parcels totaling approximately 1.70 acres (0.57 and 1.13 acres, respectively) in size. These parcels consist of a small park and a fenced in asphalt parking lot, referred to as Coyne Park and the former employee parking area, respectively.

2.1.1 Neighboring Properties

The Site limits are generally bounded by commercial buildings to the north, South Salina Street to the east, Tallman Street to the south, and South Clinton Street to the west. Several rows of multi-family houses are located northwest of the Site. The parcels immediately to the east of Cortland Avenue are currently an asphalt parking lot and landscaped area deemed Coyne Park. Surrounding property uses include headquarters for Central New York Regional Transportation Authority and Centro Inc., several industrial/light manufacturing facilities, commercial retail locations and religious affiliated facilities.

2.1.2 Site Topography

The main parcel of the Site primarily consists of one building surrounded by asphalt roads and parking lot, concrete sidewalks and chain link fencing. The Site is generally flat, with a gentle slope from the east to the west across the employee parking lot and beneath the main building. The elevation of the Site is approximately 390 feet above mean sea level (AMSL).

2.1.3 Site Geology

According to the United States Department of Agriculture (USDA) Web Soil Survey, the soil beneath the Site is indicative of Urban Land, which is soil material having a non-agricultural, manmade surface layer that has been produced by mixing and filling in urban and suburban areas. Surficial geology consists mostly of lacustrine silts and clays. Bedrock at the Site is mapped by the USGS as the Syracuse formation, which consists of dolostone, shale, gypsum, and salts.

Field observations and stratigraphic cross sections provided in the RI Report (CHA, February 2019) confirmed the presence of urban fill to a depth of approximately 8 to 10 feet below ground surface (bgs). Generally, silts and clays are present beneath the urban fill to a depth of approximately 13 to 15 feet bgs. Alternative lacustrine silts and clays, then sands and gravel, were encountered beneath the fill material to the end of each boring. At least two silt and clay layers, one below the urban fill and one at varying depths, but approximately 26 to 30 feet bgs, may act as confining layers to impede the vertical transport of groundwater and contamination.

2.1.4 Site Hydrogeology

Generally, the Site slope indicates groundwater flows in a westerly direction towards Onondaga Creek, located approximately 0.2 miles to the west of the Site.

Based on groundwater elevations measured on April 19, 2018, the depth to groundwater at the Site is typically less than 15 feet bgs. Beneath the building, groundwater contours are at a nearly flat gradient, apart from the northwestern portion of the building where slightly elevated groundwater indicates localized flow path from the north-western portion of the building toward the center of the building.

2.2 PREVIOUS REPORTS AND INVESTIGATIONS

2.2.1 Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) was prepared in 2014 by GZA GeoEnvironmental of New York (GZA) in general accordance with the American Society for Testing and Materials (ASTM) Standard Practice E 1527-13. GZA previously provided this report to the NYSDEC, and therefore, it is not included as part of this AAR Report. According to the Phase I ESA, prior to the Ranalli/Taylor St. purchase of the property in 2016, the 140 Cortland Avenue property was occupied by several manufacturing facilities and a gasoline station. Various entities of Coyne Textile Services have owned the property since the mid-1930s, and the property was utilized as an industrial laundering facility. Coyne Textile Services filed for bankruptcy and ceased operations in late 2015. Dry-cleaning activities using tetrachloroethylene (PCE) and Stoddard solvent (a petroleum mixture made from distilled alkanes, cycloalkanes (naphthene's) and aromatic compounds) were conducted at the property until 2000. These dry-cleaning products were noted to be stored in aboveground storage tanks (ASTs). Additionally, three USTs were noted to be located beneath the dry-cleaning room floor (containing Stoddard solvent) and the boiler room at 140 Cortland Avenue. A gasoline filling station was present in the southern portion of the Site in the 1980s.

The former employee parking lot and park located east of the former laundering facility was owned by Coyne Textile Services from 1989 to 2016. Prior to Coyne Textile Services, previous Site uses included bus storage and repairs, the Syracuse Street Car Barn, retail stores, and a gasoline filling station (circa 1950-1970).

Based on historic use and conditions observed during the Phase I ESA, recognized environmental conditions (RECs) were identified and subsequent investigation activities were completed.

2.2.2 Subsurface Investigations

Under the direction of the previous Site owner, multiple Site investigations were conducted in 2014 and 2015. The following reports and subsequent data tables and figures are provided and described in further detail in the RI Report and are summarized here.

November 2014 Phase II Subsurface Investigation

This Site assessment included a limited subsurface investigation (Figure 4) to evaluate if historical Site usage had impacted Site soil and/or groundwater. Based on the results including high vapor concentrations as indicated by elevated photoionization detector (PID) readings, petroleum odors, black stained soil, and an oil-like sheen on groundwater samples from the Phase II, GZA recommended additional soil and groundwater sampling to further define the extent of contamination at the Site. Additionally, it was suggested to pursue additional sampling in areas where boring installation was unsuccessful, particularly where floor trenches and drains are located in the former chemical storage and distribution room, and near the laundry machines.

March 2015 Phase III Subsurface Investigation

This additional Site assessment, titled Phase III Environmental Site Assessment, was prepared in 2015 by GZA to further delineate the vertical and horizontal extent of petroleum contamination near TMW-2 (associated with NYSDEC Spill #1408779), and to further evaluate the soil and groundwater conditions near the boiler room and dry-cleaning area. It is noted that the NYSDEC closed Spill #1408779 on March 30, 2015 for administrative reasons. This spill was ultimately consolidated with Spill #1412187 which occurred as part of the March 2015 Phase III Subsurface Investigation. Spill #1412187 is reported as closed on July 16, 2015.

As part of this investigation geophysical subsurface exploration using ground penetrating radar (GPR) was performed to identify locations that could hinder additional boring locations. An additional 23 soil borings were advanced to a maximum of 20 feet bgs, and 25 soil samples were collected to further delineate areas of contamination and evaluate areas that were previously inaccessible.

Three permanent 1-inch diameter polyvinyl chloride (PVC) monitoring wells were installed near well TMW-2, and four temporary 1-inch diameter PVC monitoring wells were installed at four of the soil boring locations referenced above (Figure 5). Eight groundwater samples were collected from these wells.

Analytical lab results identified several areas with volatile organic compound (VOC) and semi-volatile organic compound (SVOC) contamination above their applicable soil and groundwater standards.

2015 Vapor Intrusion Investigation

A vapor intrusion investigation was performed in 2015 to identify the potential for soil vapors inside the building on the Site (Figure 6). GZA collected sub-slab vapor, indoor air, and outdoor ambient air samples as part of this assessment. A total of 10 indoor air, samples were collected approximately 4 to 5 feet above the floor, 10 sub-slab air samples were collected within 10 feet of the indoor air samples, and 1 outdoor air sample was collected from an exterior upwind location. Samples were sent to the lab for analysis of for Toxic Organics, EPA Air Method 15 (TO-15).

The investigation determined that PCE and its breakdown daughter products were present in the northern portion of the Site building where the laundering activities were conducted and would require mitigation under New York State Department of Health (NYSDOH) Guidance for Evaluating Soil Vapor Intrusion, dated 2006 guidelines. Monitoring and/or source identification and exposure measures were determined to be necessary throughout the remainder of the Site building. GZA recommended the installation of a vapor mitigation system, to address the potential vapor intrusion conditions.

2.2.3 Remedial Investigation

Ranalli/Taylor St. retained CHA to conduct a RI at the Site in 2018 to identify environmental concerns and provide additional information necessary for this AAR. The RI used the data provided in the GZA reports to identify locations where additional investigation was required. The RI included a geophysical survey, surface soil sampling at Coyne Park, subsurface soil sampling at 24 boring locations (Figure 4), the installation and subsequent sampling of groundwater from 6 permanent groundwater monitoring wells, groundwater sampling from 3 existing permanent monitoring wells (Figure 5), indoor air sampling at 2 locations, and vapor intrusion sampling from 6 temporary sub-slab vapor points (Figure 6). The following summarizes the findings of the investigation:

- The exposure to Site media is limited due to the Site being primarily covered with buildings and paved asphalt parking areas and the presence of municipal water and sewer at and in the vicinity of the Site.
- The presence of two silty clay layers (beneath the fill material and at a depth of approximately 26 to 30 feet bgs) which have a lower hydraulic conductivity and have acted as a confining later to impede the vertical migration of contamination into the more permeable sand and gravel layers at depth.
- Subsurface soils are impacted with VOCs exceeding the Part 375 Commercial soil cleanup objectives (SCOs) in the approximate location of historical USTs near the northwest corner of the building (Source Area).
- SVOCs were not detected in soil at concentrations exceeding the Part 375 Commercial SCOs since 2014. These historical exceedances were located beneath the northeastern portion of building and the former employee parking area.
- Metals in soil, detected at concentrations exceeding the Part 375 Commercial SCO, were located beneath the central portion of the building (barium in 2018) and the former employee parking lot area (arsenic in 2014).
- Polychlorinated biphenyls (PCBs) were detected at concentrations less than the Part 375 Commercial SCO beneath the central/northern portion of the building.
- VOCs, including PCE, were detected at concentrations exceeding the Class GA ambient water quality standards provided in the NYSDEC's Division of Water Technical and Operational Guidance Series *Ambient Water Quality Standards and Guidance Values and*

Groundwater Effluent Limitations (TOGS 1.1.1). in groundwater. The highest concentrations of VOCs were adjacent to or downgradient of where historical USTs containing dry cleaning solvents were found to be "closed in place" but lacking appropriate closure documentation.

- Breakdown "daughter" products of PCE, including trichloroethene (TCE), 1,2-dichloroethane (DCE), and vinyl chloride, were detected in groundwater beneath the building at concentrations exceeding TOGS 1.1.1 and are considered the contaminants of concern (COC) for the Site.
- A plume of VOC groundwater contamination originates from the northwestern portion of the building and has spread laterally beneath the building. Groundwater in this area is typically slow moving and this investigation was completed a time of year when the groundwater table is typically high. Additionally, the location of physical structures beneath the slab are not well known. While there are many floor drains and vaults visible along the north end of the building, there is the potential that additional vaults or drains may be present throughout the building that have been filled in place and are that these potential preferential pathways are influencing the direction of groundwater flow beneath the slab.
- Metals, including aluminum, iron, magnesium, and manganese, were detected in groundwater at concentrations exceeding the TOGS 1.1.1. These compounds are commonly identified in groundwater and are relatively non-toxic.
- Perfluorinated alkyl substances (PFAS) and 1,4- Dioxane were detected at select groundwater monitoring wells.
- Elevated concentrations of PCE and TCE were identified in all ambient vapor and sub-slab vapor points. As a result, the sub-slab vapor and indoor air quality in the Building has been impacted by soil vapor intrusion. According to the NYSDOH Decision Matrices (including the May 2017 updates), mitigation is the recommended action.
- Soil vapor points were not found to have contaminants associated with the NYSDOH Decision Matrices. Therefore, the parking areas are not impacted by soil vapor intrusion.

Based on the RI and the proposed Site redevelopment plans, CHA recommended the development of an interim remedial measure work plan (IRMWP) to address the soil contamination in the Source Area as well as mitigate the soil vapor intrusion in both the Office and Warehouse areas. Additionally, CHA recommended this AAR be prepared to evaluate the best course of action to address the remaining soil and groundwater contamination.

2.3 AREAS OF CONCERN

As mentioned previously, as a result of the RI four primary AOCs were identified. The four AOCs are defined as: (1) the Former UST Area (Source Area); (2)Site-wide groundwater; (3) Office vapor; and (4) Warehouse vapor. A discussion of the nature and extent of contamination in the soil, groundwater, and sub-surface vapor within these AOCs is provided in the following sections.

2.3.1 Former UST Area (Source Area)

The Former UST Area is in the northwestern portion of the building. Several subsurface soil samples, several groundwater samples, and soil vapor samples have been collected in this area.

Historical subsurface soil sampling identified the presence of chlorinated VOC contamination, namely PCE, DCE, and vinyl chloride, in soil samples SB-32 and SB-33, at concentrations exceeding their respective Part 375 Commercial SCO, which is consistent with the findings of the RI. During the RI, PCE was identified at concentrations exceeding its respective Part 375 Commercial SCO in sample SOIL-116 and lesser concentrations of TCE, DCE, and vinyl chloride in samples SOIL-116 and SOIL-119. PCE was detected in excess of the Part 375 Commercial SCO throughout this area. Metals (mercury and lead) and total PCBs exceeded the Part 375 Unrestricted SCOs in this area but were detected at concentrations that are less than the respective Part 375 Commercial SCOs.

Historical groundwater sampling in this area identified the presence of chlorinated VOC contamination, including PCE, TCE, DCE, and vinyl chloride, in the wells directly adjacent to the Former UST Area. During the RI, well Temp-GW001 and the well cluster at GW-103 were located within and adjacent to the Former UST Area, respectively. COC concentrations of PCE, TCE, DCE, and vinyl chloride, among others, were detected at concentrations exceeding their applicable TOGS 1.1.1 groundwater standards and guidance values.

2.3.2 Site-Wide Groundwater

The groundwater samples collected as part of the RI confirmed the presence of VOCs and metals at concentrations exceeding their respective TOGS 1.1.1 groundwater standards and guidance values. within the northwestern portion of the building. Chlorinated VOCs in groundwater were primarily found in the location of the former dry-cleaning room (Former UST Area) and are consistent with the findings from historical Site investigations. The most recent analytical results for PCE indicate a decrease from the historical high of 2,420,000 micrograms per liter (µg/L) in well SB-32 to 21,400 µg/L in nearby temporary well Temp GW-001, and 7.1µg/L in GW-103S. While the concentration of PCE has decreased since the historical investigation, but the concentrations of daughter products TCE, DCE, and vinyl chloride have increased, likely due to some natural attenuation. SVOCs were not detected in groundwater during the RI, apart from bis(2-Elthylhexyl)phthalate, which was detected at a concentration exceeding the TOGS 1.1.1. groundwater standards and guidance values in temporary well Temp-GW001.

The groundwater samples collected as part of the RI confirmed the presence of VOCs, SVOCs and metals at concentrations exceeding their respective TOGS 1.1.1 groundwater standards and guidance values beneath the building.

The presence of a confining layer, consisting of silts and clays, beneath the urban fill at approximately 13 to 15 feet bgs and again present beneath a sand and gravel unit, at varying depths but approximately 26 to 30 feet bgs, has impeded the downward migration of contamination to the deeper sand and gravel units. This is confirmed by the cluster at GW-101 where the three wells were found to have slightly different groundwater elevations, with the deeper wells exhibiting a lower groundwater elevation. This confirmed the presence of an unconfined aquifer. The shallow monitoring well was found to have groundwater contamination exceeding applicable TOGS 1.1.1 groundwater standards and guidance values and the deeper wells (GW-101I and GW-101D) were found to have either no appreciable contamination or are at levels not exceeding applicable TOGS 1.1.1 groundwater standards and guidance values. The silty clay layer was relatively uniform across the Site and has most likely impeded contamination from breaching the deeper confining layer at approximately 26 to 30 feet bgs.

The groundwater samples collected from the employee parking lot as part of the RI confirmed the presence of VOCs and metals. However, the concentrations exceeding the applicable TOGS 1.1.1 groundwater standards and guidance values in the employee parking lot are petroleum compounds, notably benzene, isopropyl benzene, and xylene, rather than chlorinated VOCs identified beneath the Site building. Additionally, the presence of contaminants in well GW-105D indicates that deep groundwater may be impacted more than shallow groundwater. The direction of groundwater flow is generally from east to west across the employee parking lot and the well cluster GW-105 represents the upgradient wells. Impacts present in GW-105D may indicate VOC migration from an off-Site source.

2.3.3 Office Vapor

As shown on Figure 3, the Office vapor AOC is located on the southern portion of the Site where there is an expansion (circa 1980) of the building. This area is in the location of the former gasoline station and historically contained offices on the second and third floors while Coyne Textile was in operation. A concrete block wall with an overhead door and a wall cut-out separates the open space on the first floor from the Warehouse in the older section of the building. One man-door separates the lobby entrance from the Warehouse in the older section of the building.

Current and historical soil vapor intrusion samples indicate that the presence of VOCs is impacting the indoor air quality in the office portion of the building. Ambient indoor air quality sampling identified PCE at a concentration of 34.1 $\mu g/m^3$, which exceeds the NYSDOH guidance value for indoor air. Although the concentration does not require immediate action, reasonable and practical actions to reduce exposure should be taken, and therefore, it was recommended that an active sub-slab depressurization system (SSDS) be installed in this portion of the building prior to occupancy.

2.3.4 Warehouse Vapor

The Warehouse, located within the older portion of the building (Figure 3), is currently separated from the Office by a concrete block wall with an overhead door, a wall cut-out, and a man-door.

Current and historical soil vapor intrusion sampling indicates that the presence of VOCs is impacting the indoor air quality in the warehouse portion of the building as well. Ambient indoor air quality sampling identified PCE concentration of 50.9 $\mu g/m^3$, which exceed the NYSDOH guidance value for indoor air. Concentrations of TCE were identified at 1.1 $\mu g/m^3$, which does not exceed the guidance value. Although the concentration of PCE does not require immediate action, reasonable and practical actions to reduce exposure should be taken, and therefore, it was recommended that an active SSDS be installed under this portion of the building as well prior to building occupancy.

2.4 INTERIM REMEDIAL MEASURES

2.4.1 Source Removal IRM

A Source Removal IRMWP (CHA, May 2019) was approved by the NYSDEC in June 2019 that addressed contaminant source removal via excavation within the Former UST Area. In late June 2019, three USTs within the Former UST Area were removed and transported off-Site at a disposal facility, along with approximately 253.9 tons of contaminated material. Excavation of contaminated soil within the area was limited in order to maintain structural integrity of the building. Prior to backfilling, confirmation samples were collected along the sidewalls and bottom of the excavation, and indicate residual contamination exceeding Commercial SCOs remains. A complete summary of the work completed can be found within the Construction Completion Report (CCR) submitted and approved by the NYSDEC in October 2019. The remaining contamination in the Source Area is to be addressed in this AAR.

2.4.2 Vapor IRM

In April 2019 diagnostic pressure field testing was conducted within the office area AOC to determine the most effective system components, pressure gradient, installation methods, and vapor extraction locations for the vapor mitigation design. An Office Vapor IRMWP (CHA, June 2019), was approved by the NYSDEC in June 2019 that provides a design for an active SSDS for that portion of the building. The design consists of three active systems, each having its' own extraction fan and dedicated exhaust stack. The SSDS is designed to be operated in its entirety or in any combinations of sub-systems, thus enabling certain sub-systems to be shut down over time as conditions allow, per NYSDEC/NYSDOH approval.

The IRMWP also outlines post-installation testing, sampling, and monitoring as well as the requirements to be included in the CCR to be prepared after the installation of the SSDS and the post-installation system testing. At this time, the SSDS has not yet been installed on Site as the current owner is still determining which portions, if any, of the existing concrete slab may need to be removed to support the building redevelopment. Any such changes the existing building would necessitate approval of an additional work plan by the NYSDEC as well as potential modifications to the mitigation design.

2.5 EXPOSURE ASSESSMENT

2.5.1 Contaminants of Concern

As discussed previously, the primary COC for the Site include chlorinated VOCs in the soil, groundwater, and soil vapor beneath the former laundering facility. Additionally, petroleum related VOCs were identified in the soil and groundwater beneath the employee parking lot and metals typical of urban environments were identified in soil across the Site.

