FINAL
REMEDIAL DESIGN BASIS REPORT
ERDLE PERFORATING
SITE NO. 828072

WORK ASSIGNMENT NO. D007619-5

Prepared for:

New York State Department of Environmental Conservation
Albany, New York

Prepared by:

MACTEC Engineering and Consulting, P.C.
Portland, Maine

MACTEC: 3612112215

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
cm/sec	centimeter(s) per second
COC	contaminant of concern
CVOCs	chlorinated volatile organic compounds
Erdle	Erdle Perforating
ERH	electrical resistance heating
ft/ft	feet per foot
MACTEC	MACTEC Engineering and Consulting, P.C.
mg/kg	milligram(s) per kilogram
NYSDEC	New York State Department of Environmental Conservation
PCE	tetrachloroethene
POTW	publicly owned treatment waste
RA	Remedial Action
RAOs	Remedial Action Objectives
RD	Remedial Design
Report	Remedial Design Basis Report
RI	remedial investigation
ROD	Record of Decision
RQD	rock quality data
SCGs	Standards, Criteria, and Guidance
Site	Erdle Perforating site
SM	site management

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

TCA	trichloroethane
TCE	trichloroethene
TMP	temperature monitoring point
µg/L	microgram(s) per liter
UST	underground storage tank
VOC	volatile organic compound
WA	work assignment

1.0 INTRODUCTION

MACTEC Engineering and Consulting, P.C. (MACTEC) has prepared this Remedial Design (RD) Basis Report (Report) to summarize the general design methodology/approach and assumptions to be used in developing the RD in accordance with the requirements of the New York State Department of Environmental Conservation (NYSDEC) *Record of Decision* (ROD) (NYSDEC, 2010) for the Erdle Perforating (Erdle) site (Site) in Gates, New York.

The RD is being performed under NYSDEC Work Assignment (WA) Number D007619-5 in accordance with MACTEC's Scope of Work (MACTEC, 2012). The purpose of the WA is to prepare the supplemental design specifications and construction drawings for the remedial action (RA) for the Site in accordance with the NYSDEC-MACTEC Contract, Work Element III of Schedule 1.

1.1 DESIGN APPROACH

MACTEC's Report is an informative description of the development of the specifications for the implementation of the electrical resistance heating (ERH) treatment technology in such a manner as to balance the performance based objectives with adequate detail to hold vendors to an equivalent standard of technical application and performance. In this regard, the design developed will be sufficiently generic to allow bids to be obtained from multiple qualified ERH suppliers, while simultaneously providing sufficiently stringent performance requirements that will enable the cost-effective removal of source area volatile organic compound (VOC) impacts. It is understood that each qualified ERH contractor may have differing technical approaches and methods on technology implementation including electrode construction, electrode spacing, electrical hookup, power feed and distribution, and extraction mechanics. Some aspects of the ERH application may be confidential and proprietary, patented or of trade secret nature. To accommodate variability and equal accountability, terms such as "equivalent", "comparable", and "industry standard" will be incorporated into specifications and drawings where applicable. Additionally, the specifications will require submittals from the ERH contractor that will allow the Engineer and NYSDEC the opportunity to review and approve the contractor's recommended approach prior to implementation. Because the ERH contractors have specialized expertise regarding the ERH technology, MACTEC believes it is in the best interest of NYSDEC not to direct the means and methods for the ERH technology implementation at the site through prescriptive specifications. Performance-based specifications can take advantage of the contractor's expertise and place the responsibility for performance on the contractor, while allowing innovation and operational flexibility that potentially results in more cost-effective remediation, but also holds the contractor to performance requirements that are measureable.

1.2 SITE BACKGROUND AND CHARACTERIZATION SUMMARY

This subsection is a summary of the Erdle site background and characterization, excerpted from the Remedial Investigation (RI) Report (MACTEC, 2010).

Remedial Investigation Summary. The Erdle site is located at 100 Pixley Industrial Parkway in an industrial area in the Town of Gates, Monroe County. The Site is bounded on the south by Conrail railroad tracks and an undeveloped wooden property south of the railroad tracks. A townhouse development (Hidden Valley Development) is located approximately 800 feet south of the Site building.

The Site was developed in 1968 by Erdle for the manufacturing of perforated sheet metal products. Erdle used trichloroethene (TCE) during the manufacturing process to remove excess oils. From the early 1970's to 1987 Erdle collected waste TCE in a 2,000 gallon underground storage tank (UST) located outside the southwestern edge of the Site building prior to its disposal. The UST reportedly leaked spent TCE and thus the TCE UST and approximately 100 cubic yards of contaminated soil were removed in 1987.

Based on data collected during the RI, chlorinated VOCs are present in soils on the south side of the Erdle facility above NYSDEC Standards, Criteria and Guidance (SCGs) for unrestricted use. This contamination appears to be a continuing source of groundwater contamination. Concentrations in the source area shallow groundwater, as well as groundwater downgradient of the Site at MW-8 have remained fairly consistent over at least the past ten years (TCE concentrations detected in groundwater at MW-3, located in the source area, have been fairly consistent since first sampled in 1994, and concentrations of TCE detected in groundwater at MW-8 have also remained fairly consistent since MW-8 was first sampled in 1999). Although groundwater concentrations diminish south of the Site through dispersion, dilution, and biological process, concentrations may have reached a steady state due to the contamination present in soils at the Erdle Perforating property.

Analytical data collected during the 1990's indicated the continued presence of chlorinated VOCs above SCGs for unrestricted use in soils in the vicinity of the historic UST, as well as concentrations of chlorinated VOCs in groundwater above SCGs. Although a dual-phase extraction system reportedly operated for a one year period starting in 1997, the RI conducted by MACTEC indicated that chlorinated VOCs, primarily TCE (maximum detected concentration of 2,200 [milligrams/kilogram] mg/kg), exceeds the SCG for unrestricted use in the vicinity of the historic TCE UST. In addition, the potential presence of TCE as a dense non-aqueous phase liquid was noted in a groundwater sample collected approximately 40 feet south of the historic TCE UST (boring GS/GW-9).

The soils in the source area were noted as consisting primarily of silts and clays, with the two geotechnical samples reporting 72% and 90% passing the # 200 sieve. Bedrock was present at approximately 15 feet below ground surface (bgs). The estimated primary area of soil contamination is approximately 10,820 square feet and extends from approximately three feet bgs to 15 feet bgs.

During the July and September 2008 direct-push soil sampling conducted in the vicinity of the historic TCE UST, 57 soil samples (plus quality control samples) were collected from direct push locations GS-1 through GS-48 (no soil samples were collected from GS-13, GS-38, and GS-42).

The primary contaminant of concern (COC) is TCE and its breakdown products, although tetrachloroethene (PCE) and 1,1,1-trichloroethane (TCA) were also detected above their respective SCGs for unrestricted use. The table below summarizes the chlorinated VOCs detected in source area soils at concentrations above their respective SCG for unrestricted use (acetone, a common laboratory contaminant, was the only other VOC detected above its SCG). Several polyaromatic hydrocarbons were also detected in the source area at concentrations slightly above their respective SCG for unrestricted use; however, they were not considered the primary contaminants during the RI and are therefore not presented in the table below).

Parameter	Criteria (mg/kg)	Maximum Concentration (mg/kg)	# of Detections	# of Exceedances	Total # of Samples
1,1,1-Trichloroethane	0.68	12	5	3	60
1,1-Dichloroethane	0.27	0.89	9	3	60
1,1-Dichloroethene	0.33	0.58	6	2	60
Cis-1,2-Dichloroethene	0.25	120	53	46	60
Tetrachloroethene	1.3	17	10	4	60
trans-1,2-Dichloroethene	0.19	0.25	13	1	60
Trichloroethene	0.47	2200	48	41	60
Vinyl chloride	0.02	8.2	31	31	60

Criteria = Part 375 SCG for unrestricted use (for the above list of VOCs, the unrestricted use SCGs are the same as the protection of groundwater SCGs).

