AMENDED RECORD OF DECISION
SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

ANODYNE SUPERFUND SITE
MIAMI GARDENS, FLORIDA

ID#: FLD981014368

United States Environmental Protection Agency
Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street, S.W.
Atlanta, Georgia 30303

July 2016

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DECLARATION OF THE AMENDED RECORD OF DECISION

SITE NAME AND LOCATION

Anodyne Superfund Site
North Miami
1270 NW 165th Street
Miami Gardens
Miami-Dade County
Florida
ID#: FLD981014368

STATEMENT OF BASIS AND PURPOSE

This decision document presents the Amended Selected Remedy for the Anodyne Superfund Site, located in Miami Gardens, Florida, which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 U.S.C. Section 9601, et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record for the Anodyne Superfund Site. All selected remedy decisions are based on the Administrative Record for the Anodyne Superfund Site, OU1, Zone 2: Deep Groundwater.

Data collected since the initial remedy selection indicates that the potential threat of contaminants impacting the beneficial uses of the Biscayne Aquifer, a Class I drinking water aquifer, is greater than originally estimated as the extent of the plume is larger than originally estimated. The new remedy is more cost-effective given the increased size of the plume.

The State of Florida, through its Department of Environmental Protection (FDEP), concurs with the amended selected remedy.

DESCRIPTION OF SELECTED REMEDY

EPA is seeking a modification of Alternative 3 presented in the May 2014 Focused Feasibility Study (FFS). The major components of the remedy selected by EPA for OU1 Zone 2 in this amendment include:

- Conduct additional field activities to further refine the horizontal and vertical extent of the VOC groundwater plume; to assess site-specific hydraulic aquifer properties; and to identify and collect additional data needed to fill data gaps during the design phase.

- Continued monitoring of the plume and reliance on monitored natural attenuation (MNA) for further remediation, based on the measurement of significant reducing trends since the original record of decision (ROD) was issued.

- Implement in-situ bioremediation by enhanced reductive dechlorination (ERD) of groundwater at targeted locations where higher levels of residual chlorinated volatile organic compound (CVOC) residual mass appear to exist to reduce the timeframe to attain the groundwater maximum contaminant levels (MCLs).

- Develop and implement a long-term monitoring plan to verify the effectiveness of the amended remedy.

- Develop and implement institutional controls (ICs) to prevent the installation of private or public potable water supply wells within the plume boundary until the MCLs are attained.

This represents a modification of the Alternative 3A that was originally presented in the May 2014 FFS as presented in February 2016 proposed plan. Because of the magnitude of the dissolved phase CVOC reductions that were realized after the original ROD and FFS were completed, the active treatment component of the remedy will be scaled back from what was originally assumed for purposes of the FFS. Locations targeted for active treatment will be defined during the remedial design (RD) phase of the remedy based on identified locations of higher CVOC groundwater concentrations and/or inferred immobilized residual mass that represent a long-term sustained source of mass flux to groundwater. This amended remedy is considered a final remedy for the deep groundwater that is protective, achieves the remedial action objectives (RAOs) including achieving the long-term objective of restoring the Biscayne aquifer to its beneficial use as a drinking water source.

STATUTORY DETERMINATIONS

The amended remedy selected in this ROD amendment is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The amended remedy also satisfies the statutory preference for treatment as a principal element of the remedy by using ERD treatment.

Because the amended remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a policy review will be conducted within 5 years after initiation of the remedial action to ensure that the remedy is or will be protective of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Amended Record of Decision (AROD). Additional information can be found in the Administrative Record file for the Site.

Chemicals of concern (COCs) and their respective concentrations	Section 2.0
Baseline risk represented by the COCs	Section 4.2
Cleanup levels established for COCs and the basis for the levels	Section 4.4
How source materials constituting principal threats were addressed	Section 2.1-2.4
Current and reasonably anticipated future land use assumption and current and potential future beneficial uses of groundwater used in the baseline risk assessment (BRA) and the ROD	Section 2.1.4
Potential land and groundwater use that will be available at the Site as a result of the selected remedy	Section 8.1
Estimated capital, operation and maintenance (O&M), and total present worth costs, discount rate, as well as and the number of years over which the remedy cost estimates are projected	Section 6.2.5
Key factors that led to the remedy selection	Section 3.0

AUTHORIZING SIGNATURES

Pursuant to Section 104 of CERCLA, the President is authorized to undertake actions in response to a threat or potential threat to human health, welfare, or the environment. This authority was delegated to the Administrator of the U.S. EPA, then to the Regional Administrations, and through other delegations; the Division Directors of the Superfund Program are authorized to approve these actions.