2.5.2 Exposure Pathways and Routes of Exposure

According to the soil, groundwater, and vapor intrusion data collected during the RI, the following table summarizes potential routes of exposure:

Table 1. Exposure Pathways and Routes of Exposure

Environmental Media & Exposure Route	Human Exposure Assessment
Direct contact with surface soils	Surface soils do not exceed the Part 375 Unrestricted SCOs, therefore there is no potential for direct contact with contaminated surface soils at the Site.
Direct contact with sub-surface soils	There is the potential to encounter VOC and metals contamination during ground-intrusive activities at the Site. Sensitive populations may be workers at the Site during investigation and remediation activities, and workers during future construction or redevelopment activities.
Ingestion of Groundwater	Groundwater wells are not used for drinking water and on-Site buildings utilize public water service. There is no potential for consumption of impacted groundwater. There are no known domestic water supply wells in the area.
Direct contact with groundwater	There is the potential to come into contact with VOC, SVOC and metal contaminated groundwater if future intrusive work extends to the saturated zone. Sensitive populations may be workers at the Site during investigation and remediation activities and workers during future construction activities.
Inhalation of air	The Site building is currently unoccupied. Sensitive populations may be future Office and Warehouse employees that occupy the building. Past sampling at the Site has indicated that mitigation of the sub-slab soil vapor is necessary in order to comply with the NYSDOH prior to occupancy.

3.0 REMEDIAL GOALS AND OBJECTIVES

3.1 REMEDIAL ACTION OBJECTIVES

The remedial action objectives (RAOs) for the Site are medium-specific objectives that are established for the protection of human health and the environment. RAOs are typically narrative statements that identify the contaminants and environmental media of concern, the potential exposure pathways to be addressed by remedial actions relative to the exposed populations and environmental receptors to be protected, as well as the acceptable contaminant concentrations/remediation goals for each environmental medium. The RAOs for this Site are described in the following sections.

3.1.1 Surface and Subsurface Soil

RAOs for Public Health Protection

- Prevent ingestion/direct contact with contaminated soil.
- Prevent inhalation of or exposure from contaminants volatilizing from contaminants in soil.

RAOs for Environmental Protection

- Prevent migration of contaminants that would result in groundwater or surface water contamination.

3.1.2 Groundwater

RAOs for Public Health Protection

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with, or inhalation of volatiles, from contaminated groundwater.

RAOs for Environmental Protection

- Remove the source of ground or surface water contamination.
- Restore ground water aquifer to pre-disposal/pre-release conditions, to the extent practicable.

3.1.3 Soil Vapor

RAOs for Public Health Protection

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

3.2 REMEDIAL GOALS

Remedial goals (or targets) are often considered the maximum acceptable contaminant concentrations in each environmental medium that the remedial actions must meet. Remedial goals are usually based on the 6 NYCRR Part 375 applicable SCGs unless SCGs are not available for a particular chemical or medium, or the SCGs are not considered sufficiently protective of human health and the environment. For this project, the appropriate SCGs for soil remediation will be the Part 375 Commercial SCOs, which is consistent with the zoning of the property, the proposed reuse of the Site and the anticipated future institutional controls that will be placed on the Site. Similarly, the SCGs for groundwater will be the NYSDEC's TOGS 1.1.1 ambient water quality standards and guidance values for Class GA groundwaters.

It should be noted that some of the remedial alternatives evaluated may take several years before reaching the applicable remedial goals. Ideally, the goal would be that contamination be eliminated from the Site immediately. However, the actual goal of the remediation is to reduce or eliminate human exposure to the extent practical in a timely manner. In addition, the remediation should remove the source material and significantly reduce contaminant migration to groundwater, soil vapor migration into the subsoil, and migration of contaminated groundwater to downgradient surface water bodies.

Remedial goals will focus on chlorinated VOCs, namely PCE and its breakdown compounds TCE, DCE, and vinyl chloride, in sub-slab vapor, subsurface soil, and groundwater. The maximum remediation target depth is estimated at 25 feet below the surface where the first confining layer was observed during the RI.

3.3 GENERAL RESPONSE ACTIONS

After establishing the remedial objectives for the Site, several general response actions were evaluated based upon the ability of the response to address the remedial objectives. These actions are intended to mitigate potential exposure to the COCs, control the migration of the COCs on-Site, and remediate the COCs to the extent practical. The purpose of establishing general response actions is to begin to evaluate basic methods of protecting human health and the environment, such as treatment and containment, or removal of Site contaminants. The general response actions may then be combined to form alternatives, such as treating grossly contaminated material (if necessary) and providing barriers, containment, or post-treatment monitoring of any residual contaminants. The following list summarizes the general response actions that have been considered for the soil, groundwater, and soil vapor intrusion impacts at the Site, each of which are described in more detail in the following subsections:

1. No Action
2. Risk and Hazard Management
3. Natural Attenuation
4. Extraction with Ex-situ Treatment
5. In-Situ Treatment
6. Containment

7. Removal and Disposal

3.3.1 No Action

The no action response action/alternative is considered to be the baseline alternative that will provide the basis for comparison for other response actions and resultant remedial alternatives. Under this scenario, all ongoing activities associated with remediation of the Site would cease and no future cleanup would be completed. The only way that the Site contaminants would be addressed would be through the natural processes of biodegradation, dispersion, adsorption, dilution, and volatilization.

3.3.2 Risk and Hazard Management

Risk and hazard management responses typically include institutional, administrative, and ventilation controls, as well as ecological resource surveys to reduce or eliminate exposure risks associated with the on-Site contamination. Although risk and hazard management may be acceptable as the sole remedy for sites that pose minimal risk to human health and the environment, these actions are more commonly used in conjunction with other actions, such as monitoring or limited active responses.

3.3.2.1 Institutional and Administrative Controls

Institutional controls (ICs) may reduce or eliminate exposure risk by restricting some or all access to the impacted areas on the Site. ICs can be used when the contamination is first discovered, when remedies are ongoing, and when residual contamination remains on-Site at a level that does not allow for unrestricted use and unlimited exposure after cleanup is complete. Examples of ICs include the posting of signs, installation of fences or other barriers, security systems, etc. Administrative controls typically restrict the type of uses permitted on the Site and/or may restrict the use of groundwater/surface water on the Site. Example of administrative controls include zoning changes and environmental easements to limit future land use or prohibit activities that may compromise specific engineering remedies. ICs and administrative controls may be considered an appropriate component of a remedy or may be necessary to ensure that a remedy is protective under the following situations:

- The cleanup is protective for industrial/commercial reuse, but not residential exposures.
- The groundwater will remain contaminated for a period of time such that potable water well drilling should be prevented.
- Soils are remediated at the surface, but contamination at higher concentrations remains in the subsurface.
- The contamination is covered with clean soil to prevent exposure and/or reduce the leaching of the contamination to groundwater, and activities that could potentially degrade the soil cover must be prohibited.

3.3.2.2 Ventilation Controls

Ventilation controls are typically utilized to disperse VOC contaminants. The most typical application of ventilation controls is placement of an engineered ventilation system beneath a building that is constructed over residual contaminants where there could be an inhalation risk if the VOCs are not dispersed.

While this technology is often unacceptable as a sole remedial alternative, it may be combined with other technologies. Depending upon the extent and concentrations of residual contaminants remaining at the Site following cleanup, installing sub-slab depressurization systems beneath any new structures designed for human occupancy may be appropriate.

3.3.3 Natural Attenuation

Natural attenuation is defined as a remedial method that reduces the mass and concentration of contaminants in the environment without human intervention. However, unlike a "take no action" approach to cleanup, this approach requires long-term monitoring of the Site conditions to confirm whether the contaminants are being degraded at reasonable rates to verify protection of human health and the environment. Site data should clearly indicate whether concentrations of soil and groundwater contaminants are being adequately reduced without active remediation. If not, more aggressive remedial technologies may be necessary. Natural attenuation occurs through a variety of physical, chemical, and/or biological processes, including:

- Biodegradation
- Adsorption
- Volatilization
- Evapotranspiration
- Dispersion
- Dilution
- Chemical or biological stabilization
- Destruction of contaminants

One of the most important components of natural attenuation is biodegradation, which typically involves the transformation of a compound to a less toxic substance(s) by subsurface microorganisms through biotic reactions. Because natural attenuation typically allows contaminants to migrate further than active remedial measures, it is also important to determine whether individual or sensitive environmental receptors may be affected by the release.

3.3.4 Extraction with Ex-situ Treatment

Extraction involves the removal of subsurface contaminates in soil, groundwater, and other media for treatment aboveground. The goal of ex-situ treatment is to separate, destroy, or convert contaminants in extracted soil, groundwater, and/or vapor. However, if treatment only separates the contaminants for the impacted media, the contaminants will still require proper disposal. Ex-situ treatment typically requires shorter periods of time to complete the cleanup of a site than in-situ treatment, but extraction of the contaminants typically costs more than in-situ techniques. One potential component of extraction with ex-situ treatment is the excavation of subsurface soils.

The main advantage to excavating soils is that there is typically a higher degree of certainty about the uniformity of treatment because of the ability to homogenize, screen, and continuously mix the soils prior to treatment. The soils can then be treated using a variety of techniques, including biological methods (e.g. biopiles, composting, land farming), physiochemical processes (e.g. dehalogenation, soil washing, solidification), or thermal treatments (e.g. thermal desorption, incineration).

Groundwater may be extracted by pumping groundwater from a series of wells or collection trenches. The groundwater can then be treated by a variety of methods including sorption to granular activated carbon (GAC), air stripping, ion exchange, oxidation, constructed wetlands, etc. Gaseous vapors extracted from the subsurface, such as those removed using a dual-phase or soil-vapor extraction (SVE) system, can be treated using GAC sorption, thermal oxidation, ultraviolet (UV) oxidation, etc. After treatment is complete, the soil can be returned to the excavation and the treated groundwater can be discharged to a sanitary sewer system where permitted, discharged to surface water, or reinjected beneath the subsurface.

3.3.5 In-Situ Treatment

In-situ treatment techniques involve the destruction or conversion of contaminants in subsurface soils, bedrock, and groundwater to less toxic compounds without removal. There are a variety of biological, chemical, and physical techniques available for in-place treatment of chlorinated solvent-impacted soils. While the costs associated with in-situ techniques are often less than those associated with ex-situ techniques, in-situ methods typically require longer periods of time to reach the remedial objectives established. In addition, it is more difficult to determine whether contaminants have been destroyed using in-situ treatment methods.

Bioremediation treatment techniques involve the use of microorganisms to grow and utilize the contaminants as a food source and thereby convert the contaminants to less toxic substances. Although natural microorganisms exist in the subsurface and can often break down the subsurface contaminants, such as in the case of sites where natural attenuation is the selected remedy, the microorganisms often require stimulation or creation of favorable environment to have a significant role in site cleanup. In some instances, biodegradation of contaminants is also enhanced by the addition of microorganisms that are specifically adapted to degrade a particular contaminant (i.e. bioaugmentation) or by supplementing the naturally occurring microorganisms with nutrients to stimulate their growth rates. Bioremediation techniques include natural attenuation, enhanced bioremediation, phytoremediation, and bioventing.

In-situ chemical treatment techniques rely on the injection of a chemical(s) to degrade, immobilize, desorb/flush out contaminants, including techniques such as chemical oxidation, soil flushing using treatment reagents, polymerization, precipitation, etc. An example of a physical in-situ treatment method is air sparging, where air is injected into the saturated zone of a contamination plume to remove contaminants through volatilization and perhaps enhance biodegradation of contaminants by increasing the concentrations of dissolved oxygen in the groundwater. A passive reactive barrier (PRB), also referred to as a "treatment wall," may involve both physical and chemical treatment techniques. When a funnel and gate type PRB is utilized, the groundwater is intercepted by an impermeable or low-permeability wall and directed through a man-made wall of reactive media for chemical treatment.

3.3.6 Containment

Containment and/or hydraulic control measures are used to control the migration of contaminants in subsurface soils and groundwater. Although it is often impossible to prevent any migration of contaminants, the goal of containment is to significantly reduce the migration. Containment techniques are typically utilized at sites where the contaminants are intended to be buried or left in place at the site. For example, containment systems are often used at sites where the subsurface contamination is extensive, and removal of the contaminants is precluded by the potential hazards associated with the removal and/or excessive costs. Extensive monitoring of containment systems is necessary to validate the competency of the system and verify that the system has no leaks and is not being short-circuited.

The most common surface containment systems involve the use of capping systems. While capping systems reduce the infiltration of precipitation and run-off on the surface of the Site into the contaminated area, they also provide a barrier to reduce the likelihood of human contact with the subsurface contaminants and inhalation of potentially hazardous vapors. The type of capping used at a site is based upon the site contaminants present, the physical characteristics of the site, and the intended future use of the site.

Subsurface containment systems often include vertical barriers installed near the limits of the plume area to inhibit further migration of contaminants. Examples of vertical barriers include slurry walls, grout curtain walls, watertight sheeting, etc. While vertical barriers primarily restrict the horizontal migration of contaminants, the barriers are often “keyed” into bedrock or an aquitard to reduce vertical movement of the contaminants beneath the barrier. Vertical barriers may be used to contain contaminated groundwater, divert contaminated groundwater around potable water supplies, divert uncontaminated groundwater around the impacted area, and/or provide a permeable treatment wall. Depending upon the geometry of the vertical barrier, it may be necessary to remove the groundwater up-gradient of the barrier or within a closed barrier and treat the groundwater to avoid surcharging of groundwater behind the barrier that could adversely affect its integrity.

3.3.7 Removal and Disposal

Source removal involves excavation of the contaminated soil, rock, debris, etc. and transportation of the material to a permitted off-site treatment and/or disposal facility. Although on-Site disposal in contained systems (e.g. a lined containment unit) is sometimes considered, it is typically not favorable for sites where redevelopment is planned. Depending upon the objective of the removal, either partial or total waste removal may be necessary to prevent further releases into the environment. There are many issues that must be considered if source removal and disposal are considered, including consideration of odors, fugitive dust emissions, depth and composition of the material being excavated, transportation methods, the transportation of the material through populated areas, pretreatment, waste characterization as dictated by land disposal restrictions (LDRs), temporary storage of the waste on-Site, etc.

3.4 EVALUATION AND SCREENING OF REMEDIAL TECHNOLOGIES

As previously discussed, the primary contaminants of concern include several chlorinated solvents. Table 2 on the following page(s) provides a summary of the technology process options considered for managing the contamination at the Site. While technology processes were evaluated for each of the previously identified general response actions, the tables are not intended to include screening of every available remedial technology. The process options were evaluated based upon their expected effectiveness and implementability, given the Site-specific conditions. If a technology was considered to be an effective remedy and implementable, the technology was retained for further evaluation.

It is anticipated that the Site will be redeveloped into a manufacturing complex for JMA. Given that JMA wants to expedite the redevelopment of the Site, the ability to expedite remediation will be considered a primary component of each remedial alternative evaluated. If long-term remedies are selected as the desired alternative for the Site, it will be important to make any remedial equipment and/or monitoring equipment unobtrusive to the planned reuse of the Site.

Table 2. Technology Screening

General Response Action	Remedial Technology	Media	Technology Process Options	Effectiveness	Implementability	Status	Comments
No Action	None	All	Natural decay, biodegradation, dispersion, adsorption, volatilization	Natural processes including degradation, dispersion, dilution, adsorption, volatilization, etc., would provide the only source of contaminant removal. Limited effectiveness. Not considered sufficiently protective of human health and the environment.	Implementable. No additional action necessary.	Retain	Retained as a baseline to compare other remedial alternatives.
Risk & Hazard Management	Institutional & Administrative Controls	All	Land use restrictions, fencing and signs, security guards	Protects human health. Provides no protection to environment unless used in conjunction with other remedies.	Implementable. Fencing to be installed surrounding the Site. Land use restrictions are compatible with City of Syracuse zoning. Environmental Easements may require legal consultation.	Retain	Will likely be implemented to some degree with all alternatives unless contaminant levels are reduced below Unrestricted SCOs.
	Ventilation Controls	Vapor	Building Sub-Slab Depressurization System for on-Site structures	Reduces human exposure to VOCs inside buildings. No significant mass removal or protection of environment.	Implementable. Additional pressure field testing is required to facilitate mitigation design for the entire building footprint.	Retain	Required prior to building occupancy given that residual contamination is likely to remain within footprint of existing building.
Natural Attenuation	Biological	Subsurface Soil / Groundwater	Biodegradation, dispersion, dilution, adsorption, volatilization	Limited effectiveness. Not considered sufficiently protective of human health and the environment for managing grossly contaminated soils and free product. Elevated contaminant levels remain at Site; however, the releases are expected to have occurred 20+ years ago.	Implementable. Install permanent groundwater monitoring wells for long-term monitoring requirements.	Retain	Considered for residual contamination after grossly contaminated soils are treated or removed but not as sole remedy. Monitoring points may be off Site boundaries.
Ex-Situ Treatment	Biological	Subsurface Soil	Biopiles, composting, land farming	Requires excavation and transport of contaminated soil. Moderately effective with halogenated VOCs.	Difficult to implement due to space availability on-Site. Soil storage requires space for the duration of treatment. Enclosure of the treatment area would be required for strong odors emitted during handling of soils based upon past work at the Site.	Reject	Space available outside the building is limited and prevents this option from being viable. Odors may be problematic as well.

General Response Action	Remedial Technology	Media	Technology Process Options	Effectiveness	Implementability	Status	Comments
Ex-Situ Treatment (continued)	Physiochemical	Subsurface Soil	Dehalogenation, soil washing, solidification	Effectiveness varies based on method chosen. Dehalogenation most effective when treating Site COCs.	Difficult to implement due to soil needing to be excavated and transported to a batch reactor.	Reject	Below average effectiveness for treating COCs on subject Site. Dehalogenation alone does not typically fully remediate Site COCs.
		Subsurface Soil	Thermal desorption, incineration	Highly effective, but less cost effective for halogenated VOCs. Significant mass removal.	Difficult to implement due to excavation and transport of soil to treatment system for processing and limited space to stockpile soil on-Site.	Reject	Not a viable option due to excavation requirements and space limitations. Odors may be problematic as well.
		Subsurface Soil	Oxidation	Limited effectiveness for Site COCs in soil. Not considered sufficient protection of human health.	Difficult to implement to due excavation and transport of soil to treatment system for processing and limited space to stockpile soil on-Site.	Reject	Not a viable option due to ineffectiveness, excavation requirements, and space limitations. Odors may be problematic as well.
	Physiochemical	Groundwater	Granular Activated Carbon, air stripping, ion exchange, oxidation	Effective for treating Site COCs.	Implementable depending on the concentration of contaminates.	Reject	Extended time required for treatment; not conducive for proposed redevelopment of the Site. Likely groundwater concentrations exceed effective treatment using this technology. Also, increasing volatilization of Site COCs not compatible with Site redevelopment and continued occupied use.
	Biological	Groundwater	Constructed Wetlands	Limited effectiveness for treating Site COCs. Not considered sufficient protection of human health.	Difficult to implement due to space requirements as well as time required to ensure stabilization of appropriate ecosystems.	Reject	Below average effectiveness at treating COCs. Not a viable option due to space limitations.
In-Situ Treatment	Physiochemical	Subsurface Soil	Oxidation	Limited effectiveness for Site COCs in soil.	Implementable. Injections would target hot spot areas under building footprint	Reject	Not a viable option due to ineffectiveness, excavation requirements, and space limitations.
		Subsurface Soil	Thermal desorption	Heater wells and soil vapor extraction wells necessary. Highly effective for treating Site COCs.	Implementable depending on moisture content and permeability of subsurface soil.	Reject	Subsurface conditions are high in moisture, reducing the effectiveness of this treatment technology.
		Subsurface Soil	Soil Vapor Extraction	Effective for treating Site COCs.	Implementable depending on moisture content and permeability of subsurface soil.	Reject	Subsurface conditions are high in moisture, reducing the effectiveness of this treatment technology.