The highest detected concentration of TCE was found at GS/GW-001 (2,200 mg/kg at 5 feet bgs), located within approximately five feet of the historic TCE UST. The TCE has diffused into the soil matrix in the vicinity of and south of the former TCE UST. Based on photoionization detector screening and soil analytical results, a source area of soil contamination above the Part 375 SCG for unrestricted use was defined beneath the Site building in the vicinity of the former TCE UST and south of the Site building. Although TCE was detected above the Part 375 SCG for unrestricted use outside this area, these detections appear to be limited primarily to depths from 8 to 13 feet bgs and may be related more to contaminants in groundwater than contaminants sorbed to the soil matrix.

TCE in groundwater samples collected from monitoring wells was detected at a maximum concentration of 500,000 micrograms per liter (µg/l) in MW-3, which is similar to concentrations detected in this well in 1994. Maximum concentrations of chlorinated VOCs detected downgradient of the source area include TCE at 1,100 µg/l (MW-9D), cis-1,2-DCE at 2000 µg/l (MW-8) and vinyl chloride at 51 µg/l (MW-8). MW-8 and MW-9D are located approximately 450 feet south of the historic TCE UST. Concentrations of chlorinated VOCs in groundwater continue to diminish as groundwater flows further south. Evaluation of monitored natural attenuation (MNA) data indicated there was adequate evidence for anaerobic biodegradation of chlorinated VOCs in wells located at and downgradient of the Erdle property. In addition to biological degradation, dispersion and dilution of the VOCs in the water column also likely contribute to the diminishing concentrations of VOC in groundwater.

A representative cross-section depicting site conditions determined during the RI and its site location are shown in Figures 1.2 and 1.1, respectively.

Chlorinated VOCs were also detected in water samples collected from basement sumps within the Hidden Valley Development. Chlorinated VOCs were not detected in the pore water samples collected along the edge of the drainage ways at the Hidden Valley Development.

Based on an evaluation by the NYSDEC and New York State Department of Health of the soil vapor and indoor air samples collected during the 2007/2008, 2009 and 2010 heating seasons from a total of 21 residences, mitigation systems were recommended for installation in four residences and two other residences were recommended for monitoring. No further action was recommended for the remaining 15 residences.

1.3 SUMMARY OF TREATMENT AREA GEOLOGY, SURFACE WATER HYDROLOGY, AND GROUNDWATER HYDROLOGY

This subsection presents a summary of the treatment area geology, surface water hydrology, and groundwater hydrology excerpted from the RI Report (MACTEC, 2010).

Treatment Area Geology. Overburden in the vicinity of the Site is described as till in boring logs completed by Barren Associates. Soils between the Erdle property and the pond at the Hidden Valley Development are mapped by the Natural Resource Conservation Service as glaciolacustrine, glaciofluvial, or deltaic deposits, specifically: 1) Lamson very fine sandy loam – very poorly drained, 2) Claverack loamy fine sand - moderately well drained, and Cosad loamy fine sand – somewhat poorly drained.

Soil immediately south of the Erdle Perforating building in the vicinity of the historic TCE UST was logged by MACTEC as silts and clays over a till with a fine particle size. The direct push borings were completed to refusal on apparent bedrock and no sand or gravel layer was noted above the presumed bedrock.

Bedrock at the Site is mapped as Lockport Group- limestone/dolostone. Based on geologic information from the gates quarry, located approximately 8000 feet east of the Site, shallow bedrock in the vicinity of the Site likely consists of the Oak Orchard Member or Penfield Member of the Lockport Group, both lower Silurian dolostones. Existing well logs at the Site indicate that shallow bedrock is fractured and water bearing. Borings completed during the RI indicated that bedrock consisted of gray to light gray dolostone/limestone with some light grayish brown layers. The rock was characterized as medium grained with vugs, fossils, and some styolites. Fractures were noted as primarily horizontal and paralleling the apparent bedding plane (due to minimal staining, there was little difference noted between fractures and mechanical breaks along horizontal bedding planes. The rock quality data (RQD) indicated that the rock was fairly competent with calculated RQD values ranging from 83 to 100%.

Surface Water Hydrology. The southern portion of the Site property and land south of the property is fairly low lying, with areas of stagnant water that are not identified on the New York State wetlands inventory. A drainage swale is located along the west side of the Erdle site building and slopes slightly to the south, running under the railroad tracks, through the wooded land and eventually along the western edge of the Hidden Valley Development to a small pond located along the center of the western edge of the development. The swale is approximately 10 feet across and approximately 4 feet deep. Water is present in the swale most of the year (standing water depth varies, but was noted to be only an inch or less in September [extremely dry conditions] and approximately 6-inches to one foot deep in November 2007). Surface water from the western portion of the Erdle property likely drains to this swale.

Groundwater Hydrology. Contaminant flow in groundwater appears to be primarily in the overburden/weathered bedrock interface zone. Overburden groundwater in the treatment area is interpreted to flow southwest towards the drainage swale adjacent to the Site. Bedrock groundwater in the treatment area is interpreted to flow primarily to the south.

Depth to groundwater at the Erdle property was measured at only one to two feet bgs (approximately 554 feet above mean sea level adjacent to the south side of the Erdle building). Based on the shallow depth to groundwater and the shallow depth of the drainage swale, the drainage swale may be acting as a discharge point for shallow groundwater to surface water, although the silt/clay nature of the overburden may be confining/limiting this movement.

Hydraulic conductivity tests (slug tests) were not conducted in the treatment area for either the overburden or bedrock wells during the RI, but were performed at monitoring wells located approximately 120 feet downgradient from the Site. Based on groundwater gradients across and south of the Site, calculated overburden groundwater flow velocities varied from 16 feet/year in MW-14 to 172 feet per year in MW-19, with a geometric mean of 50 feet/year in the four overburden wells for which hydraulic conductivity were calculated. The corresponding hydraulic conductivity values ranged from 0.001 centimeters per second (cm/sec) to 0.012 cm/sec. Based on field observations during groundwater sampling of overburden wells, hydraulic conductivities in the treatment area are expected to be lower than these ranges.

Based on groundwater gradients across and south of the Site, calculated shallow bedrock groundwater flow velocities varied from 371 feet/year in MW-17D to 1826 feet per year in MW-14D, with a geometric mean of 962 feet/year in the five bedrock wells for which hydraulic conductivity was calculated. The corresponding hydraulic conductivity values ranged from 0.002 cm/sec to 0.010 cm/sec.

Calculated vertical gradients for the overburden to bedrock well pairs using January 2008 data were 0.15 feet per foot (ft/ft) at the MW-15 pair and 0.20 ft/ft at the MW-14 pair in the upward direction. The shallow bedrock to deep bedrock vertical gradient was calculated at 0.12 ft/ft at the MW-13D/13DD pair, again in the upward direction. Calculate vertical gradients for several of the overburden to bedrock pairs were in the downward direction, including the MW-17 pair, with a vertical gradient of 0.06 ft/ft in the downward direction and the MW-19 pair, with a slight vertical gradient of 0.02 ft/ft in the downward direction. Vertical gradients, or the measured elevation difference in groundwater head at paired wells, can give an indication of the potential for groundwater flow in a given vertical direction.

1.4 PROPOSED SITE REMEDIAL ACTION SUMMARY

The ROD (NYSDEC, 2010) for the Erdle site describes the site remedy as noted below.