Arthur J. Collins — 7/21/16

for Franklin E. Hill
Director, Superfund Division

DATE

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LIST of ACRONYMS

ARAR - applicable or relevant and appropriate requirement
BLRA - Baseline Risk Assessment
bls/bgl - below land surface/below ground level
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CLP- contract laboratory program
COC - compounds of concern
COPC – compounds of potential concern
DCE-Dichloroethene
DNAPL-Dense, Non-aqueous Phase Liquid
DO-Dissolved Oxygen
DPT –direct push technology
EAB – Enhanced Anaerobic Biodegradation
ESD-Explanation of Significant Differences
FDEP/FDER – Florida Department of Environmental Protection
FFS – Focused Feasibility Study
GRA-General Response Action
HHRA – human health risk assessment
HI - hazard index
HRC-A-Hydrogen Release Compound – Advanced
ILCR - Incremental lifetime cancer risk
ISCO – In Situ Chemical Oxidation
LTRA – Long Term Response Action
MCL-Maximum Contaminant Level
mg/kg - milligrams per kilogram (ppm)
mL- Milliliter
NAPL - non-aqueous phase liquid
NPL – national priorities list
OU - operable unit
ORC-A-Oxygen Release Compound - Advanced
ORP-Oxidation-Reduction Potential
PCE – Tetrachloroethene
RAO-Remedial Action Objectives
RI-Remedial Investigation
ROD-Record of Decision
QA - quality assurance
QC - quality control
RA – remedial action
SWDA – Safe Water Drinking Act
TCE-Trichloroethene
TOC-Total Organic Carbon
Ug/kg- microgram per kilogram
Ug/L – microgram per liter

USACE - United States Army Corps of Engineers
USEPA - United States Environmental Protection Agency
VC-Vinyl Chloride
VOC - volatile organic compound

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1.0 INTRODUCTION TO SITE AND STATEMENT OF PURPOSE

1.1 Site Location and Description

The Anodyne Superfund Site is located at 1270 NW 165th Street in Miami Gardens, Florida, on the southeast corner of the intersection of 13th Avenue and NW 165th Street (Figure 1). The site is located within the Sunshine State Industrial Park, in a mixed residential, commercial, and industrial district of northern Miami-Dade County. The original Anodyne facility is composed of a concrete block office and warehouse-type building located on approximately 4.25 acre lot. The building that formerly housed the Anodyne, Inc. (Anodyne) manufacturing operations is currently occupied by ATC, an international global security company.

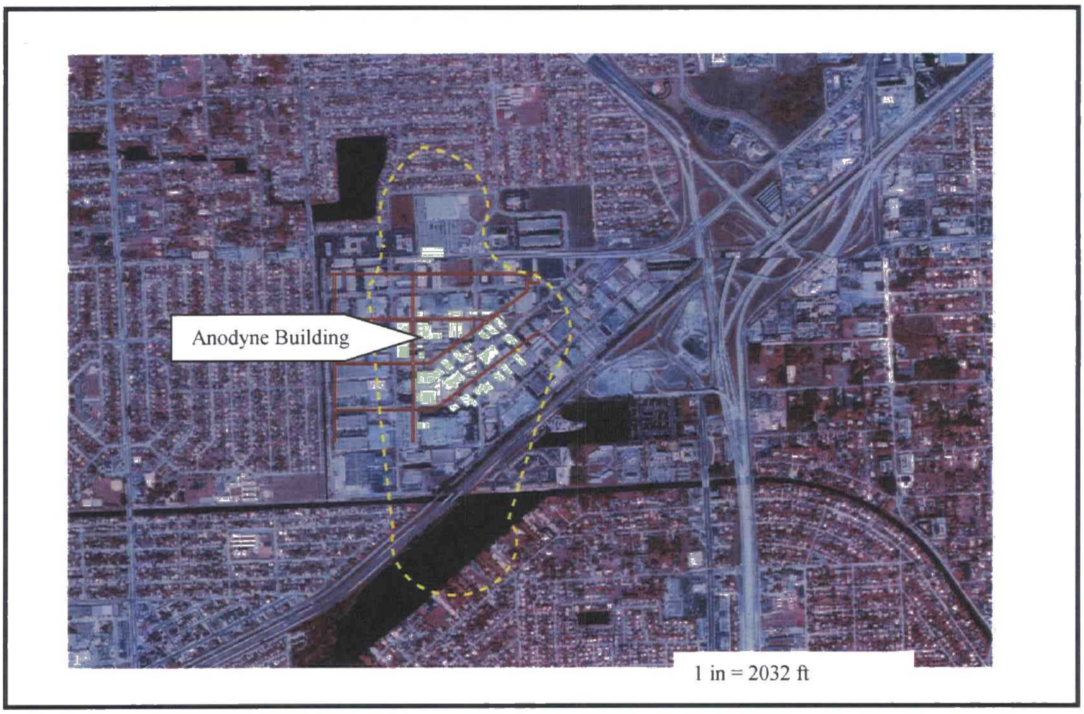


Figure 1: Vicinity Map and Estimated Groundwater Contaminant Plume
(from Pilot Study Report, June 2010 by Tearrenear PMC, LLC)

Surface water features, such as drainage canals and water-filled borrow pits, are located less than one mile from the Anodyne property. The land surface is flat with little relief, and the sandy surface soils at the Anodyne Site promotes rapid infiltration of rainfall resulting in little runoff (Law, 1992).

