IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY WORK PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
2375 Cabot Drive
Lisle, Illinois 60532

Prepared by:

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Amec Foster Wheeler Project 6252-16-2012

November 7, 2017

November 7, 2017

amec foster wheeler

Mr. Craig Zeller, P.E.
Superfund Remedial and Site Evaluation Branch
U.S. Environmental Protection Agency
61 Forsyth Street, S.W.
Atlanta, Georgia 30303-8960
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Subject: **ISCO Treatability Study Work Plan**
CTS of Asheville, Inc. Superfund Site
235 Mills Gap Road, Asheville, Buncombe County, North Carolina
Amec Foster Wheeler Project 6252-16-2012
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Dear Mr. Zeller:

Please find attached the In-situ Chemical Oxidation (ISCO) Treatability Study Work Plan (TSWP) for the above-referenced Site. Amec Foster Wheeler Environment & Infrastructure, Inc. prepared this TSWP on behalf of CTS Corporation to comply with the Consent Decree for Interim Remedial Design/Remedial Action at the CTS of Asheville, Inc. Superfund Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation (entered on March 7, 2017).

If you have questions regarding this TSWP, please contact us at (828) 252-8130.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure, Inc.

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ACRONYMS

bgs	below ground surface
cis-1,2-DCE	cis-1,2-dichloroethene
CD	Consent Decree
DHS	Department of Homeland Security
ECD	electron capture device
ERH	electrical resistance heating
FSAP	Field Sampling and Analysis Plan
g/kg	grams per kilogram
HASP	Health and Safety Plan
IDW	investigative derived waste
ISCO	in-situ chemical oxidation
MIP	membrane interface probe
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
NAPL	non-aqueous phase liquid
NCDEQ	North Carolina Department of Environmental Quality
NOI	Notice of Intent
PNOD	permanganate natural oxidant demand
PDI	Pre-design Investigation
psi	pounds per square inch
PWR	partially weathered rock
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
RDWP	Remedial Design Work Plan
TCE	trichloroethene (also, trichloroethylene)
TSWP	Treatability Study Work Plan
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DOCUMENT REVISION LOG

Revision	Date	Description
0	11/07/2017	Initial Issuance

1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) prepared this In-Situ Chemical Oxidation (ISCO) Treatability Study Work Plan (TSWP) for the CTS of Asheville, Inc. Superfund Site (Site). The activities described in this TSWP will be performed to comply with Paragraph 3.4 of the Statement of Work to the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation.

1.1 SITE DESCRIPTION

The approximate center of the Site is located at north latitude 35°29’36” and west longitude 82°30’25” (Figure 1). The Site formerly contained an approximate 95,000-square foot, single-story brick and metal structure on the southern portion of the Site. The building was demolished in December 2011 and the concrete building pad remains intact. The northeastern portion of the Site contains an asphalt-paved parking area, and asphalt-paved driveways are located parallel to the north (front) of the building pad and southeast (rear) of the building pad. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road. The Site is unoccupied. The Site and adjacent property boundaries are illustrated on Figure 2.

1.2 BACKGROUND

Previous investigations have identified a dissolved-phase volatile organic compound (VOC) groundwater plume in the Northern Area of the Site, with trichloroethene (TCE) being the primary contaminant. ISCO using emplaced potassium permanganate will be implemented in the Northern Area to reduce TCE concentrations in groundwater. The remedial action objective (RAO) is to reduce TCE concentrations in groundwater in the Northern Area by 95 percent.

A Pre-design Investigation (PDI) was performed in May and June 2017 to collect additional information regarding the vertical and horizontal extent of contamination in the Northern Area. Data regarding the permanganate natural oxidant demand (PNOD) of the subsurface materials was also collected. These data were used to develop this TSWP and will also be used in the full-scale ISCO Remedial Design.

1.3 BASIS OF ISCO REMEDIATION

Potassium permanganate will be hydraulically emplaced in the subsurface as a slurry of granular potassium permanganate, water, and a carrier fluid creating a sheet-like sub-horizontal disc in the subsurface. Due to the concentration gradient between the potassium permanganate and surrounding groundwater, the potassium permanganate will diffuse over time into the groundwater surrounding the emplacement. In addition, the potassium permanganate emplacement will be more permeable than the surrounding formation, so groundwater will preferentially flow through the emplacement. Contaminants in groundwater that migrate through the zone of solid potassium permanganate are then oxidized (i.e. destroyed). Also, the potassium permanganate dissolves into the groundwater in the surrounding formation and, via advection and dispersion, creates an "oxidative zone" that oxidizes contaminants in this zone. The potassium permanganate will continue to oxidize VOCs until the oxidative capacity is exhausted.

1.4 ISCO TREATABILITY STUDY OBJECTIVES

The objective of the Treatability Study is to collect information to determine if the proposed remedial action is effective to meet the RAO and, if so, to develop the full scale remedial action design. The objectives of the Treatability Study include:

- Evaluate the distribution of the emplaced potassium permanganate.
- Evaluate the diffusive zone created from the emplaced potassium permanganate.
- Evaluate TCE concentrations downgradient of the emplacements.
- Collect/interpret data for implementation of the full-scale ISCO remedial design.

2.0 NORTHERN AREA CONCEPTUAL SITE MODEL

The following Conceptual Site Model is based on data collected to date related to the overburden formation in the Northern Area of the Site.

2.1 SITE PHYSICAL SETTING

The area surrounding the Site is considered rural and contains residential and light commercial properties. The Site is situated on a topographic “saddle” between two prominent mountains - Busbee Mountain to the north and Brown Mountain to the south and southwest. Properties northwest and southeast are topographically downgradient of the Site. The majority of the Site is relatively flat and natural surface drainage at the Site is to the northwest. The surrounding area contains mountains and rolling hills, typical of the eastern flank of the Appalachian Mountain range.