General Response Action	Remedial Technology	Media	Technology Process Options	Effectiveness	Implementability	Status	Comments
In-Situ Treatment (continued)	Biological	Subsurface Soil	Enhanced Aerobic/Anaerobic Biodegradation	Effective for subsurface areas with aerobic/anaerobic conditions.	Implementable. Difficult to control and predict effectiveness due to variability of subsurface.	Reject	Below average effectiveness at treating COCs.
	Physiochemical	Groundwater	Dual Phase Extraction	Effective for treating VOCs.	Implementable and good for heterogeneous subsurface conditions.	Reject	Generally used for light non-aqueous phase liquids. Site COCs are dense non-aqueous phase liquids.
		Groundwater	Thermal desorption	Heater wells and soil vapor extraction wells necessary. Highly effective for treating Site COCs.	Implementable depending on moisture content and permeability of subsurface soil.	Reject	Subsurface conditions are high in moisture, reducing the effectiveness of this treatment technology.
		Groundwater	Air Sparging	Effective for treating Site COCs.	Not implementable given Site redevelopment requirements, concrete floors, and heterogeneous Site soils.	Reject	Subsurface conditions likely provide a nonuniform application. Any visible equipment on the surface would be incompatible with redevelopment activities.
		Groundwater	Reduction	Effective for treating Site COCs.	Implementable. Hot spots beneath the building can be targeted.	Retain	COCs are readily subject to chemical reduction methods.
		Groundwater	Oxidation	Effective for treating Site COCs.	Implementable. Hot spots beneath the building can be targeted.	Retain	COCs are readily subject to chemical oxidation methods.
	Biological	Groundwater	Enhanced Aerobic/Anaerobic Biodegradation	Level of effectiveness depended on COCs and the application.	Implementable. Difficult to control and predict due to variability of subsurface. Indigenous bacteria species unknown. Bioaugmentation may be required.	Retain	Difficult to predict Site-specific effectiveness. Re-application of the technique is not compatible with Site redevelopment.
Containment	Surface Caps	Surface Soil	Asphalt/Concrete/Soil Cover, Synthetic Membrane Liner/Engineered Cap	Minimizes surface exposure to contaminants. Reduces infiltration.	Implementable. Parking lots are planned as part of the Site redevelopment and the remaining portion is covered by a building. Demarcation from on-Site soils necessary.	Retain	Due to proposed Site redevelopment, much of the surface will remain capped with asphalt or buildings.
	Physical Barriers	Groundwater	Slurry Wall, Watertight sheeting	Effective at eliminating movement of groundwater to uncontaminated areas.	Implementable, but only contains and does not treat the groundwater.	Reject	Ineffective if used without groundwater pump and treat system to minimize mounding of groundwater behind barrier. Slurry walls may degrade over time.

General Response Action	Remedial Technology	Media	Technology Process Options	Effectiveness	Implementability	Status	Comments
Removal & Disposal	Excavation	Soil	On-Site disposal	Limited effectiveness.	Difficult to implement. The building on Site would limit excavation-available area. Demolition of existing building is considered impractical and unnecessary.	Reject	In order to protect the structural integrity of the building, this alternative is not feasible. Smaller source areas would remain on Site, impacting groundwater. Due to Site limits and proposed Site usage, there is limited space to store soil on Site.
		Soil	Off-site disposal	Highly effective if all contaminated soil is accessible.	Difficult to implement but will effectively meet Track 1 cleanup standards.	Retain	In order to protect the structural integrity of the building, significant shoring will be required with this alternative, however additional excavation within the building footprint can be completed.

3.4.1 No Action

Given that grossly contaminated soil and groundwater were identified at the Site, taking no action at the Site will not be considered, but will be included in the detailed analysis as a baseline alternative for comparison of other alternatives. This alternative has been included in keeping with the conditions of the National Contingency Plan to serve as a baseline comparison in reference to other alternatives considered in the AAR.

3.4.2 Risk and Hazard Management

One possible consideration for controlling human exposure to the Site contaminants is restricting access to the Site. Most of the property is currently secured by a chain-link fence perimeter with restricted gate access, except for the park area north of the former employee parking lot.

The current fencing may be useful during any active remedial work at the Site to limit access. The existing fencing and gates could be supplemented with signage to warn potential trespassers to keep off the Site. After redevelopment it is anticipated that the Site will likely retain the fencing and increased security protocols will be installed. Therefore, restricting access to the Site could be considered a permanent remedy for managing any remaining contamination at the Site.

Another risk management technology that will be considered for the Site is sub-slab ventilation controls. If residual contamination remains at the Site after the primary remedial activities are complete, it may be necessary to install a SSDS beneath any on-Site structures to reduce human exposure to VOCs while inside these structures. The need for sub-slab depressurization will be based upon the location and proposed location, of the structures relative to the residual contaminants and the type of residual contaminants remaining on the Site but will be likely needed for all current and proposed structures on the Site.

While institutional controls will not be utilized as the principal remedy for the property given the elevated levels of soil and groundwater contamination at the Site, ICs will be used in conjunction with remedial actions to reduce human exposure and impacts to the environment. ICs that may be used include retaining access restrictions to the Site, development of health and safety procedures to implement during future ground-intrusive construction activities, and restrictions on the use of the groundwater beneath the Site as a drinking water source.

3.4.3 Natural Attenuation

Given the presence of grossly contaminated soils and groundwater, and JMA's desire to redevelop the Site within a short timeframe, none of the natural attenuation mechanisms (e.g. biodegradation, dilution, dispersion, etc.) alone, would be considered sufficient to reduce the threat posed to human health and the environment to an acceptable level within the required relatively short timeframe. In addition to the potential human exposure to the Site contaminants, natural attenuation would provide little reduction in the volume and concentration of contaminants migrating off-Site to Onondaga Creek, unless combined with another remedial technology. Therefore, although natural attenuation may be utilized to remediate remaining contaminants as the Site following the implementation of an active remedy, it will not be considered as the sole remedy for the Site.

3.4.4 Extraction with Ex-situ Treatment

Several biological, physiochemical, and thermal technologies have been proven to be effective for remediating soils contaminated with halogenated VOCs. However, there are typically high costs associated with these technologies and they generally take a substantial amount of time to implement. In addition, this type of treatment requires the excavation of Site soil to provide effective remediation. Access to impacted soil within the building footprint would be limited by the structure, and because the existing building occupies most of the Site, there is insufficient room outside of the building footprint to setup biopiles, composting areas, etc. Additionally, based upon past intrusive activities completed at the Site, the treatment area would likely be required to be enclosed to address the odors emanating from the soils. Therefore, biological ex-situ technologies will not be further evaluated for treatment of on-Site soil.

All ex-situ techniques available for remediating groundwater require that the groundwater be extracted from either extraction wells, collection/interceptor trenches, or a funnel and gate system with a single extraction well. Although several technologies have been shown effective for the treatment of the extracted groundwater, the costs associated with these technologies is typically high to excessively high. In addition to the capital costs to install a groundwater pump and treat system, there are also substantial costs associated with the operation and maintenance (O&M) of this long-term treatment method. Given that pump and treat systems are costly, require long treatment periods, visible extraction and/or treatment equipment is incompatible with the proposed redevelopment, groundwater pump and treatment systems will not be considered as an appropriate remedial technology for the Site.

3.4.5 In-Situ Treatment

There are several types of in-situ treatment technologies for both, soil and groundwater. Technologies such as enhanced biodegradation, chemical oxidation, soil vapor extraction (SVE) and solidification were assessed for soil treatment. Technologies such as enhanced bioremediation, air sparging and chemical oxidation were assessed for groundwater treatment.

One in-situ remedial technology retained for further evaluation is enhanced biodegradation. By providing the naturally occurring microorganisms with oxygen and other nutrients, the indigenous microorganisms grow in population and break the contaminants down in a shorter timeframe than would be required for natural attenuation. Given the variability of the subsurface as well as the lack of wet chemistry and indigenous bacteria population data for the Site, it is difficult to predict the effectiveness of this technology; however, previous studies have shown that re-treatment is typically necessary. The re-injection of amendments may not be feasible after the property is redeveloped or may result in excessive costs to restore the Site after the re-injection is complete. If this alternative is chosen, the potential for re-injection would need to be evaluated and taken into consideration during design.

Similar to biodegradation, in-situ chemical oxidation (ISCO) has been proven effective as a remedial technology for the chemical destruction of many toxic organic chemicals. The use of permanganate, a relatively more stable and persistent oxidant, can migrate by diffusive processes into the subsurface. When used as a treatment technology permanganate will either completely oxidize the

COCs to carbon dioxide or convert COCs to innocuous compounds. While permanganate has a relatively short treatment time, it is important to note that it can also persist and react with the COCs several months after injections are complete, which helps to facilitate removal of the COCs. Given that the primary treatment zone would be under the existing building footprint, permanganate is preferred over similar chemicals due to its relatively limited off-gassing. Chemical oxidation will be further evaluated in the following sections for the treatment of soil and groundwater at the Site. Remedial success of this technology is highly dependent on the effectiveness of delivery.

Lastly, in-situ chemical reduction (ISCR) facilitates contaminant destruction by dehalogenation of chlorinated compounds by chemical reduction. Zero Valent Iron (ZVI) is a technology that can be implemented within a relatively short timeframe using drill rods to facilitate the direct injection of ZVI material into the subsurface and could be an effective remedy for the Site. Additionally, the influence of ZVI on the soil geochemistry can stimulate the growth of anaerobic microorganisms and contribute to an accelerated natural reductive degradation of chlorinated solvents. Due to the requirement of direct contact between ZVI with the contaminant mass, remedial success of this technology is highly dependent on the effectiveness of delivery.

3.4.6 Containment

A variety of surface capping technologies are available to minimize the surface exposure of the contaminants at the Site. Although installation of a surface cap would not reduce the contaminant mass, caps are useful for controlling human exposure to the contaminants while certain types of remedies are being implemented. Capping the areas of concern will not suffice as the sole remedy for the Site due to the presence of grossly contaminated soils beneath the Site. However, it may be useful for controlling the exposure to residual contaminants, especially if natural attenuation or enhanced biodegradation are selected to treat the remaining contaminants following a more active remedial approach. If capping is only utilized for preventing exposure to residual containments, it is likely that the asphalt/concrete surfaces associated with parking areas, walkways and structures/buildings will be sufficiently protective. Low permeability soil cover with a thickness of one foot will be sufficiently protective in vegetated areas across the Site.

Vertical containment systems, such as slurry walls, grout curtain walls, and watertight sheeting, are often used to control the horizontal migration of contaminants resulting from groundwater movement. These barriers are typically costly and difficult to install, especially within a building footprint and at the target depths required to address the contamination on-Site (approximately 25-feet bgs). If a vertical barrier were to be constructed down-gradient of the plume the groundwater would surcharge behind the barrier. Since significant surcharging of the groundwater behind the wall is undesirable, it would then be necessary to install a groundwater collection trench, a system of extraction wells, or other similar system to control the water levels up-gradient of the barrier. However, the groundwater extracted from behind portions of the barrier would likely be impacted from the contaminants in the AOCs and require treatment prior to be discharged. The treatment of groundwater would require significant capital costs to install the required infrastructure as well as significant O&M costs to operate, maintain, and monitor the removal system. Additionally, the building footprint extends laterally to the property boundaries on the east, south, and west sides, making it impossible to install any sort of barrier without going off-Site. Given the high costs and design challenges associated with constructing a continuous vertical barrier around the perimeter of the AOCs, this type of barrier system will not be further considered in the remedial alternatives for the Site.

3.4.7 Removal & Disposal

Removal and disposal of contaminated soils is considered an effective approach for managing the impacts to the Site. However, as mentioned previously, the current building occupies most of the property footprint. This makes excavation of soils to the required target depths of approximately 26-feet bgs (and within the saturated zone) difficult without undermining the building foundation, and without the ability to use large equipment due to ceiling heights. Additionally, the off-Site disposal of contaminated media can be costly. While disposal and management of the contaminated materials in a cell on-Site may be applicable to small quantities, it will not be considered as implementable for this Site due to the proposed redevelopment plans for the facility. Off-Site disposal of select locations will be retained for further evaluation. However, rather than disposing all materials off-Site, disposal will likely be limited to grossly contaminated soils in attempt to minimize the disposal costs. In addition to excessive disposal costs, additional drawbacks associated with disposing all soils with contaminant levels present in excess of SCOs include: temporary increased truck traffic through area communities; excavation and management of contaminated media with strong odors within an enclosed building; and the long-term liability associated with disposing waste at another location. This approach was used previously on a small targeted scale as part of the Source Removal IRM addressed in Section 2.4 and documented in a CCR approved by NYSDEC in October 2019.

4.0 DETAILED ANALYSIS OF ALTERNATIVES

Each remedial alternative that is developed and evaluated is required to conform to one of the four (4) cleanup tracks as defined in 6 NYCRR Part 375-3.8. This section will identify each alternative and identify the proposed cleanup track. The cleanup tracks are summarized as follows:

- Track 1 – Unrestricted use
  - The remedial program shall achieve a cleanup level that will allow the Site to be used for any purpose without any restrictions on the use of the Site.
  - The Soil component shall achieve the unrestrictive SCOs for all soil above bedrock.
  - The remedial program shall not include the use of long-term institutional or engineering controls; provided, however, that a restriction on groundwater use may be included as a component of the remedial program if the applicant is a volunteer and has demonstrated to the Department's satisfaction that there has been a bulk reduction in groundwater contamination to asymptotic levels.
  - The remedial program may include the use of short-term employment of institutional or engineering controls provided the remedial program: (a) includes an active treatment system which will operate for no more than five (5) years, (b) requires the institutional control to assure the operation and integrity of the remedy, and (c) includes a provision for the applicant to implement an alternative remedy to meet the SCOs in the event that the short-term institutional period is exceeded.
- Track 2 – Restricted use with generic SCOs
  - The remedial program may provide for the restriction of the Site as described in 6 NYCRR Part 375-1.8(g)(i)
  - The soil component shall achieve the lowest of the three applicable contaminant-specific soil cleanup objectives for all soils above bedrock.
  - The requirement to achieve contaminant-specific SCOs for all soils at a depth greater than 15-feet bgs shall not apply, provided that: (a) soil below 15-feet do not represent a source of contamination, (b) the environmental easement for the Site requires that any contaminated soils remaining at depth will be managed along with other Site soils pursuant to a Site management plan; (c) off-site groundwater does not exceed standards; and (d) on-Site groundwater use is restricted.
  - The remedial program does not use long-term institutional or engineering controls to achieve the restricted soil cleanup objectives. The use of short-term institutional or engineering controls is allowed under the conditions listed in Part 375-3.8.
  - The remedial program may include the use of long-term institutional or engineering controls to address contamination related to other media including, but not limited to groundwater and soil vapor.

- Track 3 – Restricted use with modified soil cleanup objectives
  - This track shall meet the requirements set for in the Track 2 program, however, the department may provide the modification of one or more of the contaminant-specific SCOs.
- Track 4 – Restricted use with Site-specific SCOs
  - Site specific SCOs may be identified as either, SCOs as defined in 6 NYCRR Part 375-6, SCOs as defined in 6 NYCRR Part 375-6.9, or may be proposed to the Department provided that they are protective of public health and the environment.
  - The remedial program may include the use of long-term institutional or engineering controls to address all media.
  - Exposed surface soils will be addressed based on the property use type (i.e. residential, commercial, or industrial), as identified in 6 NYCRR Part 375-3.8.

Although there are no Site-specific or modified SCOs that have been established for the Site at this time, given that there is contamination, though limited, exceeding unrestricted SCOs in the 0 to 15-foot soil interval the following Alternatives have been evaluated for their effectiveness in meeting either a Track 1 or Track 4 cleanup.

4.1 ASSESSMENT OF ALTERNATIVE CRITERIA

As discussed in Section 1.1, NYSDEC DER-10 requires that each alternative be evaluated using the following eight criteria:

1. **Overall Protectiveness of the Public Health and the Environment** - This criterion identifies how the alternative would eliminate, reduce, or control through removal, treatment, containment, engineering controls or institutional controls, any existing or potential human exposures or environmental impacts.
2. **Standards, Criteria and Guidance** – This criterion identifies whether the alternative conforms to the applicable SCGs applicable for the Site.
3. **Long-term Effectiveness and Permanence** – This criterion evaluates whether contamination will remain on- or off-Site after the selected remedy has been implemented and evaluates the impact of remaining contamination.
4. **Reduction of Toxicity, Mobility or Volume** – This is an evaluation of the ability of the remedy to reduce the toxicity, mobility and volume of Site contamination.
5. **Short-term Impact and Effectiveness** – This criterion evaluates the potential short-term adverse environmental impacts and human exposures during the construction or implementation of the remedy.
6. **Implementability** – Each alternative is evaluated for the technical and administrative feasibility of implementing the remedy.
7. **Cost Effectiveness** – This criterion is an evaluation of the overall cost effectiveness of a remedy. If the costs are proportional to its overall effectiveness, a remedy is considered cost effective.

8. **Land Use** – The purpose of this criterion is to evaluate the current, intended and anticipated future use of the Site and its surroundings as it relates to each alternative. The Site is currently zoned Commercial and will remain Commercial with the redevelopment. Surrounding properties are zoned commercial, industrial and local business. Land use is not further evaluated in each of the alternatives given that it is not anticipated to change, and environmental easements will be placed on the Site.
9. **Community Acceptance** – Once the NYSDEC reviews the AAR, a public comment period will begin that will provide the community the ability to comment on the remedial alternatives identified. This criterion is not evaluated as part of this document but will be evaluated by NYSDEC after the comment period has closed.
10. **Green Remediation and Sustainability** In addition to DER-10, the NYSDEC DER Program Policy 31 (DER-31) identifies the approach to remediating sites in the context of the larger environment, known as green remediation. This practice "considers all environmental effects of remedy implementation and incorporates options to minimize the environmental footprint of cleanup actions" (DER-31, January 2011). This information included in this document was used as an additional criterion for the evaluation of each of the following alternatives.

4.2 DEVELOPMENT OF ALTERNATIVES

The following alternatives analysis primarily focuses on chlorinated solvent remediation in the subsurface soil and groundwater. The following technology, action, or status will be consistent across all alternatives, and therefore, is not discussed in detail for each alternative:

- No further action associated with the greenspace identified as "Coyne Park" on the north side of the former employee parking lot. Acetone was the only parameter identified at concentrations exceeding Unrestricted SCOs in the surface and subsurface soil within the greenspace. The low levels of acetone can likely be attributed to laboratory contamination rather than a Site COC based on validated data included as part of the RI.
- Institutional controls including Site use restrictions to Commercial use development and a permanent environmental easement on the property.
- Monitored natural attenuation (MNA) of the former employee parking lot with continued groundwater monitoring. A Site management plan (SMP) that will address any remaining Site contamination will be developed after the remedy is complete and will identify the procedures for long-term groundwater monitoring.
- NYSDOH indoor air quality regulations require the mitigation of sub-slab vapors beneath occupied buildings. An active SSDS shall be installed beneath all portions of the building prior to full-time occupancy.
- Maintenance of the impervious surfaces such as the employee parking lot, the building, and the loading dock/parking lot to the north of the building. Asphalt and concrete impervious surfaces will act as a surface cover to significantly reduce infiltration and limit exposure to future Site occupants. Any disturbance of the impervious surface will be repaired in kind. Any new greenspace areas will be required to have a minimum of a one-foot thick layer of

imported, clean material (e.g. topsoil) placed above a demarcation barrier that will that will provide a physical barrier to any potential remaining contamination in existing Site soils.