The original decision documents and this AROD present the remedial actions selected in accordance with Section 117(a) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended, 42 U.S.C. § 9617(a) and Section 300.435 (c)(2)ii of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R.§300.435(c)(2)(ii).

This AROD and all documents that form the basis for this decision, will become part of the Administrative Record file for the Anodyne Superfund Site consistent with Section 300.825(a)(2) of the NCP. The Administrative Record contains the information on which the selection of this remedial action is based and is available for review at the following locations:

North Dade Regional Library
2455 N. W. 183rd St
Miami, Florida 33056
(305) 652-6424

U.S. EPA – Region 4
Superfund Records Center
61 Forsyth St., SW
Atlanta, GA 30303
(404)562-8862

2.0 SITE HISTORY, CONTAMINATION AND SELECTED REMEDY

Information from the Remedial Investigation (RI), prepared by Law Environmental Inc. (Law 1992), states that Anodyne was involved in silk screening, lithography, and metal anodizing from the early 1960's through 1975. The manufacturing processes used by Anodyne were performed within the building. Large above-ground storage tanks (ASTs) were located along the south side of the building. These ASTs were enclosed by concrete block and used for storage of chemicals used by Anodyne. The types of chemicals stored in the ASTs are unknown, as are the types of chemicals used by Anodyne for their manufacturing processes.

A 10-inch inside diameter (ID), 81-foot (ft) deep injection well was installed just outside the boundary of the Anodyne property in a railroad right-of-way during the manufacturing phase of the facility's operation. The well appears to have been constructed in the late 1960s. Spent solvents were reportedly disposed of within the former injection well during the time frame that Anodyne was in operation.

Machinery used in such processes was typically cleaned using organic solvents, usually PCE and TCE. There is no documentation available of the specific solvent or solvent mixture that was used at the Anodyne facility. The primary compounds identified within the soil and groundwater at the Anodyne Site, however, were the chlorinated compounds PCE, TCE, DCE, and VC (Law 1992). Biodegradation daughter products of PCE include TCE, DCE, and VC.

2.1 Site Characterization Studies

2.1.2 1987 Site Investigation

The initial Site Investigation (SI) was conducted and prepared by NUS Corporation. The field work was conducted in 1986 and consisted of installing and sampling eight monitoring wells, as well as sampling three off-site and up gradient wells. The SI Report was completed in 1987.

EPA placed the site on the National Priority List (NPL) in 1990 and then entered into Administrative Order by Consent with the current property owner for the RI/FS.

2.1.3 1992 Remedial Investigation/Feasibility Study

The Remedial Investigation/Feasibility Study (RI/FS), prepared by Law Environmental in 1992, documented the presence of CVOCs within the groundwater. Eighteen monitoring wells were installed during the initial RI, ranging in depth from 18 to 95 ft below ground surface (bgs). Monitoring wells were completed in three distinct zones defined by depth within the aquifer. The shallow zone was identified as the "A" series of wells, which were completed to approximately 18 ft bgs. The intermediate depths were labeled the "B" series and completed to approximately 43 ft bgs. The deepest wells were identified as the "C" series and were completed to 95 ft bgs. One well (MW-9D) was installed to 140 ft bgs.

The FS evaluated several remedies for the Anodyne Site based on two distinct zones (identified as Zone 1 and Zone 2) of contamination that had been delineated by the RI and previous investigations.

Zone 1 was defined as the upper zone of the aquifer from the ground surface to 20 ft bgs. Contaminants of concern (COCs) in the shallow groundwater were metals and volatile organic compounds (VOCs). COCs in the shallow soil were metals, VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and pesticides. The selected remedy for Zone 1 was excavation and off-site disposal of the contaminated soil with additional groundwater monitoring for natural attenuation.

Zone 2 was defined as the lower zone of the aquifer as delineated below 55 ft bgs. COCs included VOCs, in particular the chlorinated hydrocarbons (CVOCs) 1, 2-dichloroethene (DCE) and vinyl chloride (VC), with some lesser detections of trichloroethene (TCE) and tetrachloroethene (PCE). The selected remedy for Zone 2 was to recover the affected groundwater by pumping, treating the groundwater above-ground by air stripping, then returning the groundwater to the aquifer by re-injection.

2.1.4 1993 Record of Decision

A Record of Decision (ROD) was signed in 1993. The ROD identified a remedy for each of the two zones of contamination within the subsurface.

<u>Zone 1: Shallow Soil and Groundwater</u>

- Removal of contaminated soils down to groundwater around the Anodyne Facility and restoration of the site with clean fill and grass. The actual extent of soil removal would be determined during the RD phase for Zone 1 soil excavation.
- Disposal of contaminated soils
- Restoration of shallow groundwater by natural attenuation and dispersion of the metal contamination.
- Groundwater monitoring to document performance of remedy for Zone 1.

<u>Zone 2: Deep Groundwater</u>

- Installation of large capacity recovery wells for the recovery of contaminated groundwater, above-ground treatment by air stripping or oxidation by UV light, and onsite disposal of the treated groundwater within Zone 2 through a series of injection wells.
- Delineation and verification of the full extent of the contaminated deep groundwater during the RD phase.
- Treatability studies during the RD phase to determine the most cost effective method of treating the contaminated groundwater above-ground.
- Abandonment of the old Anodyne Injection well.