> "Implementation of a full-scale in-situ electrical resistance heating system to address on-site VOC soil and groundwater contamination. Implementation of this alternative will consist of the installation of electrodes throughout the source area on approximately fifteen-foot spacing. Each electrode will be paired with one vapor recovery extraction well for vapor recovery.

> In-situ enhanced biodegradation could be implemented, if appropriate, to remediate site-related groundwater contamination contributing to the existing off-site soil vapor to indoor air pathway.
>
> The decision to conduct in-situ enhanced biodegradation during implementation of remedial action will be based upon the information from the Remedial Investigation, results of the pre-design investigation and data gathered to evaluate the effectiveness of the electrical resistance heating of the on-site source area."

In addition, the ROD includes provisions for:

- imposition of an environmental easement for the property that certifies completion and maintenance of institutional and engineering controls
- development of a Site Management (SM) Plan that identifies property use restrictions and engineering controls and describes the steps necessary to assure compliance with the controls.

1.5 SITE TOPOGRAPHIC AND BOUNDARY SURVEY

Popli Design Group provided a Certified Boundary Survey of the Site in May 2012 that is the basis of the site plan (see Figure 1.1). The survey included the location of Site features (buildings, pavement, sidewalk, curbing, utility poles, utilities including electric, storm drain, sewer and gas, fences, monitoring wells and property lines), easements, topographic elevations, and groundwater monitoring wells.

1.6 ERH TECHNOLOGY DESCRIPTION

ERH is an in-situ environmental remediation method utilizing the flow of alternating current electricity for remediation of contaminated soil and groundwater. Electric current passes through a specifically targeted soil volume between subsurface electrode points. The resistance to electrical flow that exists in the soil causes the formation of heat; resulting in an increase in temperature until the boiling point of water and/or contaminants at depth is reached. After reaching this temperature, further energy input causes a phase change, changing water into steam and removing contaminants by promoting volatilization and evaporation. A subsurface vapor recovery system applies vacuum to the treatment area to collect contaminants, which are then conveyed to the surface along with recovered air and steam. Similar to soil vapor extraction, the air, steam, and volatilized contaminants are then segregated at the surface and treated in accordance with applicable NYSDEC and local discharge requirements.

A significant fraction of VOCs will be degraded in place by natural in situ processes including biodegradation, hydrolysis, and reductive dehalogenation by zero-valent iron.

- Biodegradation is observed as an anaerobic process, and elevated temperatures increase biotic reaction rates. When soils with high levels of total organic cargon are heated, some portion of carbon will convert to acetone and other water soluble compounds. Acetone provides an available biodegradable food source for microbes performing reductive dechlorination.
- Hydrolysis is a water-substitution reaction in which hydrogen ions normally present in water react with organic molecules, replacing chlorine atoms. Oxidizing conditions or available oxygen is not required for hydrolysis. The rate of hydrolysis increases with temperature.
- Dehalogenation occurs with the addition of backfill of ERH electrodes which includes steel shot, a form of zero-valent iron. The presence of iron can provide a polishing mechanism for dissolved phase VOCs after heating has ended.

During ERH, the hydrolysis process aids overall remediation by degrading a primary contaminant to a by-product. Some low volatility organic contaminants have a short hydrolysis half life (e.g., 1,1,2,2-Tetrachloroethane and 1,1,1-TCA). As the subsurface is heated, the hydrolysis half-life of the contaminant will decrease. This results in a rapid degradation of the contaminant. Hydrolysis and reductive dechlorination are strongly affected by temperature, as described by the Arrhenius equation which in general equates to a 10 degree Celsius increase in temperature will increase the reaction rate by a factor of 2.5 (Beyke and Fleming, 2005).

ERH can be achieved by three-phase and six-phase electrical load arrangements. Three-phase heating consists of electrodes in a repeating triangular or delta pattern. Adjacent electrodes are of a different electrical phase so electricity conducts between them. Six-phase heating consists of six electrodes in a hexagonal pattern with a neutral electrode in the center of the array.

There are several laws that govern an ERH remediation. Dalton's law governs the boiling point of a relatively insoluble contaminant. Raoult's law governs the boiling point of mutually soluble co-contaminants and Henry's law governs the ratio of the contaminant in the vapor phase to the contaminant in the liquid phase.

ERH is adaptable to all soil types and sedimentary bedrock. ERH is also effective in both the vadose and saturated zones. Certain lithologies can limit traditional methods of remediation by preventing a reliable removal/destruction pathway for the COC. Because electricity can and does travel through any lithology that contains some water, ERH can be effective in any soil type. By forming buoyant steam bubbles during the heating process, ERH creates a carrier gas that transports the COC up and out of any soil type. ERH is not capable of desiccating the subsurface. In order for the subsurface to conduct electricity, there must be water present in the subsurface. Conductivity will cease before the subsurface is desiccated.

After ERH treatment, elevated subsurface temperatures will slowly cool over a period of time, typically several months, and gradually return to ambient. This period with elevated temperatures is an important part of the remediation process. The elevated temperatures will enhance bioremediation, hydrolysis and iron reductive dehalogenation, under the right conditions.

1.7 DEFINITION OF REMEDIATION AREA

The proposed ERH treatment area is depicted on Figures 1.1 and 1.2. The horizontal and presumed vertical extent (15 ft-bgs) of the treatment area will be reviewed during the ERH design to determine if any modifications are appropriate.

2.0 REMEDIAL ACTION OBJECTIVES AND STANDARDS

2.1 CLEANUP STANDARDS

The selected cleanup standards are numerical goals based on NYSDEC Table 375-6.8(b): Restricted Use Soil Cleanup Objectives, Protection of Groundwater. The cleanup standards are listed in Appendix A.

2.2 OBJECTIVES

RA objectives (RAOs) outline the key parameters for tracking progress and achieving success for ERH remediation. The primary objective is to meet the cleanup standards in soil as discussed in Subsection 2.1. RAOs for tracking progress and needed to achieve success are temperature and mass recovery, as discussed below.

2.2.1 Temperature Objective

The chart below shows constituents listed in the ROD to be remediated with ERH along with their respective boiling points. Because PCE has a higher boiling point than TCE, the target temperature for remediation will be based on the boiling point for PCE unless discreet areas can be identified that are only impacted by TCE. When chlorinated VOCs (CVOCs) are dissolved in water and the vapor pressures of both the CVOC and the water increase, the result is that the two components will co-boil at a temperature lower than the listed boiling points below of the pure CVOC. As a result, it is estimated that a lower target temperature will be required at the Site. The target temperature will be analyzed and determined by the ERH Contractor. As part of the design, a rationale will be developed for temperature monitoring to demonstrate that target temperatures have been achieved throughout the treatment area, though soil confirmation sampling will determine the ultimate success of ERH treatment.

Chemical	**Molecular Weight (g/mol)**	**Boiling Point (°C)**
1,1,1-trichloroethane	133.41	74.1
1,1-dichloroethane	98.96	57.3
cis-1,2-dichloroethene	96.94	60.3
Tetrachloroethene (PCE)	165.83	121.14
Trichloroethene (TCE)	131.29	87
Vinyl Chloride	62.5	-13.4
1,1-dichloroethene	96.94	37
trans-1,2-dichloroethene	99.94	47.5
Acetone	58.08	56.2
Benzo(b)fluoranthene	252.32	No Data
Benzo(a)anthracene	228.3	162
Benzo(k)flouranthene	252.32	480
Chrysene[1]	228.3	448

CRC, 1983

1. Chrysene has been determined by the NYSDEC not to be considered a constituent applicable to the ERH treatment design.

A mechanism for tracking remediation progress is monitoring the subsurface temperatures at the temperature monitoring points which is further discussed in Section 4.1.2.