Based upon the preliminary evaluation and screening of available remedial technologies, several options have been identified for managing the COCs across the Site. The following list summarizes the remedial technologies that were retained for further evaluation:

- Removal with Off-Site Disposal
- ISCO with Soil Mixing
- ISCO with Groundwater Recirculation
- Enhanced In-Situ Bioremediation (EISB)
- ZVI Injection

One technology is not considered sufficient for addressing all AOCs for the Site. Instead the remedial alternatives evaluated in this document represent a combination of several technologies to provide an effective, implementable, and cost-effective approach to addressing both soil and groundwater contamination. Therefore, the treatment of the Former UST AOC (Source Area) will be addressed separately from the remaining contamination, identified as the contaminant "plume area" for Alternatives 3-5 but will be included with all three alternatives. The following remedial alternatives have been broken down by cleanup tracks and were assembled utilizing the technologies and process options identified for the Site COCs.

- Alternative 1: No Action
- Alternative 2: Track 1 – Excavation and ISCO
- Alternative 3: Track 4 – Source Area Treatment and ISCO with Groundwater Recirculation
- Alternative 4: Track 4 – Source Area Treatment and EISB
- Alternative 5: Track 4 – Source Area Treatment and ZVI

Each of these alternatives has the potential to remediate soil and groundwater contamination to the desired cleanup track. A more detailed analysis of each is provided in the following sections. Additionally, the treatment technologies discussed as part of Alternatives 3-5 are discussed in greater detail in the report provided by XDD Environmental (XDD) included in Appendix A.

4.3 ALTERNATIVE 1 – NO ACTION

4.3.1 Description of Alternative 1

The "No Action" alternative was retained as a basis for comparison of other remedial alternatives. However, this alternative will not be selected as the Site remedy because of the unacceptable levels of risk posed by the exposure pathways that result in a threat to human health and the environment by the Site. Natural processes, including degradation, dispersion, dilution, adsorption, volatilization, etc., would provide the only source of contaminant breakdown under this alternative. As a result, there would be no active reduction in toxicity, mobility, or mass of the contaminants. Alternative 1 does include the installation of Site institutional and administrative controls with the intent to protect the public from Site COCs.

Although the cost estimate associated with this alternative does not include any additional monitoring of the Site, CHA has estimated that it would cost approximately $14,000 for the applicants to implement institutional controls at the Site to protect the public from the Site, as well as approximately $2,000 on an annual basis in operation and maintenance costs for these controls over the next 30 years, should development not proceed.

4.3.2 Assessment of Alternative 1

The following table provides a summary of the detailed assessment for the "no action" alternative for the Site.

Table 3. Assessment of No Action

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • Some institutional controls (e.g. signing, fencing) may be installed or maintained to deter direct exposure to the Site. *Disadvantages:* • Remedial objectives not met. Provides no active reduction of Site contaminants. • No appreciable public or environmental protection from the Site contaminants. • Time frame for natural attenuation is lengthy, but unknown unless accompanied by long-term monitoring. • Site unable to be redeveloped due to potential human health impacts from Site contaminants.
Compliance with SCGs	Does not meet SCGs.
Long-Term Effectiveness & Permanence	*Advantages:* • No significant advantages. *Disadvantages:* • Not effective in reducing contaminant mass. • Potential exists for continued contaminant migration.
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • No significant advantages. *Disadvantages:* • No significant reduction in toxicity, mobility, or volume.
Short-Term Effectiveness	*Advantages:* • No intrusive activity eliminates exposures to workers and the community during implementation of an intrusive remedial project. *Disadvantages:* • No contaminant mass reduction. • Impacts to public health and the environment remain.

Criterion	Discussion
Implementability	*Advantages:* • Easily implemented with no significant technical requirements. *Disadvantages:* • Institutional controls to restrict the use of the Site remain. However, this precludes the proposed redevelopment of the Site.
Cost	The capital costs to construct and install all intuitional controls and security measures is estimated to be $14,000. Additionally, Operation and Maintenance Costs (O&M) of approximately $2,000/year would be required on an annual basis for 30 years. The total present worth value of this Alternative is estimated at $45,000.
Green Remediation and Sustainability	*Advantages:* • No significant additional environmental impact from implementation. • No fuel or material used, and no waste produced. *Disadvantages:* • Site contaminants remain and continue to impact the public and environmental health.

4.4 ALTERNATIVE 2 – EXCAVATION AND ISCO [TRACK 1]

4.4.1 Description of Alternative 2

Alternative 2 was selected for analysis because the remedial actions allow for cleanup to meet SCGs, even though this alternative was deemed impracticable due to Site infrastructure, proposed redevelopment, impact to the environment, and cost. Alternative 2 focuses on the excavation of contaminated soil to the depth of groundwater, approximately 10 feet bgs, and the remediation of groundwater using ISCO with recirculation.

The footprint of the building and extension into the loading dock on the north end is approximately 52,000 ft^2. Excavation to the groundwater table requires extensive shoring to support the building, and the transport and disposal of approximately 20,000 cubic yards (yd^3) of contaminated soil, which equates to nearly 2,000 truckloads of soil being exported off-site for disposal. Following soil excavation, the Site will be backfilled with clean, imported fill material meeting Unrestricted Use SCOs and would require a similar number of truckloads of imported fill. CHA notes that even with the installation of shoring systems to support the building foundations, complete removal of all contaminated media beneath the building is impractical.

Under Alternative 2, groundwater contamination will be managed using ISCO with sodium permanganate, or other chemical oxidant, to reduce the concentration of Site COCs. Groundwater will be extracted from the subsurface into a holding tank and would be treated with chemical oxidant. The treated groundwater would then be pumped back into the ground once it meets TOGS 1.1.1 ambient groundwater standards and guidance values.

4.4.2 Assessment of Alternative 2

The following table provides a summary of the detailed assessment for treatment of the COCs using excavation and ISCO to treat the soil and groundwater, respectively.

Table 4. Assessment of Excavation with ISCO

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • Removal and proper disposal of the most-contaminated soil in a permitted landfill, which protects human health and the environment from exposure to the Site COCs. • Relatively quick process to significantly reduce the Site COCs. *Disadvantages:* • Significant disturbance to the Site and surrounding area during implementation. • Potential significant impacts to human health from dust and vapor migration during implementation.
Compliance with SCGs	Meets SCGs. Replacement fill soil material will meet Unrestricted Use SCOs and extracted groundwater will be treated to meet TOGS 1.1.1 ambient groundwater standards and guidance values prior to being injected back into the ground (recirculation approach).
Long-Term Effectiveness & Permanence	*Advantages:* • Permanently removes most-contaminated soil from the Site. • Chemical oxidation rapidly reduces remaining mass of target COCs *Disadvantages:* • Potentially requires more than one treatment application to reach desired COC mass reduction in groundwater, particularly if rebound occurs.
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • Permanent reduction in toxicity, mobility, and volume of COCs. *Disadvantages:* • Transfer of contaminated soil to a landfill does not reduce overall contaminant mass.
Short-Term Effectiveness	*Advantages:* • Relatively short-term project that significantly reduces contaminant mass in the soil. *Disadvantages:* • Potential exposure to Site workers during mixing of chemical oxidants. • Significant short-term impact to the Site and surrounding community from the excavation procedures and transport of contaminated soil to an off-Site disposal facility as well as to import clean fill for backfill.

Criterion	Discussion
Implementability	*Advantages:* • No further pre-design investigation or delineation would be necessary. *Disadvantages:* • Not implementable based on building footprint and proposed redevelopment requiring the foundation and structure to remain intact. • The building encompasses most of the Site.
Cost	Present Worth = $8.2-million and includes shoring and excavation for the entire building, off-site disposal and transport, backfill, waste characterization and confirmation sampling, oversight, dust monitoring, and groundwater treatment and recirculation. This cost also includes quarterly groundwater monitoring would be required for 5 years with a 5 percent inflation rate, annual O&M costs would be $156,000. Total present worth = $8,356,000.
Green Remediation and Sustainability	*Advantages:* • Significant reduction in contaminant mass and potential for future exposure. *Disadvantages:* • Significant consumption of fuel and emission of greenhouse gasses to excavate and transport soil to a disposal facility as well as to import clean fill for backfilling purposes. • Does not efficiently manage waste materials and negatively impacts landfill capacity.

4.5 ALTERNATIVE 3 – SOURCE AREA TREATMENT AND ISCO WITH GROUNDWATER RECIRCULATION [TRACK 4]

4.5.1 Description of Alternative 3

Unlike the previous two alternatives, Alternative 3 focuses on the in-situ treatment of soil and groundwater across the Site. As discussed in Section 2.5, COCs within the Source Area AOC are present at levels well above TOGS 1.1.1 and the surrounding plume concentrations. For this reason, the Source Area will be treated separately from the rest of the plume.

4.5.1.1 Source Area Treatment

As shown on Figure 7, the Source Area consists of an area approximately 6,000 ft^2 in size. Within this area soil contamination was observed above Part 375 Commercial SCOs and groundwater was observed above TOGS 1.1.1 ambient water quality standards and guidance values for Class GA waters. The Source Area is believed to extend past the previous IRM excavation. Soil within the Source Area will be remediated via soil mixing and ISCO injection using chemical oxidants such as sodium or potassium permanganate. The soil will be mixed from the 9 to 16-foot bgs interval (beneath the demarcation barrier) within the area shown on Figure 7. The upper approximately 9-feet of stone within the area previously excavated as part of the IRM and above demarcation barrier will be removed and segregated as clean fill for reuse prior to mixing. Soil mixing involves the mechanical agitation of subsurface soils while blending in the treatment reagents. The mechanical agitation breaks apart the natural soil structure, homogenizes the soils, and helps to distribute the oxidant, establishing more uniform contact between oxidant and the contaminants. Given the heterogenous soils on Site, including silts and clays, soil mixing is considered a particularly useful strategy for successful treatment and provides a high certainty of effective treatment. Success of this remedy is dependent on contact with the contaminant mass and does not require advection or diffusion to distribute the oxidant to the contaminant. In an area such as the Source Area, this is a critical component to effectively treating the high levels of soil and groundwater contaminants and reducing further migration of contamination.

4.5.1.2 Plume Treatment

In addition to the Source Area, the contamination plume around the Source Area also requires groundwater treatment. Under Alternative 3, ISCO treatment is proposed to address this groundwater contamination adjacent to the Source Area. While ISCO is similar to the treatment method proposed for the Source Area, groundwater recirculation combined with the addition of an oxidant would be utilized in lieu of soil mixing. Using this strategy, contaminated groundwater will be removed through extraction wells, amended with oxidizing reagents, and reinjected into the subsurface through a series of injection wells once it has met TOGS 1.1.1 ambient water quality standards for Class GA waters. Extracted water would be amended with an oxidant such as sodium permanganate and stored above ground to allow the necessary contact time for treatment prior to injection.

4.5.2 Assessment of Alternative 3

The following tables provide a summary of the detailed assessment for treatment of the Source Area and treatment of the plume with ISCO, respectively.

Table 5. Assessment of Source Area Treatment

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • Soil mixing with chemical oxidation will destroy COCs, preventing off-Site migration of contamination and thereby provide protection of human health and the environment. *Disadvantages:* • Institutional Controls such as environmental easements may still be necessary to effectively protect human health and the environment. • Fugitive dust may be generated during application.
Compliance with SCGs	*Advantages:* • Soil mixing with chemical oxidation will destroy COCs . Treatment effectiveness is increased with oxidant distribution, accurate oxidant dosing, and sufficient contact with the contaminant. *Disadvantages:* • If significant sources of contamination are not targeted during soil mixing, additional methods may need to be applied to treat impacted soil. Additional Site investigation is necessary to determine the vertical and horizontal extent of the Source Area.

Criterion	Discussion
Long-Term Effectiveness & Permanence	*Advantages:* • Significant long-term contaminant destruction of chlorinated compounds by oxidation. *Disadvantages:* • Requires long-term management to verify continued effectiveness and evaluate potential rebound.
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • Volume of contaminants within the Source Area reduced in a short timeframe. *Disadvantages:* • The building foundation may inhibit application of soil mixing in the entire Source Area which can limit the effective reduction in toxicity.
Short-Term Effectiveness	*Advantages:* • Chemical oxidation with soil mixing rapidly breaks down COCs at high concentrations. *Disadvantages:* • Potential contractor exposure to chemical oxidant and COCs during application.
Implementability	*Advantages:* • Implementable within the Source Area. • No significant excavation or transportation of contaminated soil. *Disadvantages:* • Requires additional subsurface investigation to more accurately delineate the horizontal and vertical extents of the Source Area to potentially reduce the treatment area/volume and overall cost. • Requires bench scale testing to determine oxidant demand. Correct dosing is important for treatment effectiveness. • Requires special consideration for the restoration of the flooring system in this portion of the building as the soil mixing will disturb the consolidation of the soils and long-term subsidence of the soils following treatment would be expected.
Cost	• Present Worth = $270,000 - $1,080,000 includes treatment area delineation, bench study, application of soil mixing with chemical oxidant, and baseline and 2 post-treatment groundwater performance monitoring events. • No pilot testing would be required with this technology. • Long-term annual O&M costs are incorporated with Alternatives 3-5 and include monitoring of the Source Area.
Green Remediation and Sustainability	*Advantages:* • Significant reduction in contaminant mass and potential for future exposure. • Limited production of waste requiring disposal. *Disadvantages:* • Use of heavy equipment for an estimated 27 days of soil mixing application.

Table 6. Assessment of Plume Treatment with ISCO and Groundwater Recirculation

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • Takes a relatively short period of time to achieve cleanup goals that will provide protection of human health and the environment. • Limited secondary waste generated after remedial activities are complete. Spent carbon would require regeneration *Disadvantages:* • Alternative may not address all dissolved contaminants and some residual contaminants not directly target by the oxidant application may continue to migrate off-site
Compliance with SCGs	*Advantages:* • ISCO technology can rapidly break down the target COCs in groundwater and soils in the downgradient portions of the Site in a single application. • Groundwater would be stored above ground to allow the contact time necessary to treat the groundwater prior to re-injection. • Groundwater would be tested for compliance with SCGs before reinjection, limiting the need for long term monitoring after performance monitoring events. *Disadvantages:* • May be required to meet strict regulatory criteria for groundwater reinjection. Because permanganate does not treat benzene, additional treatment (such as the addition of a granular activated carbon treatment system) may be required before groundwater can be reinjected into the subsurface. • May need to obtain a State Pollutant Discharge Elimination System (SPDES) permit to discharge treated groundwater. • Will require coordination with the United States Environmental Protection Agency (USEPA) and may require a permit as these aquifer remediation wells may be considered Class V injection wells.
Long-Term Effectiveness & Permanence	*Advantages:* • High certainty of effective treatment. Level of certainty increases with target treatment area definition/oxidant distribution/contact with contaminants/accurate oxidant dosing. • ISCO has been shown to only temporarily inhibit microbial activity, and as geochemical conditions return to normal, bacteria can thrive. *Disadvantages:* • Long-term monitoring and groundwater restrictions may still be required.

Criterion	Discussion
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • Volume of contaminants at the Site would be reduced in a short time frame. Approximately 35 days of circulation is required to complete the treatment. • Remedial success is dependent on direct contact with contaminant mass. ISCO using recirculation involves mixing of the treatment reagents with the impacted groundwater, achieving contact between the oxidant and dissolved COCs. • Compared to a direct injection approach, a recirculation strategy provides better hydraulic control and distribution of reagents, and less likelihood of dissolved phase COCs being displaced as reagents are injected. • ISCO using a recirculation approach typically requires lower oxidant dosing than direct injection and minimizes potential for oxidant surfacing. *Disadvantages:* • More than one application may be required to achieve the desired COC mass reduction.
Short-Term Effectiveness	*Advantages:* • Minimal ground intrusive activity eliminates exposure of COCs in soil to workers during implementation of an intrusive remedial project. • Limited public exposure. *Disadvantages:* • Handling of chemical additives is necessary for treatment of groundwater. • Groundwater would be pumped into a holding tank for treatment while reaction occurs, prior to reinjection into the subsurface. Controls such as fencing and/or barricades would be required around all equipment staged outside of the building footprint.
Implementability	*Advantages:* • The plume treatment area is approximately 30,000 ft^2. Based on a 15-foot injection/extraction radius, only 21 injection wells and 22 extraction wells would be required to treat this area. • Based on a conservative injection flow rate, approximately 35 days of injection is required to complete the application. This timeframe would be favorable to the continuing redevelopment of the Site. • *Disadvantages:* • Injection/extraction wells will require coring through concrete floor. • Requires additional subsurface investigation to more accurately delineate the horizontal and vertical extents of the COC groundwater plume to potentially reduce the treatment area/volume and overall cost. • Requires a pilot test to evaluate Site hydraulics to develop full-scale design parameters including injection/extraction radius of influence, injection and extraction rates, and evaluate the impact of subsurface heterogeneities on reagent distribution.

Criterion	Discussion
Cost	• Present worth = $755,000 - $1,135,000 to complete bench study, delineation, install and complete remedy (one application), and baseline and two post-ISCO performance monitoring events. • Pilot testing costing $60,000 - $70,000 may be required to determine the potential range of injection/extraction flow rates. The wells installed as part of the pilot test would be utilized during the remedy, therefore reducing well installation costs for the full-scale application. • Some long-term groundwater monitoring may be required but is not included in the aforementioned cost. Due to groundwater meeting applicable SCGs prior to re-injection, a reduced monitoring frequency may be possible. • Assuming long-term groundwater monitoring would be required on a quarterly basis for 15 years, annual O&M costs would be $374,000 assuming a 5 percent inflation rate.
Green Remediation and Sustainability	*Advantages:* • Significant reduction in contaminant mass and potential for future exposure. • Limited production of waste requiring disposal. *Disadvantages:* • Energy requirements for groundwater pumping, treatment, and injection are higher compared to other alternatives.

4.6 ALTERNATIVE 4 – SOURCE AREA TREATMENT AND EISB [TRACK 4]

4.6.1 Description of Alternative 4

Similar to Alternative 3, the soil and groundwater within Source Area will be treated through ISCO and soil mixing. However, in this alternative the groundwater plume will be treated through enhanced in-situ bioremediation. EISB is performed by adding anaerobic amendments to stimulate the biodegradation of dissolved phase COC impacts within the overburden groundwater plume and impede further migration of the dissolved COC groundwater plume. Amendments which include an organic carbon source, nutrients, and microbial cultures such as dehalococcoides will be injected into the subsurface through a series of injection wells.

4.6.2 Assessment of Alternative 4

The following table provides a summary of the detailed assessment for treatment of the plume with EISB.

Table 7. Assessment of Plume Treatment with EISB

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • No excavation is required, limiting the direct exposure to Site COCs by greatly reducing the potential hazards associated with the generation of fugitive dust and vapor emissions. • No secondary waste generated after remedial activities are complete. *Disadvantages:* • May not reduce concentrations of contaminants in heavily contaminated areas to required concentrations, therefore some remaining contaminants may continue to migrate downgradient. • As microorganisms biodegrade contaminants, byproducts of anerobic respiration may include nitrogen gas, hydrogen sulfide, and methane. This would require additional mitigation as the building is intended to be occupied by the end of 2020.
Compliance with SCGs	*Advantages:* • Amendments injected will stimulate biodegradation of the plume to reduce concentrations to at or below required SCGs. *Disadvantages:* • Treatment may require 5+ years to fully meet SCGs, therefore some contamination may continue to migrate off-Site during the remedial treatment process.
Long-Term Effectiveness & Permanence	*Advantages:* • Amendments are injected to stimulate biodegradation of dissolved phase COC impacts within the overburden groundwater plume to reduce concentrations and impede further migration of the dissolved COC plume. *Disadvantages:* • Passive remediation relies on groundwater movement to treat the plume. • Multiple applications may be required over the life of the remedial program (ex: 3 applications over 5 years)
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • Will reduce groundwater plume over the course of the remedial program through biodegradation of dissolved phase impacts. *Disadvantages:* • Will take time to fully reduce toxicity, mobility and volume. Will require multiple treatments over several years.