2.2. Zone 1 Soil and Groundwater Contamination

<u>Explanation of Significant Differences (ESD)</u>

An explanation of significant differences (ESD) was completed for OU1, Zone 1 in 1999 to address the remedial goal for nickel. The ESD, prepared by EPA, removed the 1993 ROD requirement for disposal of the contaminated sediments in a cement kiln due to non-approval by Florida DERM. All contaminated soils were disposed of in an approved off site landfill permitted to receive non-RCRA hazardous wastes located in Miami-Dade County.

Zone 1 Soil Removal

A consent decree was signed on July 12, 2000, between the EPA and the potentially responsible party (PRP), to conduct and fund the remedial actions addressing Zone 1 contaminated soils and shallow groundwater. The work plan for the remedial action (RA) was approved in 2001; the soil removal began in 2002 and was completed in 2003. A total of 1,900 tons of soil were removed from around the western and southern sides of the Anodyne building and replaced with clean soil.

Performance groundwater monitoring of wells that had been installed within the shallow zone of the aquifer also occurred during 2003 and 2004. Analytical results documented that the shallow groundwater had met all remedial goals.

When the performance standards for the Zone 1 soils and groundwater had been met for a period of six months, the "Construction Complete Report for Zone 1" dated November 2004 (URS, 2004) was submitted to the United States Environmental Protection Agency (USEPA). The "Construction Complete Report for Zone 1" was approved by the USEPA in 2004.

2.3 Zone 2: Deep Groundwater Contamination

The 1993 ROD selected the remedy of Pump and Treat (P&T) that consists of the following six components:

- Installation of additional monitoring wells to delineate the extent of the plume and performing aquifer tests to determine the hydraulic properties needed for the remedial design;
- Collection and treatment of the groundwater by air stripping;
- Injection of the treated groundwater under pressure back into the same aquifer;
- Long-term performance monitoring of the groundwater until RAOs are reached;
- Disposal of any untreated aquifer water from pumping tests performed for the remedial design; and
- Abandonment of the former injection well.

The ROD also specified the following RAO for the Zone 2 (deep groundwater):

- Reduce contaminant levels to or below acceptable risk levels (identified as being Safe Drinking Water Act [SDWA] maximum contaminant levels [MCLs]) for ingestion of groundwater pathway.

It had been determined by the baseline risk assessment (BRA) that the following COCs posed the greatest risk to human health through potential inhalation and ingestion (direct contact pathway). The BRA also determined that there were no other receptors or pathways at risk from the Zone 2 groundwater. The COCs and their respective groundwater remediation goals were identified for the Anodyne Site based on the State of Florida SDWA MCLs and are as follows:

- PCE – 3 micrograms per liter (μg/L)
- TCE – 3 μg/L
- cis- and trans-DCE – 70 μg/L and 100 ug/L
- VC – 1 μg/L

The original ROD was based on the extent of the groundwater plume in Zone 2 as delineated in 1992 (see Figure 2 in Appendix A). Since the original 1993 ROD, there have been two supplemental groundwater investigations in 2000 and 2004 to provide additional horizontal and vertical delineation. In addition, four groundwater sampling events (one each in 2000, 2004, 2005, and 2006; two each in 2013 and 2014) and a pilot study for enhanced bioremediation in 2009 were completed. Figure 11 in Appendix A shows the extent of the currently defined plume.

2.4 Expanded Site Investigations Post ROD for Zone 2

The following additional assessment activities were performed after the original ROD was issued:

1. Ten additional monitoring wells were installed by Bechtel Environmental, Inc. in 1995 to further delineate the site-related CVOC groundwater impacts both laterally and vertically. Monitoring well depths ranged from 18 to 140 feet (ft) below ground surface (bgs). The results of this investigation are summarized in the "1997 Groundwater Investigation Report" by Bechtel. This investigation confirmed the results of the RI showing that the shallow groundwater was not impacted by the facility operations; groundwater contamination was documented in the intermediate and deep monitoring wells.

2. In 2000, Foster-Wheeler (Foster-Wheeler, 2000a) completed a supplemental groundwater investigation to further characterize the groundwater with respect to the horizontal and vertical extent of CVOC impacts. Foster-Wheeler collected vertical groundwater samples for on-site analysis from 14 temporary monitoring borings, and then converted 12 of these boring locations into permanent monitoring wells.

This sampling data, collected from the installation of the monitoring wells where significant DCE was detected during drilling (RDA-20, RDA-24, RDA-30, TMW-01, RDA-25, RDA-29, RDA-28, RDA-19, TMW-2), shows that the highest DCE concentrations were consistently detected between 110 and 130 ft bgs. The field screening data for monitoring well RDA-26 reported concentrations of DCE over 1,000 μg/L at a depth of 110 ft bgs. This well was screened at 140-150 ft bgs. The results of this investigation provided additional delineation of the deep groundwater, and are summarized in the "2000 Supplemental Groundwater Investigation Report" by Foster Wheeler. Figure 3 in Appendix A show the results of this investigation.