2.2 GEOLOGY

Fill material and residual soil (overburden) have been identified in the Northern Area of the Site. Fill material, consisting of loose silty sand with gravel, has been observed to a depth of approximately 20 feet below ground surface (bgs) in the northwestern portion of the Site where two apparent natural intermittent surface water drainage channels were historically backfilled for development/grading. Overburden is located below the fill material, where present, and has been observed to a maximum depth of approximately 81 feet bgs (monitoring well MW-6A) in the Northern Area of the Site, where the apparent top of bedrock is encountered.

The uppermost zone of overburden generally consists of fine to medium sand with 10 to 15 percent silt. The overburden “fabric” ranges from massive (i.e., no apparent geologic structure) to strongly foliated. Foliated zones were observed to be approximately horizontal to steeply dipping. Quartz veins ranging in thickness from less than 0.5 inches to approximately 12 inches, and consisting of sand to gravel-sized fragments, have been observed in the overburden. The partially weathered rock (PWR), which is a zone of less weathered rock than the shallower overburden, has been observed to be approximately 15 feet thick in the Northern Area and typically consists of fine to coarse sand with minor amounts of silt and gravel-sized rock fragments. The fabric of the PWR is similar to the overburden fabric (MACTEC, 2009).

The depth to bedrock in the Northern Area ranges from approximately 70 feet bgs to approximately 81 feet bgs, based on the depth to drilling refusal using rotary/roller cone drilling equipment (MACTEC, 2009).

2.3 HYDROGEOLOGY

A generally north to south trending groundwater divide is present in the overburden in the north-central portion of the Site. As previously discussed, the Site is located on a topographic saddle between mountains to the north and south. A portion of groundwater that is flowing from each mountain (i.e., from a higher elevation) is presumed to be toward the saddle. Therefore, a groundwater divide has developed where groundwater in the overburden flows from the mountains and turns east or west to respective discharge zones. The position and shape of the groundwater divide likely changes in response to precipitation/infiltration.

The direction of shallow groundwater flow (water table) and groundwater flow in the PWR zone are similar. Groundwater flow in the southern portion of the Site appears to flow radially, to the north and east. From the north/central portion of the Site, groundwater flows northwest and east/southeast toward the respective groundwater discharge zones.

In May 2017, the depth to the water table in the Northern Area ranged from approximately 19 to 34 feet bgs in monitoring wells MW-7 and MW-6, respectively. Considering the depth to the water table and the depth to bedrock, the aquifer thickness ranges from approximately 30 to 60 feet.

Based on depth to water measurements collected in 2015, the horizontal hydraulic gradient in the shallow overburden from the source area to the Northern Area is approximately 0.031. The horizontal hydraulic gradient in the shallow overburden in the Northern Area of the Site toward the discharge zone east of the Site is approximately 0.066 and the horizontal gradient from Northern Area of the Site toward the discharge zone west of the Site is approximately 0.015 (Amec Foster Wheeler, 2015a).

The horizontal hydraulic gradient in the PWR from the source area to the Northern Area is approximately 0.018. The horizontal hydraulic gradient in the PWR from the Northern Area of the Site toward the discharge zone east of the Site is approximately 0.063 and the horizontal gradient from the Site toward the spring west of the Site is approximately 0.014 (Amec Foster Wheeler, 2015a).

Upward and downward vertical hydraulic gradients were measured in the Northern Area between proximal overburden shallow and PWR monitoring wells, based on the May 2017 monitoring event. An upward gradient (-0.067) was measured at the MW-6/6A well pair and a relatively small upward vertical gradient (-0.005) was measured at the MW-7/7A well pair.

Groundwater elevations have fluctuated since monitoring wells were installed in 2009. From 2009 to 2013, groundwater elevations in the Northern Area increased 10.8 feet and 12.5 feet at monitoring wells MW-7A and MW-6A, respectively. This period represents a transition from generally drought conditions to above-average rainfall conditions. Groundwater elevation increases in the shallow (water table) monitoring wells were similar during this period (i.e., 11.1 feet at MW-7 and 11.2 feet at MW-6). From 2013 to 2017, groundwater elevations decreased approximately 7 to 8 feet in the Northern Area.

The groundwater seepage velocity (v) is calculated as:

$v = ki/n_e$, where
k = hydraulic conductivity
i= hydraulic gradient
n_e = effective porosity

Based on the average hydraulic conductivity of 2.3×10^{-4} cm/sec determined by slug testing conducted for the non-aqueous phase liquid (NAPL) Area FFS Report (Amec Foster Wheeler, 2015a) and an assumed effective porosity of 0.25, the groundwater seepage velocity from the Northern Area (monitoring well pairs MW-6/6A and 7/7A) ranges from 13 feet per year to the western discharge zone, to 63 feet per year to the eastern discharge zone.

2.4 NATURE AND EXTENT OF CONTAMINATION

As determined from previous investigations, and confirmed during the 2013/2014 NAPL Investigation, the contamination source area is located below the south-central portion of the former building and extends to the immediate south. The nature of the chlorinated VOC contamination, whether from pure product or from a mixed material/liquid containing a portion of chlorinated VOCs, is unknown. The primary release mechanism(s) associated with the chlorinated VOC contamination at the Site is also unknown.

The petroleum contamination identified in the source area at the Site consists primarily of fuel oil. The primary release mechanism(s) associated with the petroleum contamination observed at the Site is unknown; however, the petroleum is suspected of originating from an aboveground fuel oil storage tank formerly used to store and supply fuel oil to the facility's boiler.