Criterion	Discussion
Short-Term Effectiveness	*Advantages:* • There is no short-term effectiveness using this technology. This technology is dependent on groundwater flow, and therefore will likely require 5+ years to adequately remediate the COCs to SCGs. *Disadvantages:* • As microorganisms biodegrade contaminants, byproducts of anaerobic respiration may include nitrogen gas, hydrogen sulfide, and methane. All of which have the potential to cause gas intrusion issues inside of the building footprint.
Implementability	*Advantages:* • Amendment is injected through a series of injection wells that would be installed through the concrete floor of the building, downgradient from the Source Area and within the groundwater plume. • Does not require excavation to apply amendment. *Disadvantages:* • Building structures may impact locations of injection points. • Injection/extraction wells will require coring through concrete floor. • Requires additional subsurface investigation to more accurately delineate the horizontal and vertical extents of the COC groundwater plume to potentially reduce the treatment area/volume and overall cost. • Requires detailed analysis of indigenous bacteria populations and groundwater chemistry as well as pilot testing to determine best amendments for injection. • If indigenous bacteria capable of targeting the COCs are not present, bioaugmentation may also be required, further complicating this approach.
Cost	• Present Worth = $675,000 - $860,000. Includes cost of treatment area delineation, bench study, installation of remedy (one application), and baseline and two post treatment monitoring events • A pilot test would not be required with this technology. • Assuming long-term groundwater monitoring would be required on a quarterly basis for 15 years, annual O&M costs would be $374,000 assuming a 5 percent inflation rate.
Green Remediation and Sustainability	*Advantages:* • Little to no energy requirement and low direct greenhouse gas emissions from the remediation. • Limited production of waste requiring disposal. *Disadvantages:* • Longer negative environmental impacts due to length of time required for treatment.

4.7 ALTERNATIVE 5 – SOURCE AREA TREATMENT AND ZVI INJECTIONS [TRACK 4]

4.7.1 Description of Alternative 5

In this alternative, the soil and groundwater within the Source Area would be treated through the same methods described in Alternative 3. The groundwater plume, however, would be treated through the injection of zero valent iron to facilitate contaminant destruction by dehalogenation of chlorinated compounds by chemical (abiotic) reduction. In this alternative ZVI would be injected into the subsurface as a high concentration slurry solution using direct injection using drill rods.

4.7.2 Assessment of Alternative 5

The following table provides a summary of the detailed assessment for treatment of the plume with ZVI.

Table 8. Assessment of Plume Treatment with ZVI

Criterion	Discussion
Protection of Human Health & the Environment	*Advantages:* • If applied correctly, will destroy COCs, greatly reducing the potential for off-Site migration of contaminated compounds and thereby provide protection of human health and the environment. • No excavation is required for treatment of the groundwater plume, limiting the direct exposure to Site COCs by greatly reducing the potential hazards associated with the generation of fugitive dust and vapor emissions. *Disadvantages:* • Given the potential for rebound, Institutional Controls such as environmental easements restrictions may still be necessary to effectively protect human health and the environment.
Compliance with SCGs	*Advantages:* • At a minimum, Track 4 remedial objectives would be met because abiotic reactions result in minimal production of partially dechlorinated byproducts, such as cis-1,2-DCE. Therefore, the chlorinated VOC contaminants left behind would be minimal. *Disadvantages:* • Contaminants have the potential to rebound; however, ZVI persists in the environment for 5 to 10 years after injection to provide ongoing treatment and additional applications can be applied if contaminant levels increase to levels warranting it.

Criterion	Discussion
Long-Term Effectiveness & Permanence	*Advantages:* • ZVI facilitates contaminant destruction by dehalogenation of chlorinated compounds by chemical reduction. • ZVI typically persists in the subsurface for a duration of 5 to 10 years, thus creating a long-term treatment zone. *Disadvantages:* • Remedial success is dependent on direct contact between ZVI surface with contaminant mass, and is therefore, highly dependent on effectiveness of delivery. • Requires long-term management to verify continued effectiveness. Additional applications may be required.
Reduction in Toxicity, Mobility, & Volume	*Advantages:* • Volume of contaminants at the Site reduced in a short-time frame. • Any residual contamination remaining after the first application will eventually reach SCOs over time as ZVI is present in the subsurface for up to 10 years, without an additional application. *Disadvantages:* • The building may inhibit the ability to install injection wells at all necessary locations, therefore some contamination may remain in inaccessible areas.
Short-Term Effectiveness	*Advantages:* • Limited contact with subsurface soil and groundwater given installation techniques consist of installation and injection of ZVI using direct push techniques through drill rods in one point at a time. *Disadvantages:* • ZVI typically requires additional applications because remedial success is dependent on direct contact between ZVI and the surface contaminant mass. Given that the contaminant mass is beneath the building, there are likely areas that are inaccessible.
Implementability	*Advantages:* • Implementable at a slow rate. Injection is completed on a per-well basis, one at a time. *Disadvantages:* • Due to direct contact requirement between ZVI and surface with contaminant mass, the number of wells required is greatly increased over other, similar technologies (e.g. 90 wells for ZVI vs 22 for ISCO) • Specialized equipment required for the injections. • Injection/extraction wells will require coring through concrete floor. • Requires additional subsurface investigation to more accurately delineate the horizontal and vertical extents of the COC groundwater plume to potentially reduce the treatment area/volume and overall cost.

Criterion	Discussion
Cost	• Present Worth = $390,000 - $480,000 includes treatment area delineation, bench study, installation of remedy (one application), and baseline and two post-treatment groundwater performance monitoring events. • No pilot testing would be required with this technology. • Assuming long-term groundwater monitoring would be required on a quarterly basis for 15 years, annual O&M costs would be $374,000 assuming a 5 percent inflation rate.
Green Remediation and Sustainability	*Advantages:* • Small energy requirement after initial injections. • Significant reduction in contaminant mass and potential for future exposure. • Limited production of waste requiring disposal. *Disadvantages:* • Potential for multiple treatments, and therefore, more energy over the course of several years.

4.8 COMPARATIVE ANALYSIS

The following subsections provide a brief comparison of the alternatives relative to the same seven criteria used to evaluate the alternatives individually. As previously identified in this AAR, and as required by DER-10, the alternatives have been compared based upon the following eight criteria:

1. Overall protection of human health and the environment;
2. Compliance with Standards, Criteria, and Guidance
3. Long-term effectiveness and permanence;
4. Reduction in toxicity, mobility, and volume;
5. Short-term effectiveness;
6. Implementability;
7. Cost; and
8. Green Remediation and Sustainability.

The community acceptance criterion will be evaluated by the NYSDEC after the public comment period is complete.

4.8.1 Protection of Human Health and the Environment

As previously discussed, Alternative 1 was maintained for a baseline comparison of the alternatives and is not considered sufficiently protective of human health and the environment given the contaminated soil and groundwater at the Site. Therefore, Alternative 1 will not be selected as the preferred alternative for managing the contamination at the Site.

Alternative 2 consists of the complete removal of contaminated soil at the Site and the treatment of groundwater using ISCO recirculation techniques. Contaminated soil would be excavated and transported off-Site to a permitted facility, and the excavation would be backfilled with clean, imported fill meeting NYSDEC Part 375 Unrestricted Use material. While the removal of contaminated media would pose an increased short-term exposure risk during the excavation process, this alternative provides the greatest overall protection of human health and the environment for the Site.

Alternatives 3 through 5 consist of two remedial strategies; the first being treatment of the Source Area and the second being treatment of the plume. All three of these alternatives would address the Source Area by mixing soils from 0-16-foot bgs, while simultaneously injecting a chemical oxidant. This strategy would treat the area with the highest COCs and therefore reduce off-Site migration protecting human health and the environment.

In addition to treating the Source Area, Alternative 3 would involve the removal of groundwater throughout the groundwater plume (Figure 7), treatment of the groundwater through a chemical oxidant, and re-injection of the treated groundwater once it meets TOGS 1.1.1 criteria. This alternative would be the second-most protective of human health and the environment given that groundwater would be treated until it met TOGS 1.1.1 criteria for all COCs, therefore there would be no remaining contamination within the treated groundwater.

The fourth alternative includes the use of enhanced in-situ bioremediation for treatment of the plume. While this technology has been proven to be effective, it requires substantially more time to effectively treat the environment, and therefore, the groundwater plume may continue to migrate off-Site for several years. While eventually this technology effectively protects human health and the environment, it is likely to take a much longer time to do so than the other proposed alternatives.

The final alternative, Alternative 5, includes the use of zero-valent iron to treat contamination within the contaminated groundwater plume. If applied correctly, ZVI will destroy the COCs and greatly reduce the potential for off-Site migration of contaminated compounds, thereby protecting human health and the environment. This technology requires direct contact between the ZVI surface and the contaminant mass. Given that there may be inaccessible areas on-Site, institutional controls and long-term groundwater monitoring will likely still be required to verify adequate protection of human health and the environment.

4.8.2 Compliance with SCOs

Given that the Source Area would be treated more aggressively, via soil mixing and ISCO injections, it is anticipated to meet regulatory SCGs. Additionally, except for Alternative 1, the remaining Alternatives are all anticipated to generally comply with the SCGs for the Site. However, Alternatives 4 and 5 may require multiple treatments to meet the groundwater standards and will likely require more aggressive post-remediation long-term monitoring.

4.8.3 Long-Term Effectiveness and Permanence

Each of the Alternatives, except for Alternative 1, provide long-term effectiveness and permanence after implementation. While limited groundwater contamination may remain on-Site for Alternatives 4 and 5, there would be no human exposure or direct contact, and impacts to ecological receptors and the environment would be greatly lessened from pre-remedy conditions. Additionally, it is anticipated that additional application(s) would likely result in COCs meeting TOGS 1.1.1, therefore further reducing human exposure, impacts to ecological receptors, and the environment.

4.8.4 Reduction in Toxicity, Mobility and Volume

Alternative 1 provides no reduction in toxicity, mobility or volume of contaminants at the Site. However, Alternatives 2 through 5 all reduce toxicity, mobility, and volume effectively over varying amounts of time. By addressing the source of the contamination through the IRM discussed in Section 2.5, and further addressing the contamination in that area via soil mixing and ISCO treatment, it is no longer contributing to the groundwater plume. Alternatives 2 through 5 each effectively address the plume and will provide a remedy that will reduce toxicity, mobility and volume of the contaminants to the environment.

4.8.5 Short-Term Effectiveness

Alternative 1 does not include the risks associated with active remediation, but provides no short-term effectiveness in protecting workers, future Site occupants, nor the public, from potential exposures during redevelopment of the Site.

Alternative 2 would involve large excavations that could negatively impact short-term effectiveness in terms of protection of human health and the environment. In addition to worker safety around deep excavations, this task has the potential to generate the greatest amount of fugitive dust emissions, require large amounts of truck traffic and fuel use, and could potentially compromise the structural integrity of the building. Although these issues can be addressed via engineering controls, the alternative is likely to be the most disruptive to the community in the short term.

While the Source Area treatment in Alternatives 3 through 5 has the potential to generate dust due to soil mixing, the emissions would be confined within the building footprint to the extent practical, limiting the amount of potential public exposure. In addition to the Source Area, these alternatives would require the installation of multiple borings through the concrete slab into the subsurface soils. Although dust emissions from coring through the floor are likely, they will be limited in comparison to excavation and soil mixing and will be confined to within the building footprint.

The remedial technologies proposed in Alternatives 3 and 5 are anticipated provide an effective remedy that meets SCGs within approximately two months. However, Alternative 4 is anticipated to take a minimum of 5 years to effectively meet SCGs.

4.8.6 Implementability

Alternative 1 is readily implemented but would require a significant amount of institutional controls to protect human health, even if the Site was not redeveloped.

Alternative 2 is also implementable, but it would be more technically complex requiring a shoring system to support the building, adjacent sidewalks, roadways, utilities and structures to allow for a deep excavation. There is the potential for contamination to remain under building footers and foundations where access is limited. Duration to complete the excavation is longer due to the volume of material to be removed.

Alternative 3 would require the installation of approximately 21 injection and 22 extraction wells to effectively treat the groundwater plume, and it is anticipated that approximately 35 days of recirculation and treatment would be required to complete the application. During the implementation, a frac tank would have to be staged on-Site to facilitate groundwater storage for treatment prior to reinjection, however given that the anticipated treatment time is only approximately 35 days it is likely that this will not impact redevelopment activities and would be implementable. Additionally, once remedial activities have been completed, most of the wells would be decommissioned and would not impact future Site operations.

Alternative 4 would include the installation of approximately 90 injection wells to effectively treat the groundwater plume. Assuming a conservative injection flow rate, approximately 17 days of injection would be required to complete the first application. However, it is likely that multiple applications would be required. Given that the Site redevelopment is anticipated to occur in 2020 and be complete in 2021, returning for additional applications over multiple years may prove to be extremely difficult and disruptive to the owner's planned manufacturing operations.

The remedial success of Alternative 5 requires direct contact between ZVI surface with contaminant mass and is therefore highly dependent on effectiveness of delivery. It is anticipated that approximately 90 direct injection points would be required to treat the groundwater contaminant plume. Additionally, the slurry is injected into the subsurface using direct injection through Geoprobe drill rods, and therefore, only one injection point would be completed at a time. Assuming two drill rigs are operating simultaneously, the application is anticipated to require at least 40 days of injection to be complete. Similar to Alternative 3, this treatment is not likely to impact redevelopment activities and would be implementable. However, if it is determined that the delivery was not effective, there is the potential that an additional treatment would be required, which may prove difficult with the Site operations once the building is occupied.

4.8.7 Cost

The cost for each of the Alternatives varies from roughly $45,000 to over $8 million, for one round of treatment and including long term groundwater monitoring and O&M costs. Alternative 1 is the lowest cost alternative at $45,000 but does not achieve the remedial goals. Given the large volume of soil at the Site, the cost for removal of all impacted media as shown in Table 4 for Alternative 2, is excessive and driven by disposal and transportation costs. The total present worth for this Alternative 2 is estimated at $8,356,000. Alternative 3 has the second highest present value cost at an estimated maximum of $2,659,000; however, the groundwater would be treated to TOGS 1.1.1 standards/guidance values, and therefore, only one treatment would be required. Alternative 4 has the next highest present worth cost at an estimated maximum of $2,314,000 for one round of injections; however, there is a high likelihood that at least three applications will be required over 5 years. Each additional application would likely cost between $175,000 and $250,000, in addition to potential down-time for Site operations given that large equipment is required to inject the amendments and off-gassing may include nitrogen gas, hydrogen sulfide and methane. Lastly Alternative 5 is the most inexpensive alternative with an estimated maximum of $1,934,000 for one treatment. Similar to Alternative 4, it is likely that at least one additional treatment would be required. Each additional treatment cost ranges from $240,000 to $320,000.

4.8.8 Green Remediation and Sustainability

The NYSDEC DER Program Policy 31 (DER-31) identifies the approach to remediating sites in the context of the larger environment, known as green remediation. This practice "considers all environmental effects of remedy implementation and incorporates options to minimize the environmental footprint of cleanup actions" (DER-31, January 2011). While Alterative 1 does not consume large amounts of fuel or energy, contaminants remain on the Site and will continue to impact the public and environmental health. Alternative 2 would greatly reduce the contaminant mass, however a significant amount of fuel would be consumed between the excavation equipment and the dump trucks used to transport the materials to disposal facilities and import clean fill. Additionally, this alternative would have impacts on landfill capacities. Alternative 3 would require more energy to implement initially than Alternatives 4 and 5, however, a significant reduction in contamination would be realized. Additionally, this alternative only requires one round of treatment, and therefore, would not require additional energy consumption multiple times. Alternatives 4 and 5 require the least amount of energy to implement; however, multiple injections over the course of several years would likely be required.

4.9 DESIGN CONSIDERATIONS

While the primary objectives of the RI were to further define the nature/extent of contamination, identify potential source areas, and assess impacts, there are still several data gaps that should be filled to more accurately design a remedy for the Site. A subsequent, pre-design investigation bench scale test and plume delineation would be required for Alternatives 3 through 5. As is shown in the table provided by XDD, included in Appendix A, bench testing and plume delineation are highly recommended in order to more accurately identify the horizontal and vertical extents of groundwater contamination, and understand dosing requirements for each technology.

5.0 RECOMMENDATIONS

5.1 RECOMMENDED ALTERNATIVE

CHA recommends the selection of Alternative 3, Source Area treatment with soil mixing and ISCO, and Plume Area treatment with ISCO and groundwater recirculation. This alternative would provide the most effective protection of the public health and the environment given that the SCGs would be met, soil within the Source Area would be addressed and treated, and the groundwater on the Site would be remediated to TOGS 1.1.1 ambient groundwater standards and guidance values before being reinjected into the ground. This remedy provides long-term effectiveness, would not require additional treatments, reduces the toxicity, mobility, and volume of contamination, and is implementable. Additionally, this remediation can be performed in less than six months which is preferred in terms of meeting a redevelopment goal of September 2020. Although this Alternative is the second most costly, it would not require additional treatments, unlike Alternatives 4 and 5, and likely would only require limited long-term groundwater monitoring.

In addition to the remedial actions specific to Alternative 3, soil vapor intrusion would be addressed through the installation of an active sub-slab depressurization system that mitigates the entire building footprint. Maintenance of any existing impervious areas such as asphalt parking lots will also be required. Any alteration to these areas, or installation of pervious areas will be required to meet the criteria set forth as part of the SMP and at a minimum will be protective of human health and the environment.

5.2 SUPPLEMENTAL RECOMMENDATIONS

To provide a comprehensive remedial design, additional Site investigation work is required regardless of the selected alternative. The following items will be provided as part of a Pre-Design Investigation Work Plan to NYSDEC after the submission of this AAR.

- **Plume delineation** – In order to more accurately define the horizontal and vertical extents of the contamination within the groundwater plume, additional investigation using a membrane interface hydraulic profiling tool (MIHPT) would be used to evaluate the geologic conditions and define the lateral and vertical distribution of contaminants in the groundwater. Delineation of the groundwater plume can potentially reduce the treatment area/volume and reduce the overall cost of the treatment and will provide CHA a better understanding of the area requiring treatment.
- **Bench testing** – Bench scale testing is performed by evaluating the interaction of the specific soil geochemistry with the remediation process chemistry to determine potential interferences and oxidant demands. CHA will collect and provide Site soil and groundwater to XDD to perform these bench tests. During the bench testing an oxidant such as permanganate will be used to evaluate the total oxygen demand (TOD) from the contaminants, reduced metals, and any additional non-target demand on the oxidant that may be present in the soils. The TOD of the oxidant in the presence of a representative contaminated soil sample can then be used to determine the oxidant loading for the full remedial design.

- Additional testing may also include a treatability test that would confirm that the target COCs are fully destroyed using the oxidant dosing levels determined as part of the bench test.