3. Four additional monitoring wells (RDA-31 thru RDA-34) were installed by MicroPact in 2004 to provide additional delineation at the edges of the plume. MicroPact sampled these four new wells plus 29 of the existing 32 wells. These wells were placed in locations that were thought to be beyond the extent of the plume in order to provide a complete delineation. However, the sampling results from these four new wells indicated that they were not located at

the edges of the plume as had been planned, and that the plume extended further in the northern and southern directions than what was thought based on the previous sampling data.

Also, during the installation of new wells RDA-31 and RDA-33, the same was observed that was noted from the 2000 well installation by Foster-Wheeler. In RDA-31, the DCE concentration was the highest at a depth of 174 ft bgs, but there were also elevated concentrations of DCE noted in the 110 to 140-foot interval. Screen depths were set to correspond to the depths of highest field detections of TCE and DCE measured during vertical profiling performed during boring installations. Analytical results from the 2004 sampling events show that DCE was the CVOC detected most frequently, with concentrations ranging from non-detect (ND) to 1,100 μg/L. The detections of DCE were fairly widespread, with some of the highest concentrations occurring in the newly installed intermediate-depth monitoring wells located to the north and south of the former Anodyne Site (RDA-32 and RDA-33).

4. In 2005, MicroPact conducted a third supplemental groundwater investigation to further delineate the vertical and horizontal distribution of PCE, TCE, DCE, and VC (MicroPact, 2006). MicroPact also completed two sets of soil borings to a depth of 170 ft bgs, installing three nested wells in each boring (RDA-35 C, D, and E and RDA-36 C, D and E). Boring 35 was placed in a location again believed to be past the northern edge of the plume, and boring 36 was placed in a location believed to be past the southern edge of the plume. Both of the soil borings were converted into permanent multi-level monitoring wells that are screened over the aquifer at three discrete 20-ft intervals (100-120 ft bgs, 125-145 ft bgs, and 150 to 170 ft bgs). Both Figure 1 on Page 1 and Figure 11 in Appendix A shows the extent of the groundwater plume as identified in the 2005 investigation.

2.5 2009 Pilot Test

As a result of the larger size of the defined plume, a pilot test was conducted in 2009 to determine if more recent technologies would be more cost effective in remediating the levels of COCs in the groundwater then the pump and treat remedy selected in the 1993 ROD. A pilot study was performed by Terranear PPC, LLC in 2009 to evaluate the potential applicability of enhanced bioremediation as a remediation technique for the Zone 2 groundwater in lieu of the pump and treat detailed in the 1993 ROD. Two different treatment strategies (anaerobic and aerobic potential bioremediation amendments) were tested to evaluate their potential to attain the 1993 ROD RAOs.

- Two monitoring wells (RD-13C and RDA-31E) received injections of the hydrogen donor amendment products HRC-A and ABC Lactate, respectively (note: HRC-A has been reformatted since 2009 and is now called 3DMe by the vendor), which represented CVOC treatment by conventional in-situ enhanced reductive dechlorination (ERD) amendments.

- Three monitoring wells (RDA-20, MW-12C, and MW-9C) received injections of a co-metabolic amendment package involving aerobic degradation and hydrocarbon co-metabolites. The injected amendment package included ORC-A to provide oxygen to generate aerobic conditions and, Cl-Out to provide the hydrocarbon co-metabolites, and dextrose to provide another carbon source (also included co-metabolic microbe consortium).

Monitoring well MW-4C was amended with ORC-A only as a control to assess the effect of the Cl-Out microbial consortium at RDA-20 and MW-9C.

The pilot study results exhibited some positive results for both the aerobic co-metabolic and ERD treatment vehicles, and that both represent possible viable technologies for groundwater treatment at the Anodyne Site. However, the pilot study protocol was not intended to provide critical remedial design information related to the ability to uniformly distribute injected amendments throughout the complex, fractured geology in order to effectively contact the dissolved phase and residual CVOC mass in the aquifer necessary to affect treatment. There was no mention of flow rates, the effects of dispersion, preferential flow paths, or the many uncertainties of using a "push-pull" method of testing. A tracer study was not performed as part of the pilot study to track the amendment pathway and injection influence and distribution in the formation. Without knowledge of the distribution of the amendments and injection influence in the complex geology, it is difficult to predict the overall long-term effectiveness of a full-scale biological amendment injection system at this time. These data gaps will need to be filled as part of the remedial design (RD) phase.

Injection methods tend to preferentially deliver the amendments into the higher permeability zones in which the wells are screened, with less or no amendment entering into the lower permeability zones (often where much of the contaminant mass could reside). It is not known for the Anodyne Site what percentage of the CVOC residual and dissolved phase mass resides in less transmissive strata that may not be accessible to amendment injections, and could result in later rebound effects to groundwater concentrations following treatment (i.e., matrix diffusion). The effects from matrix diffusion and rebound from the less permeable zones is a common issue with all in-situ technologies. This is commonly addressed with soil sampling along with the performance monitoring to document the distribution of amendments within the formations.