2.2.2 Mass Recovery Objective

The mass recovery will be tracked to evaluate progress and indicate when confirmation sampling is appropriate, as well as when the ERH system can be turned off. The air effluent concentration, as well as condensate discharge during startup, will be compared to incremental air and condensate effluent samples on a regular basis to evaluate mass removal.

The primary mechanism of remediation progress monitoring will be measurement of the amount of constituents of concern that has been removed from the subsurface. The intent of defining a remediation progress metric is to provide a default condition where the treatment can be declared substantially complete and where only asymptotic removal rates are being achieved. Remediation progress will be monitored to determine when the removal rates are trending toward an asymptotic low point to trigger confirmation sampling. The rate of recovery is expected to be high at first as the high levels in soil gas are recovered upon start up of the vapor recovery system. The concentrations, and thus recovery rate of constituents of concern should decrease rapidly after start up. However, within a short term, as the saturated zone reaches boiling temperatures, the rate of recovery should rise again through a peak, and then tail off. Effective treatment will be defined as reaching an asymptotic condition where the weekly rate of mass collection represents only a small fraction (for example around 1%) of the total mass collected since start up. No fixed percentage value is established to determine whether the system should be operated further, or conversely, shutdown. NYSDEC would retain flexibility in these decisions.

3.0 ERH DESIGN PARAMETERS

3.1 DESIGN INPUTS

This section will describe the site conceptual model and summarize inputs required for preliminary design.

3.2 EQUIPMENT SIZE

In order to further develop this section a review of existing data (i.e., flow rates and k value) from previous reports will be used to assist ERH Contractors in evaluating the system flow rates for sizing the equipment.

3.3 PERMITTING CONSIDERATIONS (NATURAL RESOURCES, LOCAL CONSIDERATIONS)

The design will identify and evaluate permits required for ERH system remediation and will specify who is responsible for obtaining permits. These permits may include local construction permits such as sewer connection permits, sidewalk and roadway permits, electrical permits, water, gas, phone, cable, and all other utility permits and applications. Those identified include the following:

3.3.1 Monroe County Pure Water POTW - Wastewater Discharge Permit

It is anticipated that a publicly owned treatment works (POTW) permit will be required to discharge condensate that is unable to be re-used. It is envisioned that the Contractor will be responsible for obtaining the POTW discharge permit. The design will specify the allowable concentrations/volumes of contaminants allowed to be discharged to the sewer, and associated sampling requirements.

3.3.2 Electrical Permits

The Contractor will be responsible for obtaining electrical permits and electricity needed for the ERH system operation.

3.3.3 Air Emissions

An evaluation of the requirements of the NYS air emissions permit will be completed during the design process. It is anticipated that air emissions will need to comply with NYSDEC's DAR-1 Guidelines for the Control of Toxic Ambient Air Contaminants (NYSDEC, 1997).

Air emissions will be generated by the ERH system. Emissions from the system will be controlled (treated) as needed to meet applicable standards before discharge to the atmosphere. The methodology for air treatment, such as thermal oxidation or carbon absorption, will be left to the Contractor. The design will specify air emission limits and air/vapor emissions sampling necessary to comply with State requirements

4.0 ERH SYSTEM DESIGN SUMMARY

4.1 ELECTRODE DESIGN

The design will address the depths of the electrodes, electrode placement/spacing rationale, and temperature monitoring point locations and depths.

4.1.1 Electrode Placement

The design will specify that the contractor is responsible for developing the electrode spacing and depth necessary to achieve a temperature goal that will successfully remediate impacted soils to the required clean up standard. The design will require appropriate ERH placement and construction capable of general uniform heating which can also accommodate independent discrete area heating. The design will incorporate the ability for adjustment of electrical current capable to heat specific sub-areas within the targeted ERH area that may not be responding uniformly. The ERH Contractor will be responsible for developing the details for electrode placement within the treatment area.

4.1.2 Temperature Monitoring Points

A minimum number of temperature monitoring points (TMPs) and minimum temperature objectives will be specified. Thermocouples will be placed at specified depth intervals at each TMP for measurement of temperature.

4.2 VACUUM WELL DESIGN/ VACUUM EXTRACTION

Vapors will be recovered by vertical or horizontal vapor extraction wells, as appropriate. The vertical vapor extraction wells will be optimally located and may be co-located with electrodes. Horizontal vapor extraction wells may be more appropriate in areas near the wetland boundary on the south side of the target ERH treatment area. A sufficient number of vapor recovery wells are needed to maintain a negative pressure in the treatment area during ERH to demonstrate capture of volatilized contaminants and to prevent vapor intrusion into nearby buildings. Vacuum monitoring points will be required to demonstrate vacuum influence throughout the treatment area. Locations and construction of the vacuum wells will be developed by the ERH Contractor with guidance objectives provided in the bid specifications.

4.3 TREATMENT AREA LOGISTICS

Treatment area logistical considerations that will need to be incorporated into the design include the power control unit laydown area and electrical line routes available for connecting the electrodes as well as areas which will need to be configured to allow access of drill rigs between the electrodes for confirmation sampling. There may also be areas that need to remain open for vehicular traffic. The Contractor will need to create ramps or alter configuration to allow for access.

4.4 HANDLING OF PROCESS WATER

4.4.1 Vapor Condensation and Treatment:

Extracted vapors will be condensed. The fluids from the condenser will likely require treatment to acceptable levels. It is anticipated that the treated water will be discharged to the sanitary sewer; however, recycling of treated water to the electrode drip lines may be permissible and also be a sustainability benefit. The Contractor will be responsible for selecting the treatment methodology, such as carbon absorption or air stripping, to meet sewer discharge permit limits.

4.5 MONITORING WELL REPLACEMENT

A review of the existing monitoring wells construction material will determine which monitoring wells may be used during ERH treatment, which wells will need to be reinstalled as stainless steel to prevent melting, and if any additional wells are required to provide adequate coverage to evaluate groundwater in the vicinity of the ERH treatment area. Specifications for monitoring well abandonment and replacement will be developed as part of the design. A detail will be provided for the installation of new or replacement monitoring wells.

4.6 ELECTRICAL DESIGN

The electrical distribution design will be left to the Contractor; however, a brief electrical specification will be developed so that compliance with applicable State and local electrical codes is maintained. Available power from the local electrical utility will be provided. The Contractor will be required to provide maximum power output, average estimated usage and remote shut-off and safety disconnects for emergency shut-off. The Contractor is responsible for obtaining the necessary power.

4.7 ABOVE-GROUND PIPING DESIGN

Piping and electrical cables are preferred to be placed above-ground where possible for ease and cost effectiveness of installation and subsequent removal. Pipes connecting the ERH vapor extraction wells to the larger manifolds and the ERH vapor extraction equipment should be constructed of material which is suitable for the high temperatures of the steam and vapor collected, as well as for chemical compatibility with the extracted VOCs. The ERH area will be fenced to limit access. The aboveground ERH lines should be insulated as a safety precaution to limit the potential for electrical hazards, and to limit the amount of vapor that condenses within the piping.

4.8 BELOW -GROUND PIPING DESIGN

This section will discuss the requirements for the connection of the condensate discharge line to the sewer. If underground piping (depending on the time of year remediation is performed) is required, specifications for trenching and backfill will be developed.