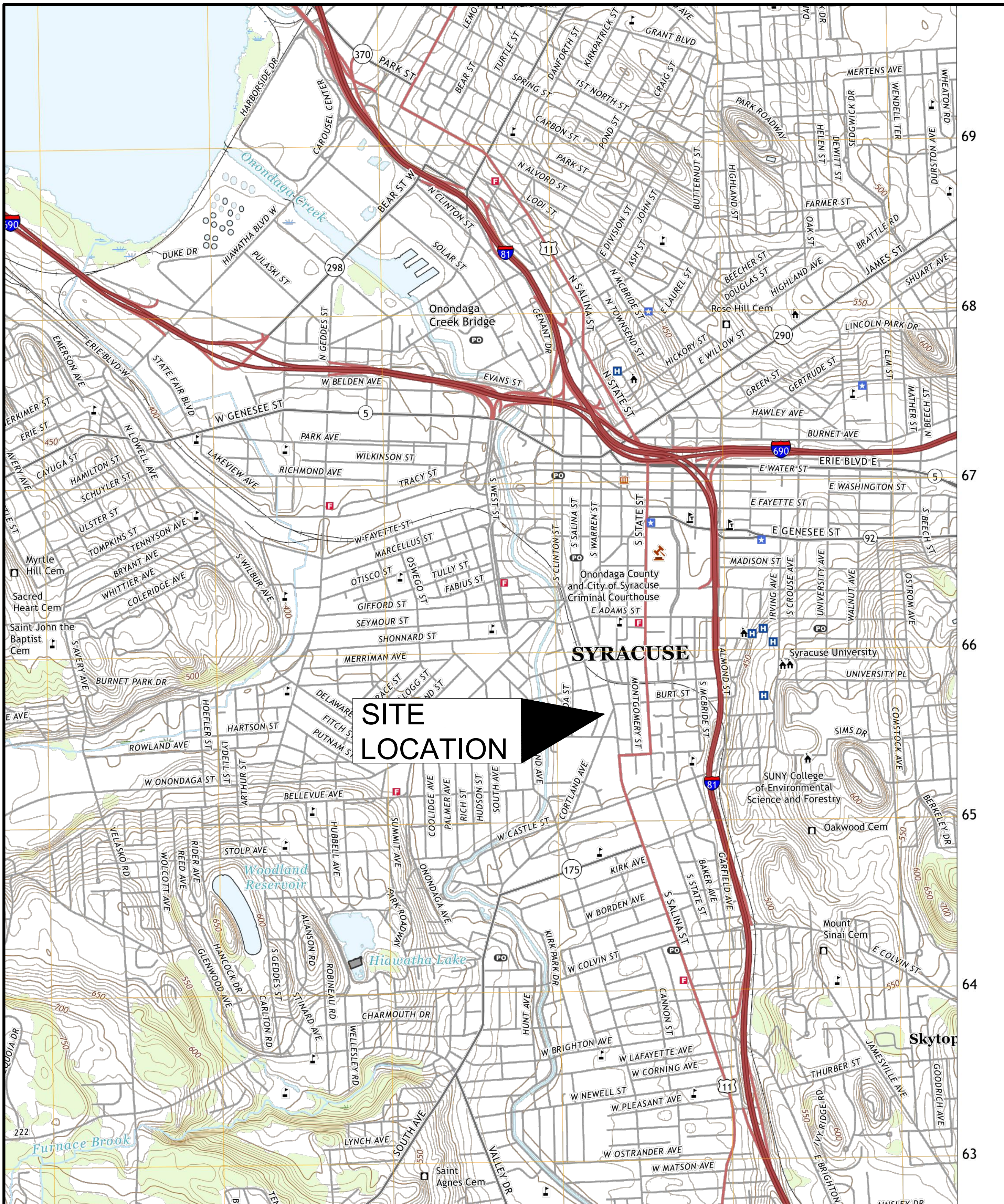
6.0 SCHEDULE

The following table provides and estimated schedule for completion of the Former Coyne Textile Facility BCP project. The overall progress of the project will be dependent upon several factors including, but not limited to, NYSDEC review and approval timeframes, time of year at which the final design documents are complete, weather conditions at the time of remedial construction, etc. As stated previously, it is important to note that redevelopment activities are scheduled for the fall of 2020. While the specific dates may be shifted slightly, it is important that Site remediation and development activities follow one another in rapid succession.

Table 9. Project Schedule

Description	Estimated Start	Estimated Finish
NYSDEC Review & Approval of AAR	Late January 2020	March 2020
NYSDEC Selection of Proposed Remedy	Late January 2020	March 2020
Public Comment Period on Proposed Remedy	April 2020	Mid-May 2020
Decision Document Issued	Mid-May 2020	End of May 2020
Remedial Design	May 2020	June 2020
Initial Remedial Activities	July 2020	September 2020

FIGURES



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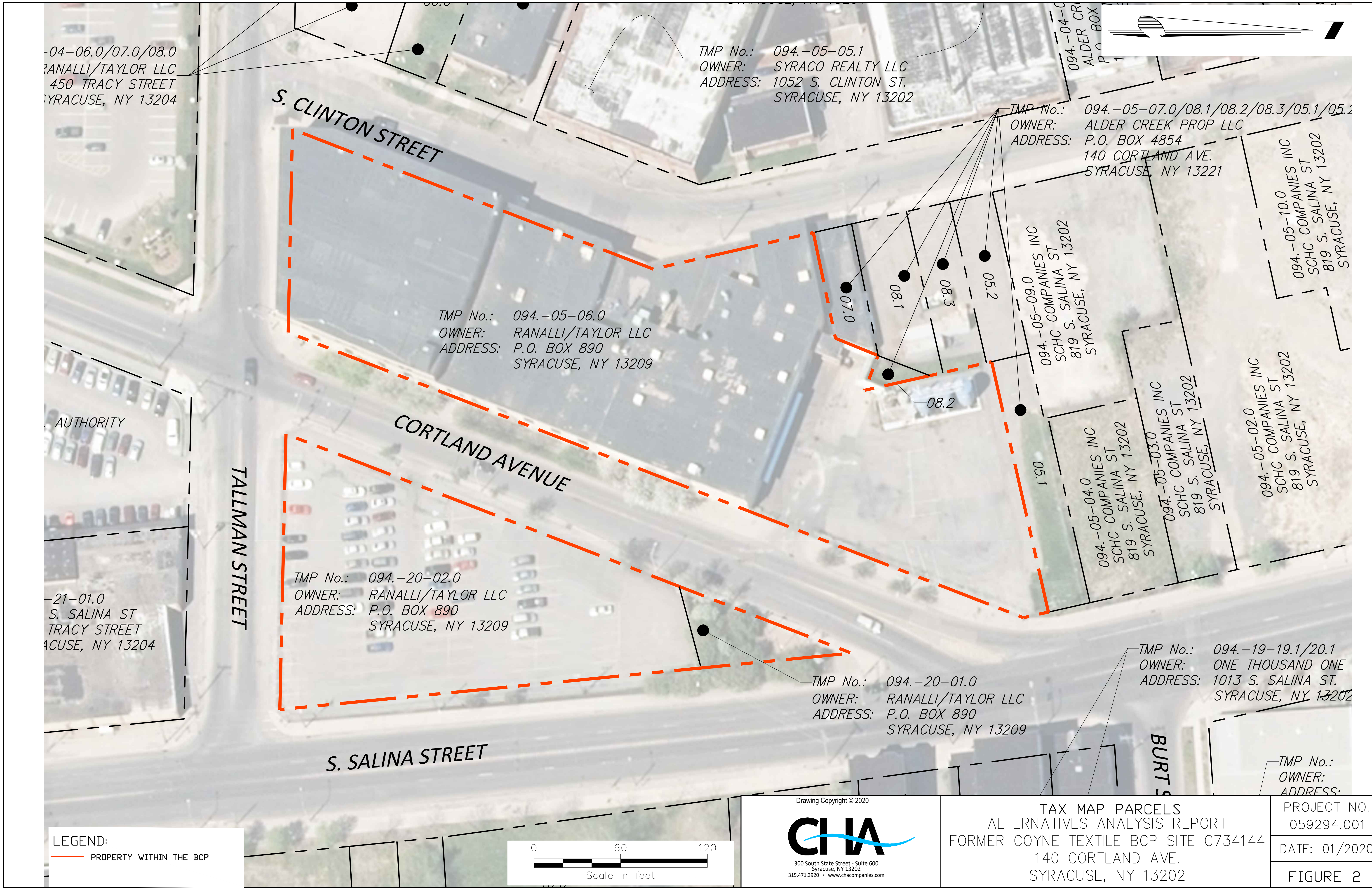
SITE LOCATION MAP

ALTERNATIVES ANALYSIS REPORT
FORMER COYNE TEXTILE BCP SITE C734144
140 CORTLAND AVE.
SYRACUSE, NEW YORK

PROJECT NO.
059294.001

DATE: 01/2020

FIGURE 1



-04-06.0/07.0/08.0
RANALLI/TAYLOR LLC
450 TRACY STREET
SYRACUSE, NY 13204
S. CLINTON STREET
TMP No.: 094.-05-05.1
OWNER: SYRACO REALTY LLC
ADDRESS: 1052 S. CLINTON ST.
SYRACUSE, NY 13202
TMP No.: 094.-05-07.0/08.1/08.2/08.3/05.1/05.2
OWNER: ALDER CREEK PROP LLC
ADDRESS: P.O. BOX 4854
140 CORTLAND AVE.
SYRACUSE, NY 13221
TMP No.: 094.-05-06.0
OWNER: RANALLI/TAYLOR LLC
ADDRESS: P.O. BOX 890
SYRACUSE, NY 13209
07.0
08.1
08.3
05.2
08.2
05.1
094.-05-09.0 SCHC COMPANIES INC 819 S. SALINA ST SYRACUSE, NY 13202
094.-05-10.0 SCHC COMPANIES INC 819 S. SALINA ST SYRACUSE, NY 13202
094.-05-04.0 SCHC COMPANIES INC 819 S. SALINA ST SYRACUSE, NY 13202
094.-05-03.0 SCHC COMPANIES INC 819 S. SALINA ST SYRACUSE, NY 13202
094.-05-02.0 SCHC COMPANIES INC 819 S. SALINA ST SYRACUSE, NY 13202
AUTHORITY
CORTLAND AVENUE
TALLMAN STREET
TMP No.: 094.-20-02.0
OWNER: RANALLI/TAYLOR LLC
ADDRESS: P.O. BOX 890
SYRACUSE, NY 13209
-21-01.0
S. SALINA ST
TRACY STREET
SYRACUSE, NY 13204
TMP No.: 094.-20-01.0
OWNER: RANALLI/TAYLOR LLC
ADDRESS: P.O. BOX 890
SYRACUSE, NY 13209
TMP No.: 094.-19-19.1/20.1
OWNER: ONE THOUSAND ONE
ADDRESS: 1013 S. SALINA ST.
SYRACUSE, NY 13202
S. SALINA STREET
BURT S
TMP No.:
OWNER:
ADDRESS:
N
LEGEND:
PROPERTY WITHIN THE BCP
0 60 120
Scale in feet
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TAX MAP PARCELS
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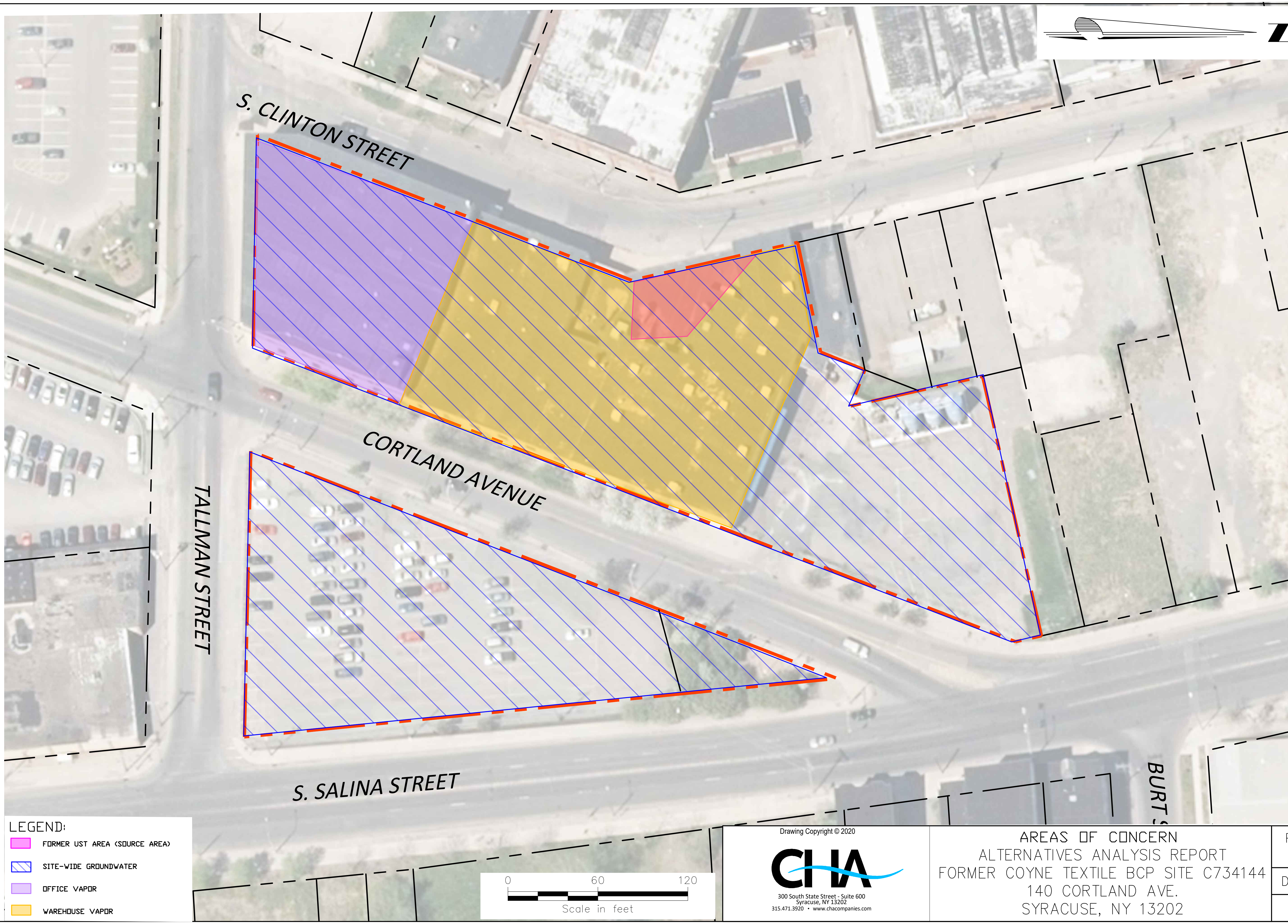
SYRACUSE, NY 13202
PROJECT NO. 059294.001
DATE: 01/2020
FIGURE 2



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059294.001

DATE: 01/2020

FIGURE 3

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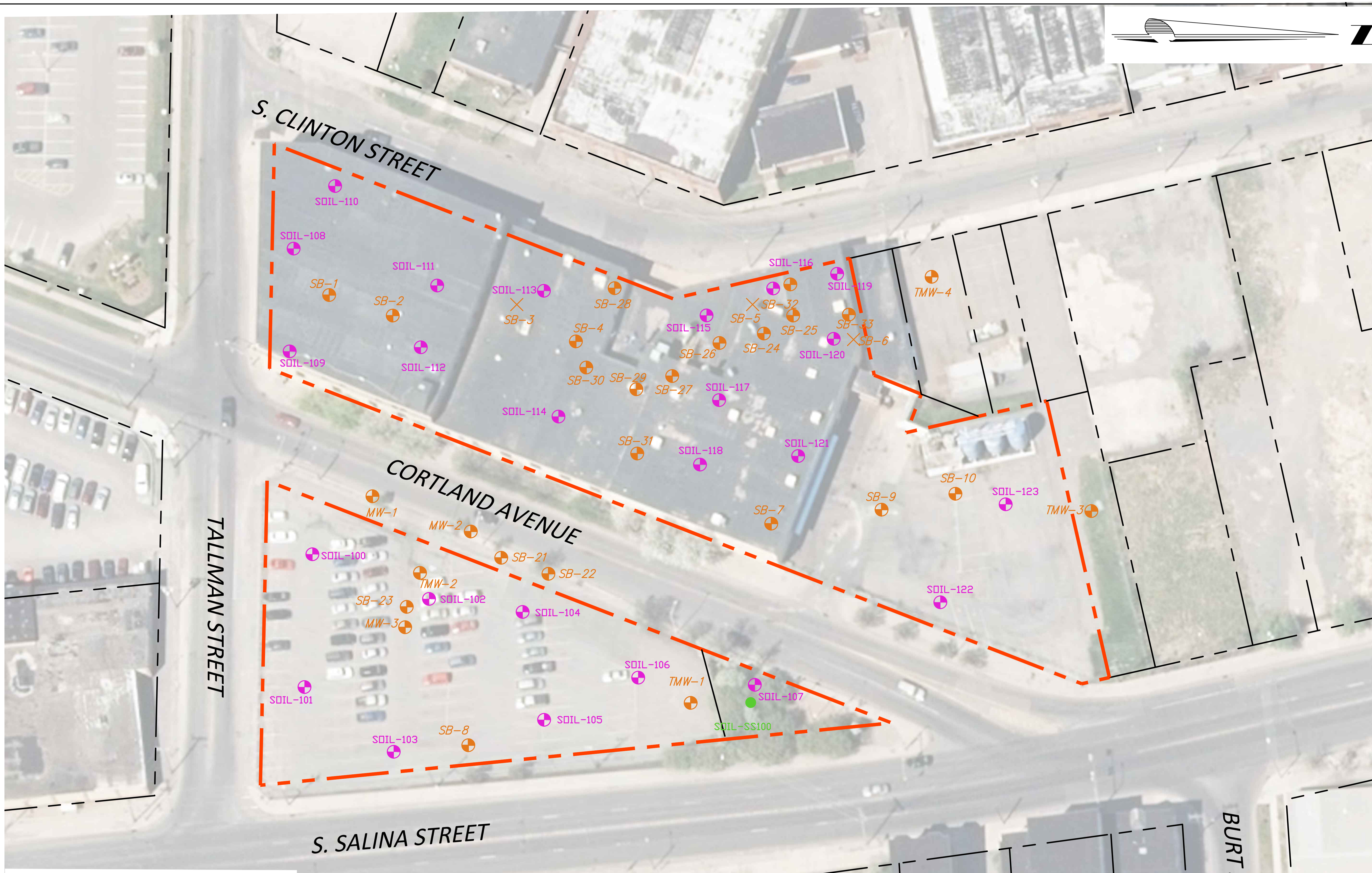

LEGEND:

- GZA 2014/2015 SOIL BORING LOCATIONS
- GZA 2014/2015 ATTEMPTED SOIL BORING
- CHA 2018/2019 RI SOIL BORING LOCATIONS
- CHA 2018/2019 RI SURFACE SOIL BORING LOCATIONS