2.6 Post-ROD Groundwater Monitoring for Zone 2

1. In May of 2006, MicroPact, Inc. conducted a sampling event that included 21 of the existing monitoring wells, plus the six newly installed monitoring wells, for a total of 27 wells (MicroPact, 2007). For this sampling event, DCE was again the primary CVOC detected in the groundwater samples, with concentrations ranging from ND to 810 μg/L. The distribution and extent of the DCE and VC plume was similar to the 2004 and 2005 sampling events, extending to both the north and south of the Anodyne Site.

The concentrations of DCE in the upper portion of the aquifer (<100 ft) ranged from 9.6 to 480 μg/L. The highest DCE groundwater concentration in the upper zone was from well RD-14C, located immediately to the northeast of the Anodyne facility. VC groundwater concentrations for monitoring wells with the same screened interval as RD-14C ranged from 3 to 190 μg/L, with the highest concentrations detected in RD-17C located southeast of the Anodyne Site.

The concentrations of DCE detected in wells screened between 101 and 149 ft bgs ranged between 1.4 μg/L and 390 μg/L. VC concentrations over this screened interval ranged from ND to 480 μg/L. The deepest wells associated with the Anodyne Site are screened between 150 and

180 ft bgs. DCE groundwater concentrations in these wells ranged from ND to 810 μg/L, while VC groundwater concentrations ranged from ND to 110 μg/L. PCE and TCE were not detected in wells screened at this deeper interval.

The results of the 2006 sampling event confirmed that the extent of the plume was larger than identified in the 1992 RI, and that the northern and southern extent has not been fully delineated. Both Figure 1 on Page 1 and Figure 11 in Appendix A, also show the extent of the groundwater plume delineated from the 2006 groundwater sampling results.

To confirm the sampling results identified in the 2009 pilot study report and trends identified in the "2007 MicroPact Sampling Report (MicroPact, 2007)", supplemental groundwater sampling events were conducted in 2011 and 2012 of selected wells. Because of the complex hydraulic characteristics that exist in the Biscayne Aquifer, a comparison of previous sampling techniques and purge volumes was performed in order to determine a sampling methodology that would provide reliable and comparable sampling results from event to event. Based on this comparison, it was recommended that groundwater samples be collected in a consistent manner during future events by purging 25 - 30 gallons using a downhole pump before samples are collected.

Three additional rounds of groundwater sampling were conducted at selected wells in January and June of 2013 and January of 2014 to obtain current groundwater analytical data. Overall, the recent groundwater analytical results confirm that the decreasing trends noted in the historical groundwater concentrations from 1991 to 2006. Several of the impacted wells appear to be experiencing plateau conditions within the last one to two years, which may result in a slower rate of natural reductive dechlorination in the future. The plateau conditions could be due to the subsurface geochemical environment, or small pockets of CVOC mass in the rock matrix that is slowing diffusing into the groundwater system.

Previous groundwater investigations at this site have consistently shown that detections of DCE and VC had the highest and most widespread concentrations. In more recent sampling events, PCE and TCE were detected in relatively few wells (two wells in 2013) and at low concentrations. Terrenear, PMC, LLC interpreted the relative larger distribution of DCE and VC, when compared to the distribution of PCE and TCE, as an indication that the reductive dechlorination processes had stalled at the DCE dechlorination step. The most common reasons for the "DCE stall" are inadequate reducing conditions (i.e., stronger reducing conditions must be sustained to degrade DCE/VC than PCE/TCE) or because the microbial populations responsible for degrading DCE and VC under anaerobic conditions were not present in sufficient numbers.

Some of the wells treated during the pilot study continue to show decreasing CVOC trends (13C and 31E) that could be the result of natural attenuation processes, or an artifact of the pilot study amendments that have allowed for the acclimation of the DHC microbes to the subsurface environment so that they support attenuation of the CVOCs. The 2012 and 2013 analytical results for the most northern and southern wells (RDA-35C and D to the north, and RDA-36 C and D to the south) have been consistently lower than the 2006 analytical results, indicating the plume size is stable or shrinking.

Post-ROD Microbial Testing

In December of 2013, Biotrap™ samplers from Microbial Insights were deployed in five selected wells to discover if indigenous microbes capable of dechlorination of CVOCs were present in the subsurface. Results from the Biotrap™ samplers seem to be consistent with the groundwater analytical results. The Biotrap™ results indicate the presence of Dehalococcoides (DHC) microbes and other reductase genes at low to moderate levels across the site, indicating that the DHC microbe populations do exist in the subsurface. The result from one sample was inconclusive, however. To confirm these results, additional samples were collected in July of 2014 from the same five wells plus two additional wells for a CENSUS® analysis for DHC and other reductive dechlorination bacteria. The DHCs counts measured in the Biotrap™ samplers and CENSUS® studies were orders of magnitude higher than levels measured during the pilot study in 2009. These data confirmed the 2013 results.