4.9 INSTALLATION AND OPERATIONAL SEQUENCE

<u>Project Sequence</u>: This section lists the phases of the project from start to finish. The phases will include the following:

- Engineer Review of Contractor Work plan
- Procurement
- Permitting

- Site Preparation
- Site Grubbing and Clearing, Where Applicable
- Utility Installation
- Engineer Review of Contractor Submittals
- Monitoring Well Abandonment/Replacement
- ERH System Installation
- ERH System startup
- ERH Heating
- Operational Monitoring
- Confirmation Monitoring
- ERH Shutdown or continuation based on meeting remedial goals
- Post Confirmation Monitoring
- ERH Dismantlement
- Site Restoration

4.10 DISPOSAL OF CONTAMINATED MATERIALS

The design will identify waste characterization, handling, and disposal procedures for ERH installation waste and Investigative Derived Waste for both soil and water (purge water and development water.

5.0 GREEN ELEMENTS OF DESIGN

The NYSDEC Division of Environmental Remediation is committed to applying green remediation concepts. Cleanup of NYSDEC sites should utilize remedial activities that minimize ancillary environmental impacts by minimizing energy consumption, conserving natural resources, maximizing the reuse of land and recycling of materials. Incorporating green remediation concepts ensures the consistent and pro-active application of more sustainable methods to remediate sites while still protecting public health and the environment and striving to achieve the established cleanup goals.

5.1 GENERAL PROCEDURES

Green remediation concepts and techniques will be considered during the remedial program from site characterization and implementation of the remedy to long-term SM obligations with the goal of improving cleanup sustainability. See Appendix B for specific examples.

5.2 DOCUMENTATION OF GREEN REMEDIATION EFFORTS

In addition to statutory and regulatory requirements, Contractor work plans must include a discussion of the green remediation practices/technologies employed throughout the ERH system process. Green remediation principles must also be considered during each periodic review and remedial system optimization review conducted during the SM phase.

6.0 INFRASTRUCTURE REQUIREMENTS

6.1 OWNER/NYSDEC FURNISHED INFRASTRUCTURE

6.1.1 Site Access

It is anticipated that the NYSDEC will work with the Site Owner as well as adjacent property owners as necessary to make arrangements for access. Primary Site access is anticipated to be from Benton Street. On-site access routes will be further developed during the design process and shown on the Contract Drawings.

6.1.2 Site Security

The Contractor will be solely responsible for the security of the Contractor work areas, equipment, materials, and supplies. The design will include development of specifications for fencing to be utilized for security and health and safety purposes. The ERH remediation area will be fenced to prevent access to the remediation area. This will be installed as safety precaution to prevent accidental exposure to high voltage and VOCs. Requirements for fencing will be provided in the specifications. The Contractor will be responsible for ensuring Site visitors are escorted as necessary and do not enter contaminated or otherwise hazardous areas without authorization. A visitors' entrance/exit log will be maintained. Furthermore, security personnel will be required to check the Site during off-hour operational periods (e.g., evenings and weekends) and maintain a log of such inspections.

6.2 CONTRACTOR FURNISHED INFRASTRUCTURE

The Contractor will be required to furnish all temporary facilities and controls necessary to execute the Work.

6.2.1 Electrical Power

The Contractor will be required to make all contacts and arrangements for electrical power necessary to execute the Work (e.g., field trailer, generators, and welders). Also, the Contractor will be required to evaluate the effect of ERH power demand on local and area businesses, and provide protection from potential accidental power interruptions that could be caused by the current draw of the ERH system, as well as providing a secondary power source to keep the treatment system operational (i.e., maintain vacuum on the subsurface) in the event of a power failure.

6.2.2 Water/Sanitary Facilities

The Contractor will be required to provide an adequate supply of potable water for drinking and hand washing. Ancillary supplies (e.g., soap, paper towels, trash bin) will also be provided and maintained by the Contractor. The Contractor will be required to provide and maintain sanitary facilities in sufficient numbers for the use of all persons employed in the Work. When no longer needed, all items will be removed from the Site and properly managed/dispose of.

6.2.3 Contractor/Engineer Office Areas/Trailer

Contractor will be required to furnish, install, and maintain one field trailer for use by the ENGINEER/DEPARTMENT and Contractor. The trailer will be required to have separate rooms as follows: (1) office for the ENGINEER/DEPARTMENT, (2) office for the Contractor, and (3) conference room. It need not have integrated water and sanitary facilities as long as approved (i.e., Contractor-provided) conveniences are readily accessible nearby. The trailer will be required to have adequate furnishings, lighting, electric, heating/cooling, phone and internet service, etc. All utilities will be paid for by the Contractor.

6.2.4 Decontamination Facilities

The Contractor will be required to construct a decontamination pad on a properly graded and prepared surface. The decontamination pad will be located as close to the active work area as practical for the purpose of cleaning equipment and trucks prior to leaving the Site. The decontamination pad will consist of an aggregate (sand and crushed stone) working base, impervious geomembrane, nonwoven geotextile, and a collection sump and pumping system (detail to be provided in the Contract Drawings). Liquid waste resulting from decontamination operations will be collected and stored in a tank for testing prior to disposal (either discharged directly to sewer or transported off-site to a permitted facility).

6.2.5 Interferences

During the design process, potential site interferences will be assessed including overhead wires, other utilities, nearby buildings, etc.

7.0 ERH SYSTEM MONITORING

7.1 PERFORMANCE MONITORING

The design will identify performance data associated with sampling.

7.1.1 Soil Sampling

To document the extent of remediation accomplished, confirmatory soil samples will be collected when mass removal rates have reached asymptotic conditions and temperatures in the treatment area have reached the target. The confirmatory soil samples would be used to evaluate the effectiveness of the ERH technology and the need to continue ERH operation. Soil sampling results would be used as a basis to measure the Contractor's performance in meeting the cleanup standards for soil.

The Contract Documents will include the flexibility to restart ERH as an option. The Contractor will be required to collect and analyze a specific quantity of samples (to be specified in the Contract Documents). Special techniques will be specified for sample collection to minimize the potential for loss of volatile organics from the sample. These techniques may include immediate capping of the sample collection tube followed by immediate cooling in an ice water trough. Once cooled, the sample sleeve would be cut open, and a core would be taken from the sample and placed in a vial for delivery to the laboratory. Samples would be taken from random locations throughout the area and depth of treatment. The results of these samples will be submitted to the NYSDEC for review and evaluation.

7.1.2 Groundwater Sampling

Because of the large extent of the plume, extending far offsite, absolute remediation of groundwater is not a goal of ERH treatment. However, groundwater samples will also be collected to evaluate contaminant reduction and track the estimate mass remaining in groundwater before, during, and after treatment, while groundwater is available for sampling. Groundwater will be sampled from wells within the treatment area. The proposed well locations will be identified in a figure to be included in the design package. Because temperatures would be high, special groundwater purging and sampling techniques will be specified. The design will incorporate requirements for pre-installed dedicated Teflon® tubing, well depressurization as needed, purging through a heat exchanger coil and ice bath to reduce the groundwater temperature to ambient conditions prior to placement in the sampling container.

7.1.3 Air Sampling

Air sampling will include both influent and effluent air samples from the ERH treatment system. These samples will be used to measure the mass removal of the ERH treatment from the in-situ conditions as well as pre and post air treatment process evaluation. The air sampling plan will be specified in the design package by outlining the frequencies for air samples at each location.

As part of its Health and Safety requirements, the Contractor will implement an air-monitoring program to assess on-site conditions and boundary conditions of ambient air quality. The air sampling plan will specify in the design package the frequencies for ambient air samples and recommend sampling locations.

7.2 SYSTEM OPTIMIZATION

The Contractor will be required to discuss in its workplan the flexibility of the system to address issues when RAOs are not met in terms of mass removal and temperature goals.

8.0 SITE RESTORATION

8.1 WELL/ELECTRODE CLOSURE

This section will outline the specifications for abandonment and closure of groundwater monitoring wells, vapor extraction wells, and electrodes.