0 60 120
Scale in feet

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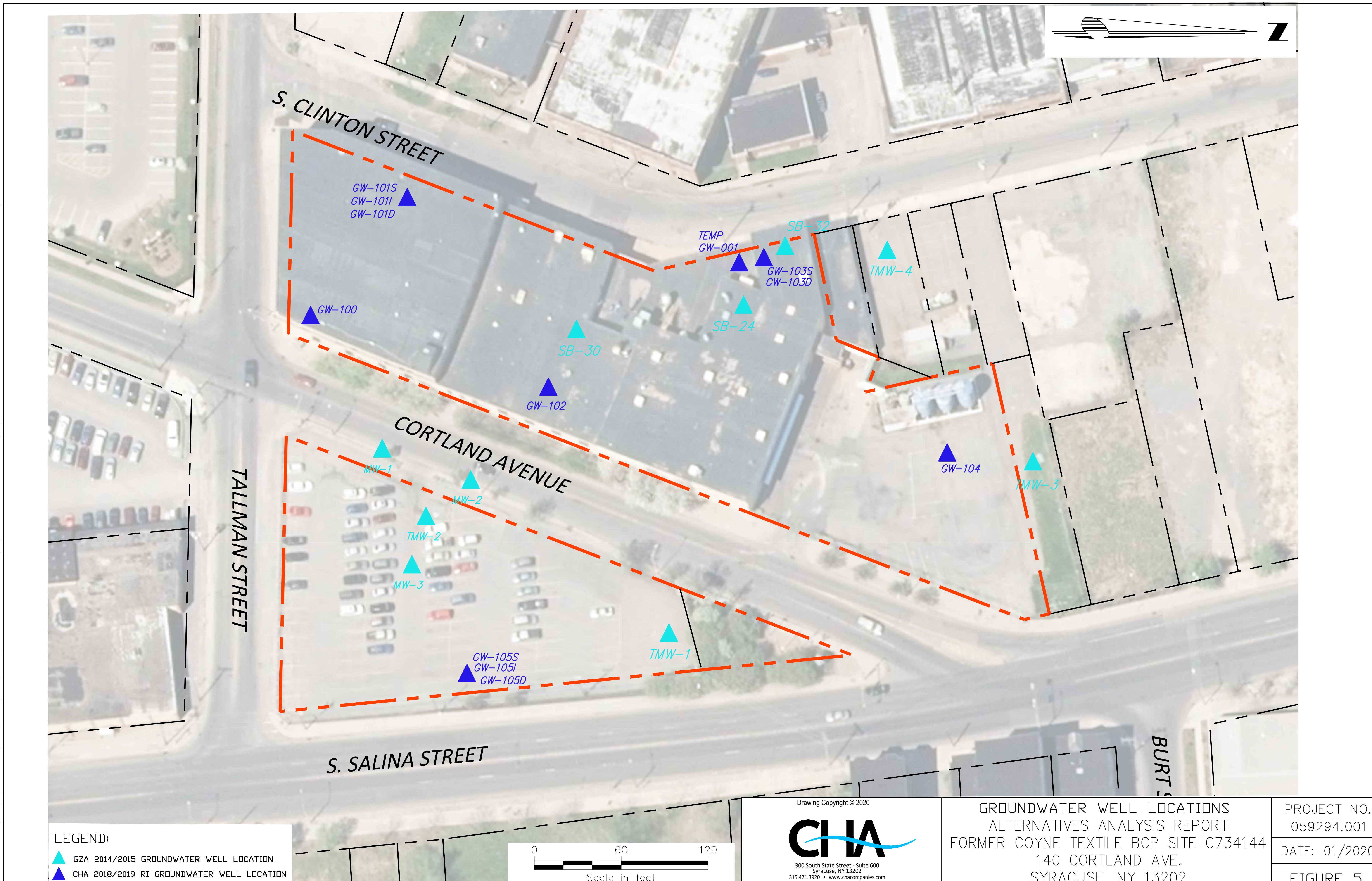
SOIL SAMPLE LOCATIONS
ALTERNATIVES ANALYSIS REPORT
FORMER COYNE TEXTILE BCP SITE C734144
140 CORTLAND AVE.
SYRACUSE, NY 13202

PROJECT NO.
059294.001

DATE: 01/2020

FIGURE 4



File: V:\PROJECTS\ANY\K5\059294.001\CADD_ACAD\ENVP\COYNE\AAR FIGURES.DWG Saved: 1/24/2020 8:58:22 AM Plotted: 1/24/2020 8:59:03 AM Current User: Miller, Samantha LastSavedBy: 4187

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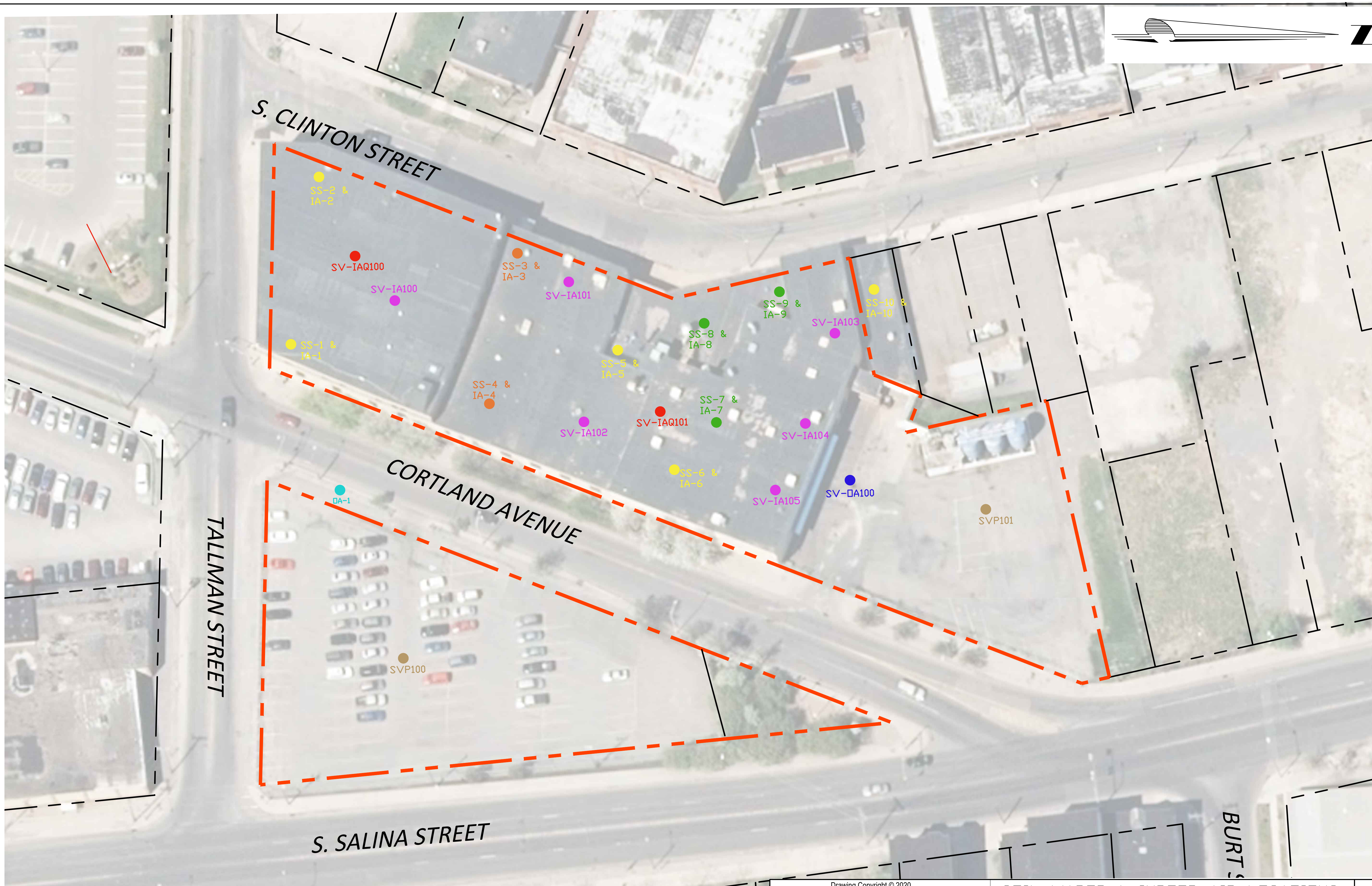
GROUNDWATER WELL LOCATIONS
ALTERNATIVES ANALYSIS REPORT
FORMER COYNE TEXTILE BCP SITE C734144
140 CORTLAND AVE.
SYRACUSE, NY 13202

PROJECT NO. 059294.001

DATE: 01/2020

FIGURE 5



LEGEND:

- GZA 2015 SUB-SLAB SOIL VAPOR AND INDOOR AIR (TPA)
- GZA 2015 SUB-SLAB SOIL VAPOR AND INDOOR AIR (MONITOR)
- GZA 2015 SUB-SLAB SOIL VAPOR INDOOR AIR (MITIGATE)
- GZA 2015 OUTDOOR AIR
- CHA RI SUB-SLAB SOIL VAPOR
- CHA RI SOIL VAPOR POINT
- CHA RIWP OUTDOOR AIR
- CHA RI INDOOR AIR QUALITY

0 60 120
Scale in feet

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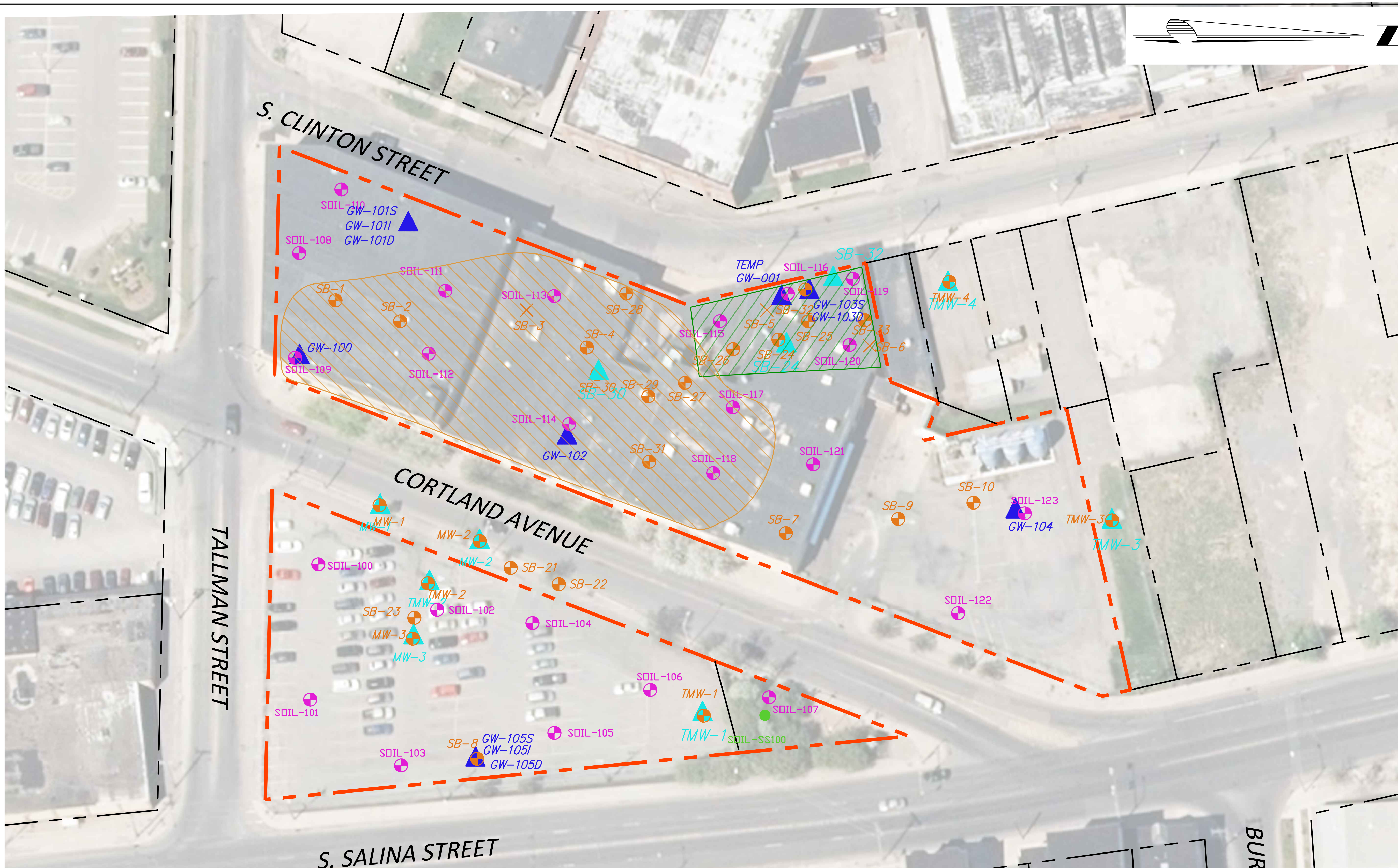
SOIL VAPOR & INDOOR AIR LOCATIONS
ALTERNATIVES ANALYSIS REPORT
FORMER COYNE TEXTILE BCP SITE C734144
140 CORTLAND AVE.
SYRACUSE, NY 13202

PROJECT NO. 059294.001
DATE: 01/2020
FIGURE 6

File: V:\PROJECTS\ANY\K5\059294.001\CADD_ACAD\ENVR\COYNE\AAR FIGURES.DWG Saved: 1/24/2020 8:58:22 AM Plotted: 1/24/2020 8:59:07 AM Current User: Miller, Samantha LastSavedBy: 4187



LEGEND:

- GZA 2014/2015 SOIL BORING LOCATIONS
- GZA 2014/2015 ATTEMPTED SOIL BORING
- GZA 2014/2015 GROUNDWATER WELL LOCATIONS
- CHA 2018/2019 RI SOIL BORING LOCATIONS
- CHA 2018/2019 GROUNDWATER WELL LOCATIONS
- APPROXIMATE SOURCE AREA
- APPROXIMATE PLUME AREA
- CHA 2018/2019 RI SURFACE SOIL BORING LOCATIONS

0 60 120
Scale in feet

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TREATMENT AREAS
ALTERNATIVES ANALYSIS REPORT
FORMER COYNE TEXTILE BCP SITE C734144
140 CORTLAND AVE.
SYRACUSE, NY 13202

PROJECT NO. 059294.001

DATE: 01/2020

FIGURE 7

File: V:\PROJECTS\ANY\K5\059294.001\CADD_ACAD\ENVP\COYNE\AAR FIGURES.DWG Saved: 1/24/2020 8:58:22 AM Plotted: 1/24/2020 8:59:12 AM Current User: Miller, Samantha LastSavedBy: 4187

APPENDIX A

XDD Environmental Summary Memo and Table

MEMORANDUM

To: Samantha Miller, CHA Consulting, Inc.

Date: January 17, 2020

From: Karen O'Shaughnessy

cc: Michael C. Marley
Dennis Keane

Re: Remedial Options Evaluation Summary
Former Coyne Textiles Facility
Syracuse, New York

XDD Environmental (XDD) appreciates the opportunity to provide this evaluation of remedial options to CHA Consulting, Inc. (CHA) for the Former Coyne Textile Facility (site) located in Syracuse, New York. This technical memorandum provides an overview of the remedial alternatives evaluated for the site with a table summarizing potential costs for each option (**Table 1**).

1.0 <u>Assumptions</u>

Based on the site conceptual model presented in historical reports provided by CHA, XDD evaluated remedial options for two primary on-site treatment areas: the area near and including the Former UST Area (Source Area) and the groundwater contaminant plume downgradient of the Source Area (Downgradient Plume). Based on available soil and groundwater data (collected from 2014 through 2019) and the applicable Title 6 New York State Codes, Rules, and Regulations (NYCRR) Part 375 Soil Cleanup Objectives (SCOs) and New York State Department of Environmental Conservation (NYSDEC) Technical and Operational Guidance Series (TOGS) 1.1.1 Class GA Ambient Groundwater Quality Standards, the following treatment areas were developed for the Source Area and Downgradient Plume and the treatment area dimensions presented below were assumed when developing costs for the remedial options.

- <u>Source Treatment Area</u> – Includes soils with contaminant of concern (COC) concentrations exceeding applicable NYCRR SCOs and assumes a target treatment area of 6,000 square feet (ft^2) below and around the area of previously excavated in the Former UST Area.
  - Includes soil below the excavated area (approximately 500 ft^2) with COC concentrations remaining above applicable NYCRR SCOs. The assumed treatment interval is from the bottom of the excavation to a depth of approximately 16 feet below ground surface (bgs)
  - Includes approximately 5,500 ft^2 of soils around of the excavated area with COC concentrations remaining above applicable NYCRR SCOs. The assumed target treatment interval is from approximately ground surface to 16 feet bgs.
- <u>Downgradient Plume Treatment Area</u> – Includes the area downgradient of the Source Area where COC groundwater concentrations exceed NYSDEC GA criteria. The downgradient groundwater plume appears to originate at the Former UST Area and continues in a south-southeasterly direction for approximately 300 feet towards Cortland Avenue. The assumed treatment area is approximately 30,000 ft^2 with a 5-foot vertical treatment interval at varying depths between 15 and 25 feet bgs, primarily in the highly permeable sand and gravel layer.

2.0 Remedial Options Overview

The following remedial technologies were evaluated:

- In situ chemical oxidation (ISCO) Soil Mixing (*Source Area*) - ISCO using a soil mixing application strategy involves the mechanical agitation of subsurface soils while blending in the treatment reagents. ISCO using a direct injection method would not be a practical option in the Source Area due to the presence of lower permeable soils such as silts or clays, as well as the presence of high COC concentrations historically observed in the vadose zone. ISCO using a soil mixing application strategy will be an effective remedial option for reducing COC mass in high and lower permeable soils in both the unsaturated overburden and the saturated zone.
- ISCO Groundwater Recirculation (*Downgradient Plume*) – In an ISCO application using a recirculation application strategy, groundwater is extracted from a series of extraction wells, amended with treatment reagents, then reinjected into the subsurface through a series of injection wells. Because remedial success is dependent on direct contact between the oxidant with contaminant mass, ISCO using recirculation allows the treatment reagents to be mixed with the impacted groundwater, achieving contact between the oxidant and dissolved COCs. Compared to a direct injection approach, a recirculation strategy provides better hydraulic control and distribution of reagents, with less likelihood of dissolved phase COCs being displaced as reagents are injected. Because the Downgradient Plume consists primarily of dissolved phase COCs in groundwater (predominantly cis-1,2-dichloroethylene [cis-DCE] and vinyl chloride [VC]), this application strategy will be particularly effective at the site.
- Enhanced in situ bioremediation (EISB) (*Downgradient Plume*) - EISB involves the injection of a small volume of amendments downgradient of the source area to stimulate biodegradation of dissolved phase COC impacts within the overburden groundwater plume to reduce COC concentrations and prevent further migration of the dissolved COC groundwater plume. EISB treatment reduces the risk of forming degradation by-products (i.e., cis-DCE and VC) by increasing the potential to drive reductive dechlorination to completion.
- Zero-valent Iron (ZVI) Slurry Injection (*Downgradient Plume*) - ZVI is injected into the subsurface to facilitate contaminant destruction by dehalogenation of chlorinated compounds by chemical (abiotic) reduction. A low volume of ZVI is injected into the subsurface as a high concentration slurry solution using direct injection through Geoprobe drill rods. The influence of ZVI on the soil/groundwater geochemistry can stimulate the growth of anaerobic microorganisms and contribute to an accelerated natural reductive degradation of chlorinated compounds.

3.0 Data Gaps

3.1 Pre-Design Investigation

Additional pre-design site investigation is recommended to define the lateral and vertical distribution of contaminants in the Source Area and the Downgradient Plume to increase the likelihood of remedial success and potentially reduce the area/volume requiring treatment, minimizing remedial cost.

The Source Treatment Area includes soils with COC concentrations exceeding NYSDEC criteria, which are likely contributing to dissolved COC concentrations in downgradient groundwater. It is likely that over time, contaminants may have migrated and diffused from highly permeable source area soils into less permeable zones. Remedial success is dependent on direct contact between the oxidant and contaminant mass. If the highly impacted source area soils are not directly contacted by the oxidant and significant contaminant mass remains after the treatment, back diffusion of COCs from low permeability soils will continue to be a source of groundwater contamination and will require additional or alternate treatment. Therefore, complete delineation of the source area (laterally and vertically) is critical for remedial success while refining both scope and cost of the treatment.