Based on results from the NAPL Investigation, a significant portion of TCE has partitioned into (i.e., dissolved into) the petroleum NAPL. Based on geochemical parameters, primarily the octanol-water coefficient, TCE will more readily partition into the petroleum NAPL than dissolve into groundwater; however, via equilibrium conditions, the TCE will dissolve into groundwater over time (Amec, 2014). Therefore, the petroleum NAPL acts as the primary source to the dissolved-phase groundwater plume, which extends north from the north lobe of the NAPL zone, and east from the east lobe of the NAPL zone. From the Northern Area of the Site, the dissolved-phase groundwater plume extends east and west to discharge zones. Based on previous investigations, there is no evidence of NAPL (either light or dense) in the overburden in the Northern Area of the Site.

2.4.1 Unsaturated Soil

Unsaturated soil samples collected to date from the overburden in the Northern Area do not indicate a source of soil contamination that contributes to the contaminated groundwater plume in the Northern Area. For instance, four unsaturated soil samples collected by USEPA contractors in late 2007/early 2008 did not indicate the presence of Site-related VOCs in the Northern Area of the Site (TNA, 2008). Also, an unsaturated soil sample collected from the MW-6 soil boring in September 2008 did not indicate Site-related VOCs (MACTEC, 2009).

In 2010, the facility's sanitary sewer line was located and unsaturated soil samples were collected within approximately two feet below the identified sewer line, which extends from the eastern portion of the former building to Mills Gap Road. Five unsaturated soil samples (SS-126 through SS-130) were collected below the sewer line in the Northern Area and minor concentrations of TCE were reported in two of the samples (e.g., 5.4 and 8.1 micrograms per kilogram in SS-127 and SS-128, respectively; MACTEC, 2010).

During the 2013/2014 NAPL Investigation, elevated ECD responses indicating the presence of chlorinated VOCs were not observed in the unsaturated soil (Amec, 2014).

2.4.2 Groundwater

The dissolved-phase chlorinated VOC plume in overburden, primarily consisting of TCE, extends from the source NAPL Area to the Northern Area and then east and west toward groundwater discharge zones. Based on data collected during the NAPL Investigation (Amec, 2014) and the Western Area Remedial Investigation (Amec Foster Wheeler, 2015b), the Northern Area dissolved-phase chlorinated VOC groundwater plume likely does not extend north of Mills Gap Road.

TCE is the primary chlorinated VOC present in groundwater in the Northern Area. Minor concentrations of chlorinated VOC degradation products, such as 1,2-cis-dichloroethene (cis-1,2-DCE), have been detected in groundwater samples collected from the Northern Area. The lack of elevated concentrations of degradation products indicates that natural biodegradation does not appear to be readily occurring in the Northern Area.

The pH of groundwater in the Northern Area is generally between 5 and 6. Furthermore, the aquifer is mildly aerobic (i.e., dissolved oxygen generally between 1 and 4 milligrams per liter) and reducing conditions are not present (i.e., oxidation reduction potential generally in the 100 to 300 millivolt range). These aquifer conditions could be factors limiting the ability of microbes to anaerobically biodegrade TCE to cis-1,2-DCE.

Concentrations of TCE vary horizontally and vertically in the Northern Area (from tens of micrograms per liter [µg/L] to tens of thousands µg/L). Based on TCE concentrations in collected groundwater samples and ECD responses measured during the NAPL Investigation and the ISCO PDI, chlorinated VOC concentrations generally increased with depth (Note: the ECD probe did not advance to the depth of bedrock due to limitations of the drilling equipment; the ECD probe generally advanced to a depth of approximately 40 to 50 feet bgs). Nearest the source area, VOC concentrations increased rapidly at the water table. However, farther away from the source area, VOC concentrations began to increase 5 to 20 feet below the water table. For example, at MIP-80 near the source area, the water table is estimated to be at 19 feet bgs, and the ECD response immediately increased to a maximum reading just below this depth. Conversely, at MIP-100 in the downgradient plume area, the water table is at approximately 20 feet bgs, but the ECD responses began to increase at approximately 35 feet bgs and maximum readings were not obtained until a depth of approximately 42 feet bgs.

In the southwestern area of the investigation, VOC concentrations began to decrease after a zone of elevated readings. For example, at MIP-105, ECD responses increased at approximately 30 feet bgs, but began to decline at approximately 45 feet bgs. Two drainage swales formed by intermittent streams were formerly located in this area of the Site, indicating that there was at one time an upward gradient and discharge zone. This ‘upwelling’ could be inhibiting the downward migration of groundwater containing VOCs in this area.

Based on the results of the NAPL Investigation, an area generally to the east and northeast of the former building was identified where groundwater was not highly contaminated (i.e. outside of the dissolved-phase TCE plume core). However, data collected for the ISCO PDI identified elevated TCE concentrations in this area deeper than during the NAPL Investigation. For example, MHP-11 was advanced in this area during the NAPL Investigation to a refusal depth of approximately 42 feet bgs, and a groundwater sample collected at 42 feet bgs indicated a TCE concentration of 419 µg/L. During advancement of MIP-102 and MIP-103 in this area for the ISCO PDI, ECD responses began to increase at 40 feet bgs and maximum responses were measured at 45 to 48 feet bgs. A groundwater sample collected at 52 feet bgs at MIP-102 indicated a TCE concentration of 17,800 µg/L.

Petroleum constituents have not been detected at elevated concentrations in groundwater samples collected in the Northern Area of the Site. Relatively minor concentrations of petroleum constituents (i.e., compared to reported TCE concentrations) were detected in soil and groundwater samples from nearest the NAPL source area. In general, the petroleum constituents that have been detected/estimated are ring-structured hydrocarbons (e.g., benzene, toluene, and xylenes) which more readily dissolve into groundwater from a petroleum fuel source, such as the petroleum NAPL in the source area. Petroleum constituents in groundwater in the Northern Area are not considered to contribute significant mass to the overall contaminated groundwater plume.

2.5 PERMANGANATE NATURAL OXIDANT DEMAND

In addition to the contaminants present in the area to be treated, the subsurface formation contains organic and inorganic materials that will be oxidized by the chemical oxidant (potassium permanganate). This natural oxidant demand will consume some portion of the injected oxidant. Therefore, the PNOD was measured during the ISCO PDI to determine the magnitude of the PNOD that will potentially be consumed by the potassium permanganate, in conjunction with the contaminants present in the groundwater.