8.2 SITE SURFACE RESTORATION

The Site will be graded and finished in kind with existing surface conditions. Surface treatments are expected to include vegetation (i.e., topsoil, seed, and mulch) where applicable. Compromised wetland areas (including cleared vegetation and soils compromised by the heating process) will be restored to existing conditions.

9.0 REFERENCES

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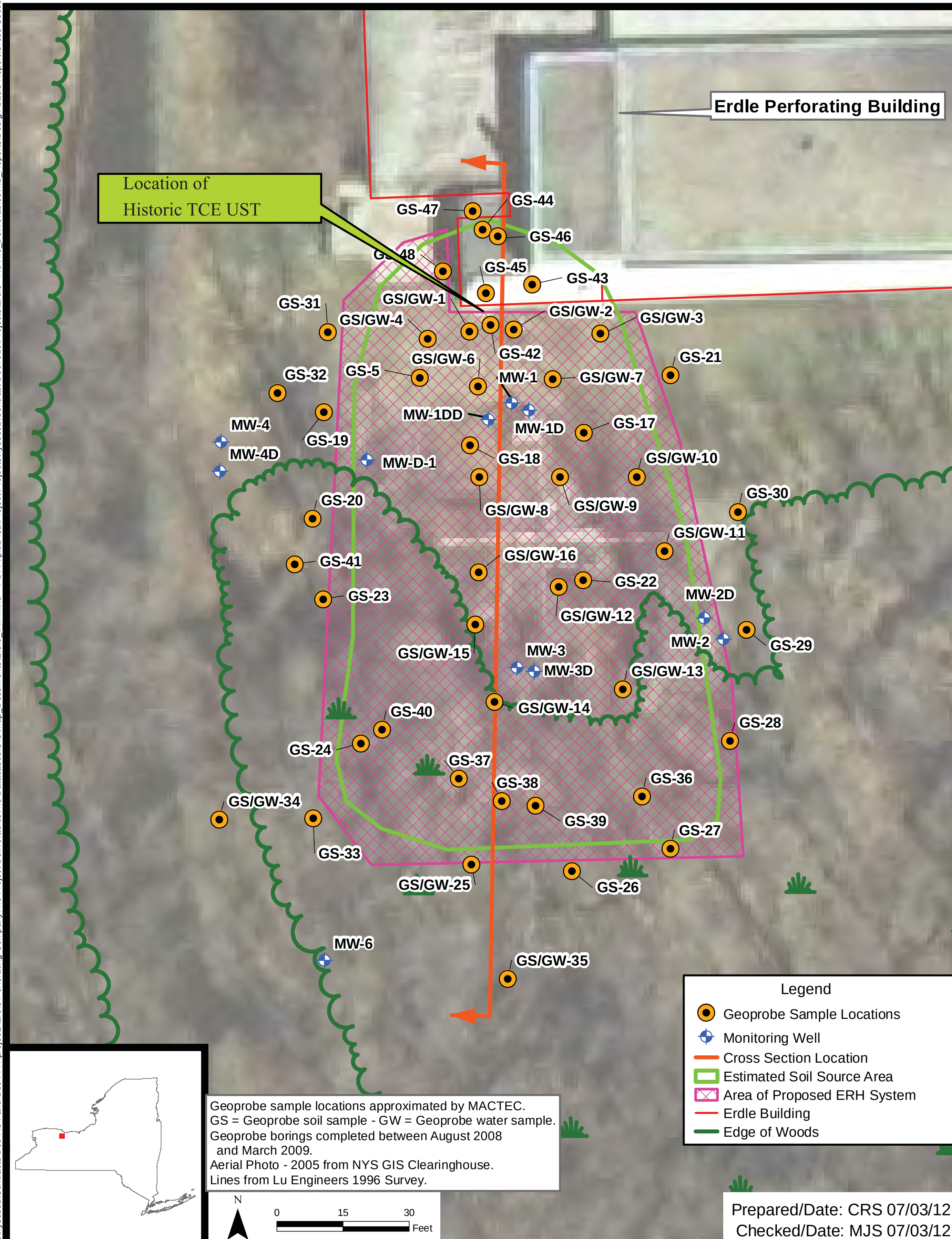
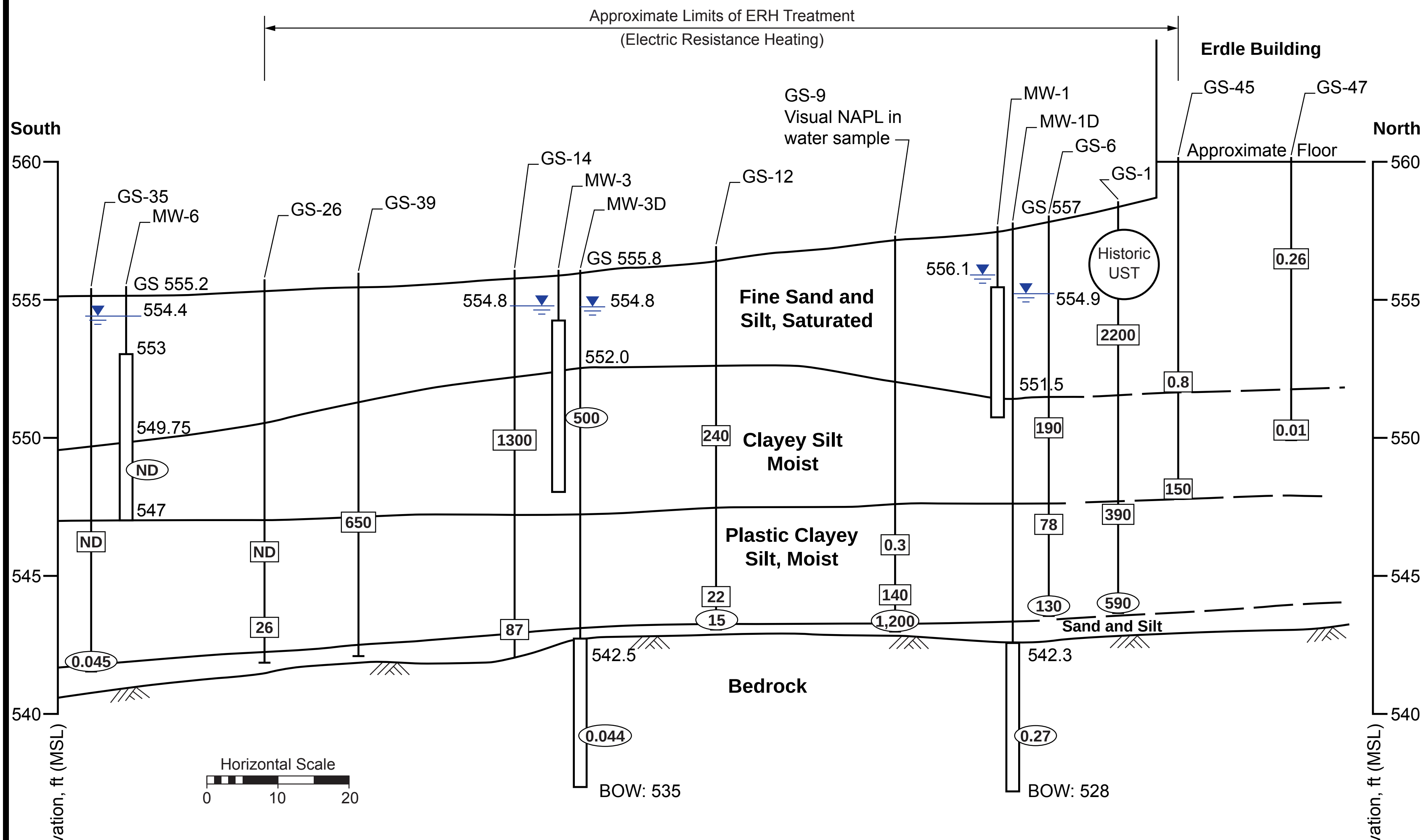
FIGURES