The treatment area and volume of the Downgradient Plume is a conservative estimate based on available data, although it may not fully contain the extent of dissolved COC groundwater concentrations exceeding NYSDEC GA criteria. Conversely, this estimate may unnecessarily include areas that do not require treatment. Therefore, additional delineation is recommended in the downgradient areas of the site to evaluate geologic conditions and define the lateral and vertical extents of the downgradient COC groundwater plume, which would refine both scope and cost of the remedy.

3.2 Bench Testing

ISCO treatment costs are highly dependent on the total oxidant demand (TOD) of treatment area soils and groundwater as well as the volume of the treatment area. If the oxidant demand is high, a significant amount of oxidant may be required to overcome the non-target demand and achieve the desired treatment goal, which will increase ISCO costs. Bench-scale testing is highly recommended to determine sufficient oxidant dosing.

In addition, ISCO using a recirculation approach typically requires that regulatory criteria are met before groundwater is re-injected. Therefore, it is critical to establish contact between a sufficient mass of oxidant with the contamination for a sufficient duration of time. The contact time between the oxidant and groundwater necessary to achieve necessary re-injection criteria can be determined during bench testing.

Microcosm testing is typically recommended to ensure bioremediation is not limited (bacteria, nutrients and/or geochemistry) and to determine accurate amendment dosing and/or bioaugmentation requirements. However, microcosm tests may require several months to complete. Due to time restrictions for the completing the remedial application, complete microcosm bench testing may not be feasible during the given timeframe.

3.3 Pilot Testing

A pilot test is recommended for the ISCO recirculation to evaluate site hydraulics to develop full-scale design parameters including:

- Injection and extraction radius of influence to determine the number and spacing of injection and extraction wells.
- Injection and extraction rates to determine estimated duration and cost of the application and identify potential failure points (i.e., oxidant surfacing or short-circuiting).
- Impact of subsurface heterogeneities on reagent distribution.

Recommended pilot testing for ISCO recirculation involves hydraulic testing only (without oxidant).

Although pilot testing is typically recommended to develop full-scale design parameters and to evaluate ISB and ZVI amendment distribution and treatment effectiveness, due to time constraints for completing the remedial application and the slower treatment timeframe of ISB and ZVI, pilot testing may not be feasible within the available schedule. Due to the low treatment volume applied during full-scale applications of ISB and ZVI, pre-design hydraulic evaluation is less critical for a successful application.

4.0 REMEDIAL OPTIONS EVALUATION

Major points associated with the evaluated remedial options are summarized below.

- ISCO Soil Mixing
  - High certainty of effective treatment within a short timeframe. The level of certainty increases with treatment area definition, sufficient contact between the oxidant and contaminants, and accurate oxidant dosing.
  - It is assumed that significant contaminant mass remains in the source area below and around the tank excavation area. The success of the treatment requires direct contact between the oxidant and contaminated soil. This may not be feasible with the current building structure around the Source Area (walls and concrete floors).
  - Potential future subsurface infrastructure will need to be considered due to active oxidant that may remain in the subsurface for an extended period of time.
  - Limited space and clearance inside the facility may not allow for the heavy equipment typically used for soil mixing. Alternatives mixing strategies may need to be considered.

- ISCO Recirculation
  - High certainty of effective treatment within a short timeframe. The level of certainty increases with treatment area definition, sufficient contact between the oxidant and contaminants, and accurate oxidant dosing.
  - A recirculation approach may be required to meet strict regulatory criteria for groundwater reinjection. Because permanganate does not treat benzene, additional treatment (such as the addition of carbon) may be required before groundwater can be reinjected into the subsurface. Regulatory approval for an ISCO recirculation application may be challenging.
  - If the upgradient source area is not removed, COCs remaining in the source will continue to diffuse into groundwater, requiring additional treatment applications.

- Enhanced ISB Injection
  - Initially inexpensive relative to other technologies evaluated. However, multiple applications are likely required. Therefore, the costs provided are likely optimistic.
  - If upgradient source area is not removed, COCs remaining in the source will continue to diffuse into groundwater, requiring a long-term implementation program.
  - Slower treatment timeframe relative to ISCO.

- <u>ZVI Injection</u>
  - Initially the lowest cost treatment option relative to other technologies evaluated. However, multiple applications may be required.
  - Application timeframe is longest of technologies evaluated, with approximately 40 days of injection required to complete the ZVI application.
  - Remedial success is dependent on direct contact between ZVI surface with contaminant mass, and is therefore, highly dependent on effectiveness of delivery.
  - Slower treatment timeframe relative to ISCO.

Table 1
Remedial Option Summary
Former Coyne Textile Facility
Syracuse, New York

REMEDIAL OPTION	TECHNOLOGY			
	SOURCE AREA TREATMENT	**PLUME TREATEMENT**		
Technology	**In Situ Chemical Oxidation (ISCO) - Soil Mixing**	**In Situ Chemical Oxidation (ISCO) - Groundwater Recirculation**	**Enhanced In Situ Bioremediation (EISB)**	**Zero Valent Iron (ZVI) Injection**
Approach Description	• Treatment of site contaminants of concern (COCs) using chemical oxidants, such as sodium or potassium permanganate, to reduce contaminant mass in heterogeneous soil in the source area. ISCO treatment will be applied to both the unsaturated overburden and the saturated soils. • A soil mixing application strategy involves the mechanical agitation of subsurface soils while blending in the treatment reagents. The mechanical agitation breaks apart the natural soil structure, homogenizes the soils, and helps to distribute the oxidant, establishing more uniform contact between oxidant and the contaminants. This contact is key for successful treatment. A soil mixing application strategy is particularly useful when treating source areas and lower permeable soils such as silts or clays. • The oxidant (concentrated solution or dry chemical) is applied to the soils within the source area using specialized soil mixing equipment (augers or excavator buckets equipped with soil mixing tooling). • Treatment primarily occurs within the limits of the source area (area with the highest observed soil and/or groundwater concentrations).	• Treatment of site COCs in groundwater using chemical oxidants, such as sodium permanganate, to reduce contaminant concentrations in the downgradient portions of the site, primarily in groundwater. • In an ISCO application using a recirculation strategy, groundwater is extracted from a series of extraction wells, amended with treatment reagents, then reinjected into the subsurface through a series of injection wells. • The extracted groundwater will be amended with an oxidant, such as sodium permanganate, and stored above ground to allow the contact time necessary to treat the groundwater to concentrations below NYSDEC criteria prior to re-injection into the subsurface. The necessary contact time is dependent on the concentrations of both the oxidant and contaminants in groundwater. • Treatment conducted in downgradient portions of the site where COC groundwater concentrations exceed NYSDEC GA criteria.	• Addition of amendments downgradient of the source area to stimulate biodegradation of dissolved phase COC impacts within the overburden groundwater plume reduce COC concentrations to below NYSDEC GW criteria and prevent further migration of the dissolved COC groundwater plume. • Amendments are injected into the subsurface within the treatment area through a series of injection wells. • Treatment conducted in downgradient portions of the site where COC groundwater concentrations exceed NYSDEC GA criteria. • May require inoculation/bioaugmentation.	• Injection of ZVI into the subsurface to facilitate contaminant destruction by dehalogenation of chlorinated compounds by chemical (abiotic) reduction. • ZVI is injected into the subsurface as a high concentration slurry solution using direct injection through Geoprobe drill rods. • Treatment conducted in downgradient portions of the site where COC groundwater concentrations exceed NYSDEC GA criteria.
Pros/Cons	• ISCO technology can rapidly break down the target COCs at high the contaminant concentrations within the source area using a single dose of oxidant. • High certainty of effective treatment (level of certainty increases with target treatment area definition/ oxidant distribution / contact with contaminants / accurate oxidant dosing). • Remedial success is dependent on direct contact with contaminant mass. Soil mixing does not require advection or diffusion to distribute the oxidant to contact the contaminant. • ISCO has been shown to only temporarily inhibit microbial activity, and as geochemical conditions return to normal, bacteria can thrive. • Soil geology and/or building infrastructure may limit effective distribution of oxidant to impacted soil. • If significant sources of impacts are not directly contacted by the oxidant and remain beyond the extents of the source area, this source of impacts to groundwater would need additional/alternate treatment (discussed below). • ISCO treatment costs are dependent on the total oxidant demand of treatment area soils and the volume of the treatment area (discussed below). • If dry chemical, such as potassium permanganate, is used during the treatment application, dust mitigation/controls may be required.	• ISCO technology can rapidly break down the target COCs in groundwater and soils in the downgradient portions of the site in a single application. However, more than one application may be required to achieve the desired COC mass reduction. • High certainty of effective treatment (level of certainty increases with target treatment area definition/ oxidant distribution / contact with contaminants / accurate oxidant dosing). • Remedial success is dependent on direct contact with contaminant mass. ISCO using recirculation involves mixing of the treatment reagents with the impacted groundwater, achieving contact between the oxidant and dissolved COCs. Compared to a direct injection approach, a recirculation strategy provides better hydraulic control and distribution of reagents, and less likelihood of dissolved phase COCs being displaced as reagents are injected. • ISCO has been shown to only temporarily inhibit microbial activity, and as geochemical conditions return to normal, bacteria can thrive. • ISCO treatment costs are dependent on the total oxidant demand, the volume of the treatment area, and the duration of the application. Site geology/ hydraulics will dictate injection time and distribution of oxidant (discussed below). • ISCO using a recirculation approach typically requires lower oxidant dosing than direct injection and minimizes potential for oxidant surfacing. • May be required to meet strict regulatory criteria for groundwater reinjection. Because permanganate does not treat benzene, additional treatment (such as the addition of carbon) may be required before groundwater can be reinjected into the subsurface.	• Generally not practical to address free-phase product or heavily contaminated areas. More effective for remediating low-level residual contamination. ISB may not reduce concentrations of contaminants in heavily contaminated areas to required concentrations. • Treatment may require greater than 5-10 years, depending on source area treatment and groundwater flow velocities. Passive remediation relies on groundwater movement to treat plume, therefore slower timeframe than active remediation. • With source removal, may requires multiple applications over life of program (assumes 3 applications over 5 years). • Without source removal, assume this is a long term implementation program (assume a timeframe of 30 years and reinjection ISB every 5 years). • As microorganisms biodegrade contaminants, byproducts of anaerobic respiration may include nitrogen gas, hydrogen sulfide, and methane. • Requires long-term management to verify continued effectiveness.	• Remedial success is dependent on direct contact between ZVI surface with contaminant mass, and is therefore, highly dependent on effectiveness of delivery. • The influence of ZVI on the soil geochemistry [consumption of oxygen, nitrate, sulphate and production of hydrogen & Fe (II)] can stimulate the growth of anaerobic microorganisms and contribute to an accelerated natural reductive degradation of chlorinated compounds. • Sufficient ZVI must be applied to generate the strongly reducing conditions necessary for abiotic reduction of COCs. Abiotic reactions result in faster dehalogenation of CVOCs with minimal production of partially dechlorinated byproducts, such as cis-1,2- DCE. • Requires long-term management to verify continued effectiveness. Additional applications may be required. • A low volume of ZVI slurry is injected into the subsurface using direct injection through Geoprobe drill rods. Therefore, only one injection point will be injected into at one time, potentially increasing the application timeframe, depending on achievable injection flow rates. • Site geology/ hydraulics will dictate injection time and distribution of oxidant.
Supplemental Components	• Bench Testing: If the oxidant demand of soils in the source treatment area is high, a significant amount of oxidant may be required to overcome the non-target demand and achieve the desired treatment goal, which will increase ISCO costs. Bench-scale testing is highly recommended to determine sufficient oxidant dosing. • Source Area Delineation: Additional site investigation is recommended to refine the horizontal and vertical extents of the source area, including non-aqueous phase liquid. Refining the extents of the source area can potentially reduce the treatment area and overall cost.	• Bench Testing: If the oxidant demand of soils and/or aquifer media in the downgradient plume is high, a significant amount of oxidant may be required to overcome the non-target demand and achieve the desired treatment goal, which will increase ISCO costs. Bench-scale testing is highly recommended to determine accurate oxidant dosing. • In addition, ISCO using a recirculation approach typically requires that regulatory criteria are met before groundwater is re-injected. The contact time between the oxidant and groundwater necessary to achieve this criteria can be determined during bench testing. • Plume Delineation: Additional site investigation is recommended to define the horizontal and vertical extents of the COC groundwater plume, to potentially reduce the treatment area/volume and overall cost. Investigations may include membrane interface probe (MIP) investigations to evaluate geologic conditions and define the lateral and vertical distribution of contaminants in groundwater. Pilot Testing: A pilot test is recommended to evaluate site hydraulics to develop full-scale design parameters including injection/ extraction radius of influence (for well spacing) and injection and extraction rates, and to evaluate the impact of subsurface heterogeneities on reagent distribution. Pilot testing involves hydraulic testing only and no oxidant is applied.	• Bench Testing: Microcosm testing should be performed to ensure bioremediation is not limited (bacteria, nutrients and/or geochemistry). Bench-scale testing is highly recommended to determine accurate amendment dosing and/or bioaugmentation requirements. However, microcosm tests may require several months to complete. Due to time restrictions for the completing the remedial application, microcosm bench testing may not be feasible. • Plume Delineation: Additional site investigation is recommended to define the horizontal and vertical extents of the COC groundwater plume, to potentially reduce the treatment area/volume and overall cost. • Pilot Testing: Pilot testing is typically recommended to develop full-scale design parameters (such as radius of influence for well spacing and optimal amendment dosing) and to evaluate ISB amendment distribution and treatment effectiveness. However, due to time restrictions for completing the remedial application and the slow treatment timeframe of ISB, pilot testing may not be feasible.	• Bench Testing: Bench-scale testing is highly recommended to determine accurate ZVI dosing requirements. • Plume Delineation: Additional site investigation is recommended to define the horizontal and vertical extents of the COC groundwater plume, to potentially reduce the treatment area/volume and overall cost. • Pilot Testing: Pilot testing is typically recommended to develop full-scale design parameters (such as radius of influence for well spacing and optimal amendment dosing) and to evaluate amendment distribution and treatment effectiveness. However, due to time restrictions for completing the remedial application and the potential slow treatment timeframe of ZVI, pilot testing may not be feasible.

Table 1
Remedial Option Summary
Former Coyne Textile Facility
Syracuse, New York

REMEDIAL OPTION	TECHNOLOGY			
	SOURCE AREA TREATMENT	PLUME TREATEMENT		
Technology	**In Situ Chemical Oxidation (ISCO) - Soil Mixing**	**In Situ Chemical Oxidation (ISCO) - Groundwater Recirculation**	**Enhanced In Situ Bioremediation (EISB)**	**Zero Valent Iron (ZVI) Injection**
Cost	**$170,000 - $980,000**	**$660,000 - $1,040,000**	**$370,000 - $440,000**	**$280,000 - $370,000**
Remedy Cost Per Cubic Yard	**$115 - $340 /yd^3**	**$190 - $120 /yd^3**	**$70 - $80 /yd^3**	**$50 - $67 /yd^3**
Assumptions	• Includes capital costs for one ISCO soil mixing application. • Assumes a target Source Treatment Area of 6,000 square feet (ft^2) ○ Includes the soil below the excavated area (500 ft^2) with an 8-foot treatment interval from approximately 8 - 16 feet below ground surface (bgs) (4,000 cubic feet [ft^3]). ○ Includes approximately 5,500 ft^2 of soils outside of the excavated area, with a target treatment interval from surface to approximately 16 feet bgs (88,000 ft^3). ○ Total Treatment Volume = 92,000 ft^3 • Assuming a soil mixing productivity rate of 3,500 ft^3 per day, approximately 27 days is required to complete the ISCO soil mixing application. • Source area delineation is recommended to refine treatment area (lateral and vertical). • Costs assume a range of oxidant mass required based on a potential range of non-target demand in source area soils and size of source treatment area. Bench testing and source area delineation are recommended to refine oxidant costs.	• Includes capital costs for one ISCO application. • Assumes a treatment area of approximately 30,000 ft^2. • Based on a 15-foot injection / extraction radius of influence (ROI), 21 injection wells and 22 extraction wells are required to treat the 30,000-ft^2 downgradient groundwater plume. Additional investigation is recommended to refine the treatment area, potentially reducing the treatment volume and the number of wells to be installed. Pilot testing is also recommended to determine injection and extraction ROIs (for well number and spacing). • Assuming a conservative injection flow rate for higher-permeability soils (2.0 gpm per well), approximately 35 days of injection is required to complete the ISCO application. Pilot testing is recommended to determine injection and extraction rates. • Costs assume a range of oxidant mass required based on a potential range of non-target demand in downgradient groundwater and soil. Bench testing is recommended to refine oxidant costs.	• Includes capital costs for 1 ISB application. Likely requires multiple applications (each additional application approximately $175K - $250K) • Assumes a treatment area of approximately 30,000 ft^2. • Based on a 10-foot injection ROI, 90 injection wells are required to treat the 30,000-ft^2 downgradient groundwater plume. Additional investigation is recommended to refine the treatment area, potentially reducing the treatment volume and the number of wells to be installed. • Assuming a conservative injection flow rate for higher-permeability soils (2.0 gpm per well), approximately 17 days of injection is required to complete the ISB application. • Cost range based on range of injection flow rates/ duration of the ISB application.	• Includes capital costs for 1 ZVI application. May require additional applications (each additional application approximately $240K - $320K). • Assumes a treatment area of approximately 30,000 ft^2. • Based on a 10-foot injection ROI, 90 direct injection points are required to treat the 30,000-ft^2 downgradient groundwater plume. Additional investigation is recommended to refine the treatment area, potentially reducing the number injection points. • Assuming a slurry injection flow rate for higher-permeability soils of 2.5 gpm per point, and assuming 2 drill rigs are operating simultaneously for the duration of the application, approximately 40 days of injection is required to complete the ZVI application. • Costs assume a range of ZVI mass required and a range of achievable injection flow rates/ duration of the application. Bench testing is recommended to refine ZVI costs
Additional Costs				
Treatment Area Delineation	• **$40,000**	• **$52,000**	• **$60,000**	• **$60,000**
Bench Study	• **$15,000 - $20,000** Cost based on specific scope of testing	• **$15,000 - $20,000** Cost based on specific scope of testing	• **$20,000 - $25,000** Cost based on specific scope of testing	• **$15,000 - $20,000** Cost based on specific scope of testing
Pilot Testing	• **NA**	• **$60,000 - $70,000** ○ Cost range based on potential range of injection/extraction flow rates. ○ Cost includes the installation of 3 injection wells and 6 extraction wells. These wells would be used for a full-scale application, reducing well installation costs for the full-scale application.	• **NA**	• **NA**
Monitoring	• **$38,000** ○ Baseline and 2 post-ISCO groundwater performance monitoring events. ○ 1 post-ISCO soil performance monitoring event. ○ Does not include regulatory groundwater monitoring.	• **$23,000** ○ Baseline and 2 post-ISCO groundwater performance monitoring events. ○ Does not include regulatory groundwater monitoring.	• **$45,000** ○ Baseline and 2 post-ISB groundwater performance monitoring events (analytical costs include MNA parameters). ○ Does not include regulatory groundwater monitoring.	• **$45,000** ○ Baseline and 2 post-treatment groundwater performance monitoring events (analytical costs include MNA parameters). ○ Does not include regulatory groundwater monitoring.
Total Potential Remedy Cost	**$270,000 - $1,080,000**	**$820,000 - 1,200,000**	**$675,000 - $860,000**	**$390,000 - $480,000**

XDD ENVIRONMENTAL

CHA