PNOD samples were collected from the saturated zone in the ISCO treatment area. Each soil sample was analyzed in triplicate. The average PNOD results for each sample ranged from 0.9 grams per kilogram (g/kg) to 2.2 g/kg (Amec Foster Wheeler, 2017). The results indicate that the PNOD does not vary greatly in the Northern Area and is relatively low.

2.6 FATE AND TRANSPORT

The fate and transport of contaminants in soil and groundwater is influenced by numerous factors, including the primary and secondary release mechanisms; the physical and chemical properties of the constituents that were released; and the characteristics of the subsurface medium through which the contaminants migrate.

2.6.1 Contaminants of Concern

The primary contaminant of concern for the Northern Area is TCE.

2.6.2 Contaminant Transport Pathways

The primary transport pathway for contamination in the overburden in the Northern Area is via groundwater. The unsaturated soil pathway, where contaminants leach from the soil to the underlying groundwater, is not considered a transport pathway, as evidence of contamination in the unsaturated soil has not been identified in the Northern Area. The dissolved-phase groundwater plume in the Northern Area discharges at surface water features east and west of the Site resulting in an airborne contaminant pathway via volatilization of VOCs, as well as a surface water contaminant transport pathway.

2.6.3 Mass Distribution

The NAPL source area at the Site contains the largest mass of contaminants. The downgradient dissolved-phase plume contains chlorinated VOC degradation compounds and minor concentrations of petroleum constituents. Groundwater in the Northern Area contains concentrations of TCE ranging from hundreds µg/L to tens of thousands µg/L. As previously described, concentrations of TCE vary horizontally and vertically in groundwater in the Northern Area.

3.0 SCOPE OF WORK

The ISCO Treatability Study will be conducted to collect data for the full-scale remedial design.

3.1 MOBILIZATION ACTIVITIES

The following mobilization activities will be conducted.

3.1.1 Underground Injection Permit

Injection/emplacement of chemicals into the subsurface for groundwater remediation is regulated by the North Carolina Department of Environmental Quality (NCDEQ) and is permitted in accordance with 15A NCAC 02C .0217. Injection activities associated with a pilot, or treatability, study, are permitted by rule and an injection permit is not required. However, NCDEQ requires that a Notification of Intent (NOI) to Construct or Operate Injection Wells be completed and submitted at least two weeks prior to the injection activities. Although an underground injection permit is not required under the Comprehensive Environmental Response, Compensation, and Liability Act, NCDEQ has requested that it be notified of injection activities for tracking/recordkeeping purposes, so the NOI will be completed and submitted as requested.

3.1.2 Mobilization, Staging, and Materials Management

FRx, Inc., an environmental injection contractor, will mobilize equipment and materials for the emplacement activities is described in Section 3.4.3. Granular research-grade potassium permanganate, which is marketed as RemOx® S by Carus Corporation, will be delivered in 2,000-pound weather-proof 'super sacks' and will be stored on wooden pallets and covered in the vicinity of the Treatability Study area. In the event of a release of potassium permanganate to the ground surface, the material will be promptly swept, vacuumed or shoveled up and placed back in a super sack. Remnants will be neutralized in place with either sodium thiosulfate pentahydrate, or a mixture of equal parts of vinegar, peroxide, and water. The resulting manganese dioxide is a common, non-hazardous material which can be disposed in a municipal landfill. Bentonite will be delivered in 50-pound bags and will be stored in an enclosed trailer. The equipment and materials for the Treatability Study will be stored in a secure manner at the Site to protect property and the public.

Potassium permanganate in quantities exceeding the screening threshold quantity of 400 pounds is regulated by the Department of Homeland Security (DHS) Chemical Facility Anti-Terrorism Standards. According to the regulation, a property owner coming into possession of a chemical of interest, such as potassium permanganate, must, within 60 days, submit a Top-Screen survey to DHS. Upon receipt of the potassium permanganate at the Site, a Top-Screen survey will be completed and submitted to DHS.

3.1.3 Health and Safety

A Site Health and Safety Plan (HASP) has been developed and submitted to the USEPA for Site activities, which are applicable to the Treatability Study. The HASP applies to Amec Foster Wheeler employees and Amec Foster Wheeler subcontractors only. Field teams will have a copy of the HASP during field activities. Personnel working at the Site during the ISCO Treatability Study will be required to read, understand, and conform to the requirements of the HASP. A daily safety meeting will be conducted to review the daily work activities and associated hazards.

3.2 TREATABILITY STUDY LOCATION

The Treatability Study will be conducted in the north-central area of the Site within the Northern Area. This location was selected for the following reasons:

- The Treatability Study area is located downgradient of the electrical resistance heating (ERH) remediation area, such that ERH activities are not expected to influence TCE groundwater concentrations that ‘enter’ the treatment area during the evaluation period.
- The Treatability Study area is located in the vicinity of a groundwater divide, where groundwater flow diverges and flows to the east and west. The greatest certainty of the direction of groundwater flow is in the Treatability Study area; therefore, there is greater likelihood that performance monitoring wells can be positioned to provide representative data regarding the effectiveness of the ISCO treatment.
- The Treatability Study area is located outside of where construction activities for the ERH remediation will be on-going.
- Existing monitoring wells MW-7 and MW-7A with historical groundwater concentration data are located in the Treatability Study area.

The locations of the emplacement wells and proposed monitoring wells will be staked in the field using existing surveyed Site features. The emplacement wells and monitoring wells will be surveyed after installation, as described in Section 3.5.