3.0 BASIS FOR THIS DOCUMENT

Despite the prior source removal activities for the Zone 1, groundwater CVOC concentrations in Zone 2 continue to persist at concentrations that exceed the remediation goals for protection of public health. Contamination continues to threaten human health and the environment through either direct contact with the deep groundwater or potential future ingestion of drinking water. The previous remedy selected in the 1993 ROD has not been implemented due to the results of several post-ROD site investigations showing a much larger plume than delineated during the RI exists in the groundwater. A 2010 pilot test also showed the potential for alternative technologies to treat this larger plume more effectively than the pump and treat technology identified in the original ROD.

The expanded site investigations documented a much more extensive plume than was considered in the 1992 Feasibility Study and for the 1993 selected remedy (pumping and above-ground treatment plus reinjection). In order to reduce contaminant concentrations and achieve RAOs in a reasonable time frame, the implementation of a more effective remedy is needed given the larger size of the deep groundwater plume. Treatment of groundwater is necessary to address risks from exposure, reduce CVOC mass flux to prevent further down gradient plume migration and degradation of groundwater quality and restore groundwater to its beneficial use.

A fundamental change is being made to the remedy selected in the original ROD in order to achieve overall remedy effectiveness and permanence, and have a much higher probability of achieving the ultimate RAO of groundwater restoration. The amended remedy selected in this AROD best satisfies the threshold criteria of protectiveness and compliance with applicable or relevant and appropriate requirements (ARARs), is expected to achieve substantial long-term risk reduction through treatment in a reasonable timeframe, and is cost effective.

Natural Attenuation and Lines of Evidence

As part of the investigations and consistent with EPA's 1998 Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, natural attenuation lines of evidence were identified in the 2004 MicroPact Groundwater Sampling Report. This report evaluated the existing groundwater data following the 1998 EPA Guidance referenced above, which indicated that natural attenuation processes were occurring in some parts of the plume.

Following procedures in the 1998 Guidance, MicroPact documented the indirect lines of evidence by scoring groundwater data collected from each well throughout the site. Scores ranged from 7 to 21 points, with 11 of the 34 wells scoring 15 or higher. According to the 1998 guidance, a score of 15 or greater indicates that biodegradation (natural attenuation) is likely to be occurring. The results of the 2005 natural attenuation scoring are also located on Figure 12 in Appendix A. A review of the groundwater data shows that the redox conditions and dissolved oxygen levels in the subsurface are reducing and generally anaerobic which favors natural attenuation. The presence of nitrate and sulfate levels in some groundwater samples may inhibit or slow the reductive declination reactions (See Figures 12 and 13 in Appendix A).

In other parts of the plume, the natural attenuation process may be inhibited by the subsurface geochemical conditions, or by the apparent high groundwater velocities that may exist in some subsurface zones resulting in a rapid turnover of groundwater pore volumes. This rapid turnover results in less residence time for impacted groundwater to be exposed to the microbes, and for the microbes to become acclimated to the subsurface geochemical conditions.

The post-ROD groundwater sampling results showed significant trends supporting eventual acclimation of the DHC microbial population and resulting natural reductive dechlorination throughout the Anodyne plume. Monitoring well RDA-32, located toward the northern part of the plume, exhibited an increasing followed by decreasing DCE and VC daughter product trend since its installation in 2004; while monitoring well RDA-33, located near the southern end of the plume, has exhibited a similar trend. This monitoring well also had detections of TCE and PCE in the 2012 sampling event, which may indicate that the source material has traveled this far with the groundwater flow during previous years. Prior to the pilot study event, source area monitoring wells RDA-31E and RDA-20 had begun to exhibit a decreasing DCE trend and increasing VC trend between the 2004 and 2006 sampling events with subsequent strong decreasing trends. Monitoring well MW-9D, located immediately down gradient of the source area, also exhibited a decreasing DCE trend and increasing/stable VC trend since the beginning of the RI sampling activities

Monitoring wells RD-16 and RD-17 were installed in 1995, and are both located down gradient from the source area. Historical sampling results from both wells show a trend of decreasing DCE concentrations (now less than 5 ug/L), along with a corresponding increase in VC concentrations (currently relatively stable) since the beginning of RI sampling activities. Monitoring wells MW-4C and MW-9C, both located in close proximity to the source area, have shown decreasing concentrations of PCE and TCE over time, with corresponding increases followed by decreases in concentrations of DCE and VC. This is the second line of evidence for natural attenuation (a direct line of evidence) as described in the 1998 Guidance. Concentration of DCE and VC have fluctuated over time in monitoring well MW-9C, while the trends of DCE and VC were more consistent for monitoring well MW-4C since the beginning of RI sampling activities. Wells MW-9C and MW-4C (in addition to RDA-31E and RDA-20 listed above) were used as injection wells in the pilot study, and thus received amendment injections in 2009, so are now considered biased for purposes of trend analysis.