NYSDEC
Erdle Perforating Company
Gates, New York

MACTEC

Site Plan
Project 3612112215
Figure 1.1



LEGEND

26	Trichloroethene result in parts per million (soil)
130	Trichloroethene result in parts per million (water) (results from MACTEC 2008)
▼	Water Elevation (January 2001 - water can be 2.5 feet lower in July)

Elevations from Radian Engineering (feet above mean sea level)
G.S. = ground surface

Prepared/Date: JPH 6/28/12
Checked/Date: CRS 6/28/12

Design Basis Report
Erdle Perforating Site
Gates, New York

MACTEC

Cross Section A-A'
Project 3612-11-2215.02
Figure 1.2

PORT2012035a.ai

APPENDIX A

TABLE 375 6.8(b) - NYSDEC REMEDIAL PROGRAM SOIL CLEANUP OBJECTIVES

(b) Restricted use soil cleanup objectives.

Table 375-6.8(b): Restricted Use Soil Cleanup Objectives

Contaminant	CAS Number	Protection of Public Health				Protection of Ecological Resources	Protection of Ground-water
		Residential	Restricted-Residential	Commercial	Industrial		
Metals							
Arsenic	7440-38-2	16[f]	16[f]	16[f]	16[f]	13[f]	16[f]
Barium	7440-39-3	350[f]	400	400	10,000 [d]	433	820
Beryllium	7440-41-7	14	72	590	2,700	10	47
Cadmium	7440-43-9	2.5[f]	4.3	9.3	60	4	7.5
Chromium, hexavalent [h]	18540-29-9	22	110	400	800	1[e]	19
Chromium, trivalent[h]	16065-83-1	36	180	1,500	6,800	41	NS
Copper	7440-50-8	270	270	270	10,000 [d]	50	1,720
Total Cyanide [h]		27	27	27	10,000 [d]	NS	40
Lead	7439-92-1	400	400	1,000	3,900	63[f]	450
Manganese	7439-96-5	2,000[f]	2,000[f]	10,000 [d]	10,000 [d]	1600[f]	2,000[f]
Total Mercury		0.81[j]	0.81[j]	2.8[j]	5.7[j]	0.18[f]	0.73
Nickel	7440-02-0	140	310	310	10,000 [d]	30	130
Selenium	7782-49-2	36	180	1,500	6,800	3.9[f]	4[f]
Silver	7440-22-4	36	180	1,500	6,800	2	8.3
Zinc	7440-66-6	2200	10,000 [d]	10,000 [d]	10,000 [d]	109[f]	2,480
PCBs/Pesticides							
2,4,5-TP Acid (Silvex)	93-72-1	58	100[a]	500[b]	1,000[c]	NS	3.8
4,4'-DDE	72-55-9	1.8	8.9	62	120	0.0033 [e]	17
4,4'-DDT	50-29-3	1.7	7.9	47	94	0.0033 [e]	136
4,4'-DDD	72-54-8	2.6	13	92	180	0.0033 [e]	14
Aldrin	309-00-2	0.019	0.097	0.68	1.4	0.14	0.19
alpha-BHC	319-84-6	0.097	0.48	3.4	6.8	0.04[g]	0.02
beta-BHC	319-85-7	0.072	0.36	3	14	0.6	0.09
Chlordane (alpha)	5103-71-9	0.91	4.2	24	47	1.3	2.9
delta-BHC	319-86-8	100[a]	100[a]	500[b]	1,000[c]	0.04[g]	0.25
Dibenzofuran	132-64-9	14	59	350	1,000[c]	NS	210
Dieldrin	60-57-1	0.039	0.2	1.4	2.8	0.006	0.1
Endosulfan I	959-98-8	4.8[i]	24[i]	200[i]	920[i]	NS	102
Endosulfan II	33213-65-9	4.8[i]	24[i]	200[i]	920[i]	NS	102
Endosulfan sulfate	1031-07-8	4.8[i]	24[i]	200[i]	920[i]	NS	1,000[c]
Endrin	72-20-8	2.2	11	89	410	0.014	0.06
Heptachlor	76-44-8	0.42	2.1	15	29	0.14	0.38
Lindane	58-89-9	0.28	1.3	9.2	23	6	0.1
Polychlorinated biphenyls	1336-36-3	1	1	1	25	1	3.2

(b) Restricted use soil cleanup objectives.

Table 375-6.8(b): Restricted Use Soil Cleanup Objectives

Contaminant	CAS Number	Protection of Public Health				Protection of Ecological Resources	Protection of Ground-water
		Residential	Restricted-Residential	Commercial	Industrial		
Semivolatiles							
Acenaphthene	83-32-9	100[a]	100[a]	500[b]	1,000[c]	20	98
Acenapthylene	208-96-8	100[a]	100[a]	500[b]	1,000[c]	NS	107
Anthracene	120-12-7	100[a]	100[a]	500[b]	1,000[c]	NS	1,000[c]
Benz(a)anthracene	56-55-3	1[f]	1[f]	5.6	11	NS	1[f]
Benzo(a)pyrene	50-32-8	1[f]	1[f]	1[f]	1.1	2.6	22
Benzo(b)fluoranthene	205-99-2	1[f]	1[f]	5.6	11	NS	1.7
Benzo(g,h,i)perylene	191-24-2	100[a]	100[a]	500[b]	1,000[c]	NS	1,000[c]
Benzo(k)fluoranthene	207-08-9	1	3.9	56	110	NS	1.7
Chrysene	218-01-9	1[f]	3.9	56	110	NS	1[f]
Dibenz(a,h)anthracene	53-70-3	0.33[e]	0.33[e]	0.56	1.1	NS	1,000[c]
Fluoranthene	206-44-0	100[a]	100[a]	500[b]	1,000[c]	NS	1,000[c]
Fluorene	86-73-7	100[a]	100[a]	500[b]	1,000[c]	30	386
Indeno(1,2,3-cd)pyrene	193-39-5	0.5[f]	0.5[f]	5.6	11	NS	8.2
m-Cresol	108-39-4	100[a]	100[a]	500[b]	1,000[c]	NS	0.33[e]
Naphthalene	91-20-3	100[a]	100[a]	500[b]	1,000[c]	NS	12
o-Cresol	95-48-7	100[a]	100[a]	500[b]	1,000[c]	NS	0.33[e]
p-Cresol	106-44-5	34	100[a]	500[b]	1,000[c]	NS	0.33[e]
Pentachlorophenol	87-86-5	2.4	6.7	6.7	55	0.8[e]	0.8[e]
Phenanthrene	85-01-8	100[a]	100[a]	500[b]	1,000[c]	NS	1,000[c]
Phenol	108-95-2	100[a]	100[a]	500[b]	1,000[c]	30	0.33[e]
Pyrene	129-00-0	100[a]	100[a]	500[b]	1,000[c]	NS	1,000[c]
Volatiles							
1,1,1-Trichloroethane	71-55-6	100[a]	100[a]	500[b]	1,000[c]	NS	0.68
1,1-Dichloroethane	75-34-3	19	26	240	480	NS	0.27
1,1-Dichloroethene	75-35-4	100[a]	100[a]	500[b]	1,000[c]	NS	0.33
1,2-Dichlorobenzene	95-50-1	100[a]	100[a]	500[b]	1,000[c]	NS	1.1
1,2-Dichloroethane	107-06-2	2.3	3.1	30	60	10	0.02[f]
cis-1,2-Dichloroethene	156-59-2	59	100[a]	500[b]	1,000[c]	NS	0.25
trans-1,2-Dichloroethene	156-60-5	100[a]	100[a]	500[b]	1,000[c]	NS	0.19
1,3-Dichlorobenzene	541-73-1	17	49	280	560	NS	2.4
1,4-Dichlorobenzene	106-46-7	9.8	13	130	250	20	1.8
1,4-Dioxane	123-91-1	9.8	13	130	250	0.1[e]	0.1[e]
Acetone	67-64-1	100[a]	100[b]	500[b]	1,000[c]	2.2	0.05
Benzene	71-43-2	2.9	4.8	44	89	70	0.06
Butylbenzene	104-51-8	100[a]	100[a]	500[b]	1,000[c]	NS	12
Carbon tetrachloride	56-23-5	1.4	2.4	22	44	NS	0.76
Chlorobenzene	108-90-7	100[a]	100[a]	500[b]	1,000[c]	40	1.1
Chloroform	67-66-3	10	49	350	700	12	0.37

(b) Restricted use soil cleanup objectives.