3.3 MONITORING WELL INSTALLATION AND BASELINE SAMPLING

Monitoring wells will be installed upgradient and downgradient of the ISCO emplacements to monitor VOC concentrations and geochemical parameters during performance of the Treatability Study. Monitoring wells will be installed in pairs, with one shallow and one deep well per location. Based on the analytical results of groundwater samples and direct sensing data collected in this area of the Site in overburden, the treatment zone extends from approximately 30 feet bgs to the base of the overburden. At nearby monitoring well MW-7A, the base of the overburden (i.e., also top of apparent bedrock) was encountered at 72 feet bgs. The locations of the proposed monitoring wells are depicted in Figure 3 and summarized in the table below.

Table: Proposed Monitoring Wells

Monitoring Well	Depth Interval (feet bgs)
MW-19	40 – 45
MW-19A	60 – 65
MW-20	45 – 50
MW-20A	60 – 65
MW-21	40 – 45
MW-21A	55 – 60
MW-22	50 – 55
MW-22A	65 – 70

An approximate eight-inch diameter borehole will be advanced using nominal 4.25-inch inner diameter hollow stem augers. The borings will be advanced to the target depth and a Type II monitoring well will be installed. A two-inch diameter Schedule 40 polyvinyl chloride (PVC) riser pipe and two-inch diameter, five-foot long, Schedule 40 PVC 0.010-inch slotted screen will be installed in each of the borings. The annulus of each well will be filled with filter sand and topped with a bentonite seal and grout in accordance with North Carolina Well Construction Standards.

The wells will be completed with a flush-mount wellhead and will be equipped with a locking well cap. An approximate four square-foot concrete pad will be placed around each wellhead in a manner that precludes surface runoff towards the well. Permanent well identification labels that include well construction details will be placed inside the wellheads.

Monitoring well grout seals will be allowed to cure for at least 24 hours prior to well development. Wells will be developed by the pump and surge method using a submersible pump. Water quality parameters (pH, temperature and conductivity) will be monitored during development. Each well will be developed until the development water is relatively clear of silt and sand particles, or until the water quality parameters have stabilized, whichever occurs first.

Prior to initiation of the Treatability Study emplacement installation activities, groundwater samples will be collected from the newly-installed monitoring wells, as well as from monitoring wells MW-7 and MW-7A. Groundwater samples will be collected from the monitoring wells using low-flow purging/sampling techniques, as described in the Remedial Design Work Plan (RDWP) Field Sampling and Analysis Plan (FSAP). Water quality parameters (pH, temperature, conductivity, oxidation reduction potential and dissolved oxygen) will be monitored during purging. The groundwater samples will be collected for analysis of Site-specific VOCs (TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) via USEPA Method 8260. QA/QC procedures will be implemented in accordance with the RDWP Quality Assurance Project Plan (QAPP); however, the groundwater samples will be submitted for a Level 2 data package.

3.4 EMPLACEMENT INSTALLATIONS

Three emplacement locations are proposed. Seven emplacements are proposed for each location, at an approximate 6-foot vertical interval from approximately 35 to 71 feet bgs, as described below. The emplacements are anticipated to have a radius of approximately 15 to 20 feet.

3.4.1 Emplacement Well Installation

The three emplacement well borings will be advanced using a sonic drill rig and an 8-inch nominal diameter casing bit shoe. Soil cores will be collected on a continuous basis from the surface to the total depth and logged by a field geologist. Care will be taken not to over-ream the boreholes as this increases the thickness of the grout seal in the annular space which must later be breached to allow fracture initiation, propagation, and substrate jetting. The boreholes will be extended until apparent bedrock is encountered.

The emplacement wells will consist of a solid (un-screened) 4-inch diameter, schedule 40, PVC flush threaded casing. Centralizers will be installed at approximately a 15-foot spacing in the annulus of the borehole.

The surrounding approximate 2-inch annular space between the casing and soil will be pressure grouted from the bottom of the borehole to ground surface using a tremie pipe and grout pump. The grout development will be completed using Type I Portland cement with less than three percent powdered bentonite. The emplacement wells will be completed flush with ground surface and be equipped with a locking cap.

3.4.2 Emplacement Installation Overview

The emplacement process occurs in two steps. First, a high velocity water jet is used to cut the PVC casing/grout and create a kerf, or notch, in the surrounding formation. Second, the potassium permanganate slurry is mixed and injected into the formation using a positive displacement pump. The potassium permanganate slurry is injected until a proposed amount has been emplaced.

A sufficient amount of materials will be mobilized to the Site to complete an estimated 21 emplacements (seven emplacements at each of the three wells). The table below provides a summary of initial target quantities for water and potassium permanganate requirements. Quantity requirement adjustments will be made in real time during fracture propagation activities, as necessary. Any surplus materials not used during the emplacement event will be removed from the Site at the time of demobilization.

Table: Proposed Emplacement Schedule

Fracture Depth (feet bgs)	Approximate TCE Concentration (μg/L)	Potassium Permanganate (pounds)	Water (gallons)
Emplacement Well 1 (EPW-1)			
35	3,000	500	75
41	10,000	750	100
47	20,000	1,000	100
53	35,000	1,000	100
59	35,000	1,000	100
65	35,000	1,000	100
71	35,000	1,000	100
Emplacement Well 2 (EPW-2)			
38	3,000	500	75
44	10,000	750	100
50	20,000	1,000	100
56	35,000	1,000	100
62	35,000	1,000	100
68	35,000	1,000	100
Emplacement Well 3 (EPW-3)			
35	3,000	500	75
41	10,000	750	100
47	20,000	1,000	100
53	35,000	1,000	100
59	35,000	1,000	100
65	35,000	1,000	100
71	35,000	1,000	100

3.4.3 Equipment

The equipment necessary to create emplacements includes machinery for materials handling, pumping and mixing, and downhole tooling which are described below.

Material handling: An all-terrain forklift will be used to off-load materials at the area of the Treatability Study. A 1,000-gallon polyethylene tank will be used for mixing bentonite and water. Water will be pumped into the tank from the water hydrant on Mills Gap Road adjacent to the Site. Bentonite will be added to the incoming water stream using an in-line mixing device.

Pumping and mixing: FRx has custom equipment to prepare the slurry for the creation of the emplacements. The “rig” is a self-contained system for storing, metering, mixing, and pumping the slurry. Flow rates and pressures will be monitored and recorded in the field. It is anticipated that flow rates and pressures will range from up to 30 gallons per minute and up to 450 pounds per square inch (psi), respectively.

Downhole tooling: Inflatable packers, inflation tubing, a tape measure, 12,500 psi hose, 500 psi slurry hose, cable, and an FRx-manufactured “jet cage” system will be deployed downhole as a single tool. This downhole tool is used to cut the casing/grout, and initiate/propagate the emplacements at the specific depths. Upon completion of an emplacement at each location, the downhole tools will be relocated to the next target location and the process repeated.

3.4.4 Emplacement Sequence of Events

The sequence of events for the emplacements will be as follows:

1. FRx will mobilize to the Site and unload equipment.
2. Materials (potassium permanganate and bentonite) will be received and stored.
3. Water will be provided from water hydrant located adjacent to the Site fence.
4. Downhole tools will be placed, by pump hoist truck, to the target depth (deepest first).
5. The packers will be inflated.
6. The rig will be loaded with emplacement materials and the emplacement slurry will be prepared.
7. The casing/grout will be cut using the high velocity water jetting machine and tooling.
8. The potassium permanganate slurry emplacement will be completed.
9. Downhole tools will be relocated to the next higher target depth in the well and the next emplacement completed.

Steps 3 through 9 will be repeated at the remaining emplacement depths/locations. After completion of the final emplacement, the downhole tooling will be removed and the finished well secured.

3.5 SURVEYING

The locations and elevations of the monitoring wells and emplacement wells will be surveyed by a North Carolina Professional Land Surveyor.

3.6 PERFORMANCE MONITORING

Performance monitoring will be conducted using several methods, as described below.

3.6.1 Groundwater Monitoring

Performance monitoring will be conducted to determine the effectiveness of the emplaced potassium permanganate at reducing TCE concentrations in groundwater. Groundwater samples will be collected from the eight new monitoring wells, MW-7, and MW-7A on a quarterly basis for at least three quarters. Upon completion of the third quarterly sampling event, an evaluation of whether additional monitoring events should be conducted will be performed.

The groundwater samples will be collected using low-flow purging/sampling techniques, as described in the RDWP FSAP. Water quality parameters (pH, temperature, conductivity, oxidation reduction potential, dissolved oxygen and turbidity) will be monitored during purging. The presence of potassium permanganate in the purged groundwater will be measured using a colorimeter. The groundwater samples will be submitted for analysis of Site-specific VOCs (TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) via USEPA Method 8260. QA/QC procedures will be implemented in accordance with the RDWP QAPP; however, the groundwater samples will be submitted for a Level 2 data package and cursory data validation will be conducted.

3.6.2 Emplacement Distribution

Approximately five months after the emplacements have been constructed, the aerial distribution of the emplacements will be investigated. A direct-push technology rig will be used to collect continuous soil samples in the vicinity of the emplacements. Borings will be advanced at various locations surrounding the emplacement wells and the soil will be visually observed to identify potassium permanganate and the diffusive zone vertically above and below an identified emplacement. Up to 15 boring locations are anticipated.

3.7 INVESTIGATION DERIVED WASTE

Investigative derived waste, such as soil cuttings and purged groundwater will be managed in accordance with the RDWP FSAP.

3.8 REPORTING

An ISCO Treatability Study Evaluation Report will be submitted to USEPA within 45 days of receipt of analytical results from the last quarterly sampling event. The Evaluation Report will include a summary of field activities (including operational measurements), a summary of groundwater analytical results, a discussion of the quantity of potassium permanganate emplaced versus proposed, a discussion of the emplacement distribution and potassium permanganate diffusion, and recommendations for design of the full-scale remedial action.

4.0 SCHEDULE

Installation, development and initial sampling of monitoring wells for the Treatability Study is scheduled for December 2017, and installation of the emplacements is scheduled for January 2018, pending USEPA approval of this Work Plan. The first quarterly groundwater sampling event will be conducted approximately three months after the emplacements are constructed. The Treatability Study Evaluation Report will be submitted within 45 days of receipt of analytical results from the last quarterly sampling event.

5.0 REFERENCES

Amec, 2012. NAPL Investigation Work Plan (Revision 1), CTS of Asheville, Inc. Superfund Site, November 9, 2012.

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MACTEC Engineering and Consulting, Inc., 2009. Report of Phase I Remedial Investigation. Mills Gap Road Site, July 27, 2009.