Table 375-6.8(b): Restricted Use Soil Cleanup Objectives

Contaminant	CAS Number	Protection of Public Health				Protection of Ecological Resources	Protection of Ground-water
		Residential	Restricted-Residential	Commercial	Industrial		
Ethylbenzene	100-41-4	30	41	390	780	NS	1
Hexachlorobenzene	118-74-1	0.33[e]	1.2	6	12	NS	3.2
Methyl ethyl ketone	78-93-3	100[a]	100[a]	500[b]	1,000[c]	100[a]	0.12
Methyl tert-butyl ether	1634-04-4	62	100[a]	500[b]	1,000[c]	NS	0.93
Methylene chloride	75-09-2	51	100[a]	500[b]	1,000[c]	12	0.05
n-Propylbenzene	103-65-1	100[a]	100[a]	500[b]	1,000[c]	NS	3.9
sec-Butylbenzene	135-98-8	100[a]	100[a]	500[b]	1,000[c]	NS	11
tert-Butylbenzene	98-06-6	100[a]	100[a]	500[b]	1,000[c]	NS	5.9
Tetrachloroethene	127-18-4	5.5	19	150	300	2	1.3
Toluene	108-88-3	100[a]	100[a]	500[b]	1,000[c]	36	0.7
Trichloroethene	79-01-6	10	21	200	400	2	0.47
1,2,4-Trimethylbenzene	95-63-6	47	52	190	380	NS	3.6
1,3,5- Trimethylbenzene	108-67-8	47	52	190	380	NS	8.4
Vinyl chloride	75-01-4	0.21	0.9	13	27	NS	0.02
Xylene (mixed)	1330-20-7	100[a]	100[a]	500[b]	1,000[c]	0.26	1.6

All soil cleanup objectives (SCOs) are in parts per million (ppm). NS=Not specified. See Technical Support Document (TSD). Footnotes

[a] The SCOs for residential, restricted-residential and ecological resources use were capped at a maximum value of 100 ppm. See TSD section 9.3.

[b] The SCOs for commercial use were capped at a maximum value of 500 ppm. See TSD section 9.3.

[c] The SCOs for industrial use and the protection of groundwater were capped at a maximum value of 1000 ppm. See TSD section 9.3.

[d] The SCOs for metals were capped at a maximum value of 10,000 ppm. See TSD section 9.3.

[e] For constituents where the calculated SCO was lower than the contract required quantitation limit (CRQL), the CRQL is used as the SCO value.

[f] For constituents where the calculated SCO was lower than the rural soil background concentration as determined by the Department and Department of Health rural soil survey, the rural soil background concentration is used as the Track 2 SCO value for this use of the site.

[g] This SCO is derived from data on mixed isomers of BHC.

[h] The SCO for this specific compound (or family of compounds) is considered to be met if the analysis for the total species of this contaminant is below the specific SCO.

[i] This SCO is for the sum of endosulfan I, endosulfan II, and endosulfan sulfate.

[j] This SCO is the lower of the values for mercury (elemental) or mercury (inorganic salts). See TSD Table 5.6-1.

APPENDIX B

EXAMPLES OF GREEN REMEDIATION TECHNIQUES

Appendix B

Examples of Green Remediation Techniques

Examples of Green Remediation Techniques Applicable to all Phases of the Remedial Programs

- Increase energy efficiency/Minimize total energy use and direct and indirect CO_2/GHG emissions to the atmosphere
- Reduce emissions of air pollutants
- Minimize habitat disturbance and create or enhance habitat or usable land
- Conserve natural resources such as soil and water; promote the sequestration of carbon through reforestation or afforestation
- Minimize fresh water consumption and maximize water reuse during daily operations and treatment processes
- Prevent long-term erosion, surface runoff, and off-site water quality impacts
- Prevent unintended soil compaction
- Minimize waste or implement beneficial use of materials that would otherwise be considered a waste
- Minimize equipment and truck idling and use sustainably produced biofuels to reduce discharges of pollutants and GHGs to the atmosphere
- Utilize clean diesel (new or retrofitted) equipment to reduce emissions to the atmosphere
- Minimize truck travel for disposal to save energy, reduce emissions, reduce localized noise, vibration, and wear and tear on roads
- Minimize use of heavy equipment to save energy and reduce emissions

Examples of Green Remediation Techniques Applicable to the Remedy Selection, Design and/or Construction Phases

- Maintain, use, mimic or enhance natural processes where possible to effect remediation
- Encourage development and evaluation of low energy alternatives such as enhanced bioremediation, phytoremediation, permeable reactive barriers (PRBs), source removal with monitored natural attenuation (MNA), enhanced attenuation of chlorinated organics (EACO), engineered wetlands, and remedies which can be driven to MNA or monitoring only (e.g., remedies which will not need external power indefinitely)
- Use renewable energy if possible, or purchase Renewable Energy Credits

- Evaluate if a remediation system could be protective with an intermittent energy supply (e.g., pumping or venting only during daytime or adequate winds)
- Encourage the use of remediation technologies that permanently destroy contamination to reduce impacts associated with long-term site management
- Address sources more aggressively to reduce long-term operation and maintenance of treatment or containment systems
- Design for efficiency (e.g., size motors optimally) to reduce indirect emissions of electricity production
- Design adaptable systems (e.g., systems that use less energy as the site cleans up) Incorporate green building design
- Reuse existing buildings and infrastructure to reduce waste
- Reuse and Recycle construction and demolition (C&D) debris and other materials Maximize beneficial use of materials that would otherwise be considered a waste Integrate remedial design with contemplated reuse of site
- Design cover systems to be usable (e.g., habitat, recreation, renewable energy generation, bio-fuel crop production)
- Design storm water management or cover systems to recharge aquifers/minimize the creation or replacement of impervious surfaces
- Use native vegetation requiring little or no irrigation
- Reclaim treated water for beneficial use such as process water or irrigation

Examples of Green Remediation Techniques Applicable to Site Management

- Focus on optimization to reduce energy use or time to closure
- Increase energy efficiency/minimize total energy use and CO_2/GHG emissions to the air by replacing equipment, altering operation or shutting down unnecessary equipment
- Improve reliability to reduce O&M visit frequency
- Evaluate the possibility of switching to renewable energy either directly (generated on site, off-grid or grid-tied), or indirectly through a utility (green power purchase program)
- Complete the Remedial Site Optimization Process to identify opportunities to reduce energy and other impacts
- Incorporate sustainability into periodic reviews to identify opportunities to reduce energy and other impacts
- Assess if an energy intensive remedy is still the best remedy for the site
- Evaluate the possibility of MNA for sites where this was not originally considered