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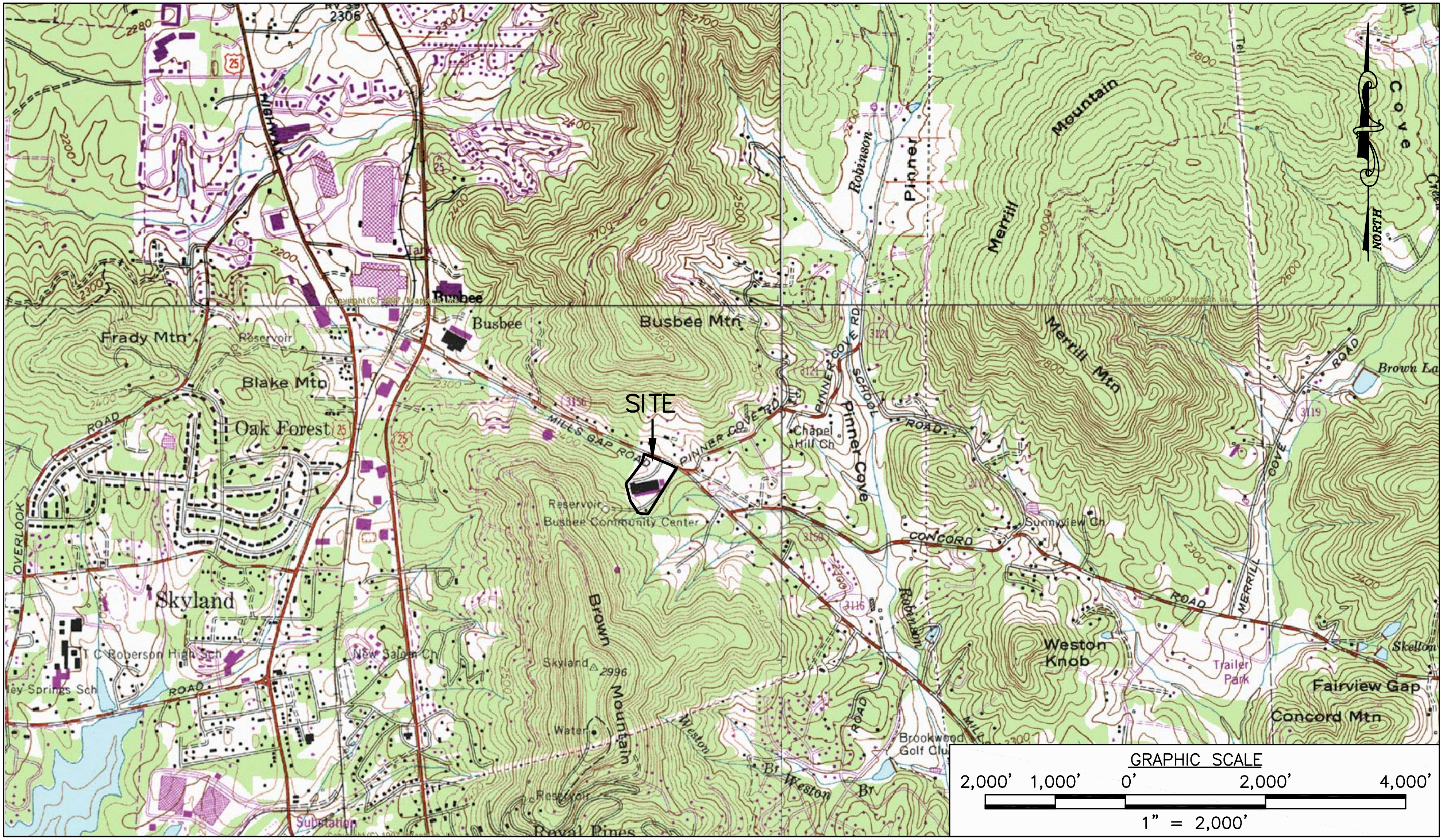
TN & Associates, Inc. (TNA), 2008. Subsurface Soil and Groundwater Sampling Report, Revision 1, April 23, 2008.

FIGURES

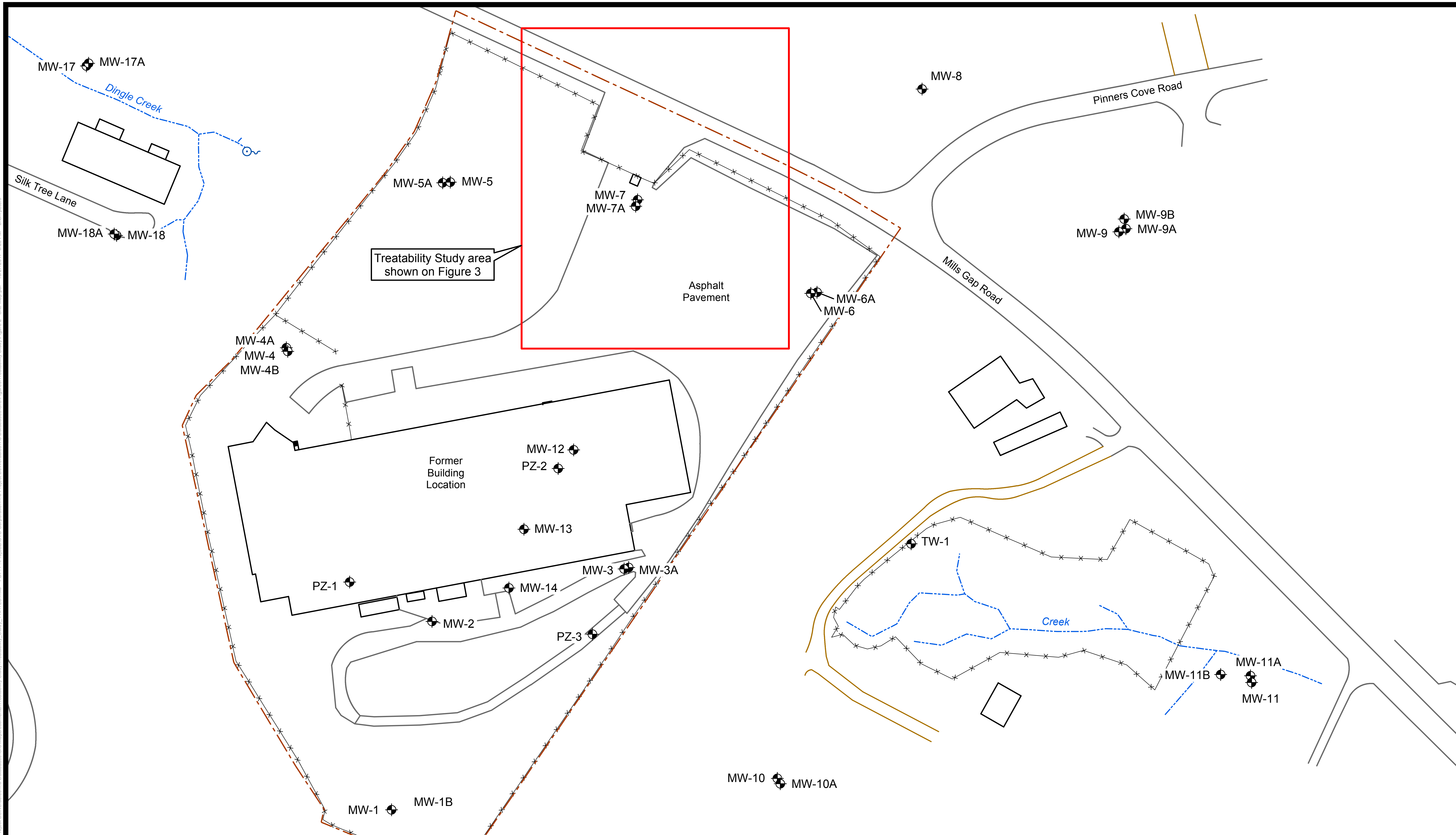


TOPOGRAPHIC SITE MAP
CTS OF ASHEVILLE, INC. SUPERFUND SITE
ASHEVILLE, NORTH CAROLINA

amec foster wheeler

DRAWN: SEK	ENG CHECK: --	DATE: APRIL 2017	PROJECT: 6252162012
DFT CHECK: MEW	APPROVAL: MEW	SCALE: 1" = 2,000'	FIGURE: 1

REFERENCE: USGS QUADRANGLES: ASHEVILLE (1961), OTEEN (1962), FRUITLAND (1978) AND SKYLAND (1978)



Prepared/Date: BRP 10/27/17
Checked/Date: SEA 10/27/17

N
0 50 100 Feet

Legend

Monitoring Well/Piezometer
Spring
Fence
Property Line

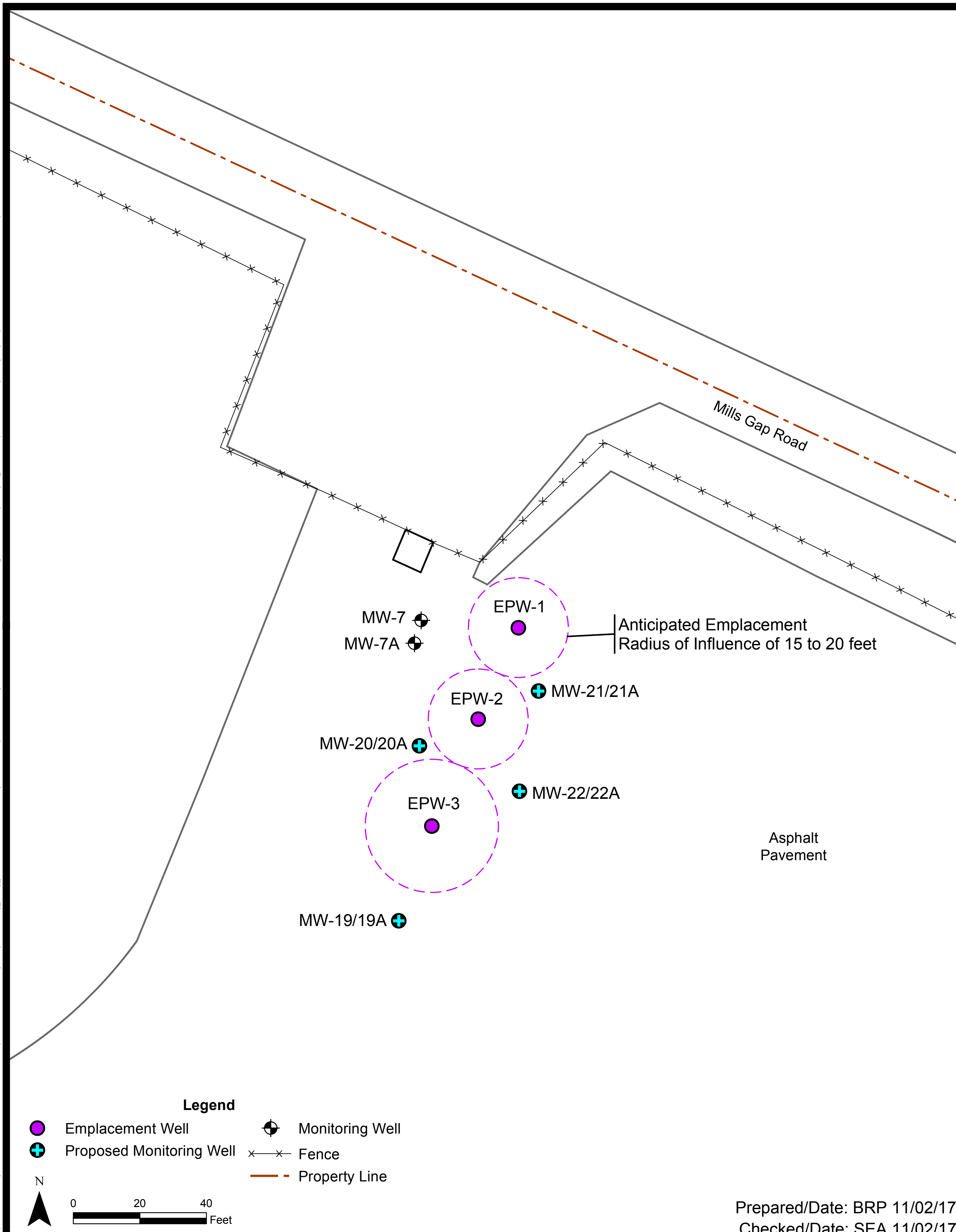
amec foster wheeler

CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Site Map

Project 6252162012

Figure 2



CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

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Proposed Treatability Study Layout

Project 6252162012

Figure 3