Results from microbial analytical testing conducted in December 2013 indicate the presence of a DHC population capable of supporting reductive dechlorination. Measuring DHC populations is the third line of evidence (a direct line of evidence) for natural attenuation as described in the 1998 Guidance. The DHC populations were measured at levels between 10^1 to 10^4 cells/bead for the most part, indicating that reductive dechlorination could be supported. It is possible that higher microbial population counts existed during previous periods of downward CVOC groundwater concentration trends, but have decreased given the current lower concentrations. The measured microbial population counts could be enhanced by amendment injections (such as the HRC and ABC- Lactate tested in the 2009 push pull test by Terranear PPC, LLC) to promote further natural bio-stimulation and degradation of CVOC groundwater concentrations after a period of acclimation. The DHC microbes themselves can also be injected in the subsurface once the reducing conditions have been enhanced. However, the low CVOC concentrations now present at many of the monitoring wells may no longer be adequate to support further DHC growth to appreciably accelerate reductive dechlorination and the corresponding timeframe to attain the remediation goals.

4.0 DESCRIPTION OF SIGNIFICANT DIFFERENCES

The 1993 ROD selected remedy for the Zone 2 deep groundwater is described above in Section 2.1.3. The selected remedy included pumping of the groundwater for above-ground treatment by air stripping or UV light, then re-injecting the treated groundwater back into the aquifer.

4.1 Description of Selected Remedy

This AROD fundamentally amends the deep groundwater component of the selected remedy described in the 1993 ROD as follows:

- Eliminate the 1993 ROD requirement to install large capacity (300 – 500 gpm) recovery wells over the full extent of the CVOC plume.

- Eliminate the 1993 ROD requirement for on-site treatment of extracted groundwater by air stripping or UV light to regulatory discharge levels.

- Eliminate the 1993 ROD requirement for on-site re-injection of treated groundwater into the Biscayne aquifer via injection wells.

- Replace the current ROD pump and treat remedy with Alternative 3 from the May 2014 FFS, with more emphasis on the use of natural attenuation as the predominant groundwater remedy. In-situ bioremediation by ERD would be at targeted locations of higher CVOC groundwater concentrations to be refined during the remedial design/remedial action phase to accelerate the timeframe for natural attenuation to attain the remediation goals. Because of the degree of reductions in CVOC groundwater concentrations that have been realized since the original ROD and FFS preparation, the extent of proposed treatment for the source area component of the plume identified in the FFS Alternative 3 has been reconfigured to address the more current data from what the original assumptions used in the FFS.

- Retain the requirement for treatability studies to determine the most effective method of treatment and additional data collection necessary for the RD phase.

- Develop and implement a Long Term Monitoring program, including a sampling plan to collect groundwater samples from selected monitoring locations over time. The purpose for this monitoring and assessment program is to evaluate the remedy progress by comparing data trends before and after the OU1 Zone 2 remedy is implemented. This data will be used for the following:

  - Provide a baseline for future sampling events conducted after remedy implementation.

  - Refine the extent that the natural attenuation processes are reducing the levels of CVOCs and delineate the vertical extent where targeted in-situ bioremediation by ERD will be applied.

  - Provide data that can be used in designing a remedial action for targeted zones and fill in data gaps.

  - Monitor and evaluate the overall remedy effectiveness and progress of the OU1 Zone 2 remedy.

4.2 Basis For Proposed Changes

The Biscayne Aquifer is a Class I drinking water aquifer. The objective of the remedial action selected in the 1993 ROD for the Zone 2 groundwater was to restore the portions of the Biscayne Aquifer that have been impacted by the Anodyne Site to acceptable levels that allow potable use of the groundwater. An additional short-term objective for the deep groundwater zone includes a reduction in the mass flux of the CVOCs migrating toward the public water supply well fields that exist both to the north and south of the site.

Of the remedial technologies evaluated in 1993, the selected remedy contained in the 1993 ROD represented the best mix of technologies available at the time to achieve the goal of reducing the levels of COCs in the deep groundwater to levels that would no longer pose a threat to human health. However, the size of the plume identified in 1993 has increased almost 10 fold from approximately 23 acres to over 200 acres. Implementing the OU1 Zone 2 ROD on such a large scale would be technically infeasible and cost prohibitive. As such, EPA proposed completion of a revised FFS for the OU1 Zone 2 groundwater to evaluate innovative technologies, such as the use of an in-situ amendment (product) using a direct injection technology, which would promote the bioremediation by ERD of the CVOCs in the groundwater.

These types of amendments were not widely available and did not have a history of performance data in 1993 at the time of the original ROD, therefore were not considered at that time. Since 1993, various types of in situ remediation products became readily available from several vendors, and have been demonstrated to be effective in many instances of reducing contaminant levels in groundwater. Based on the May 2014 FFS, EPA is proposing to amend the OU1 Zone 2 ROD to include the use of in-situ remediation technology along with natural attenuation in place of the extraction and above-ground treatment of the Zone 2 groundwater proposed in the 1993 ROD.

The 1993 ROD requirement to use groundwater extraction and above-ground treatment was based on higher concentrations of CVOCs and a much smaller groundwater plume area. Since 1992, additional investigations have revealed a much more extensive groundwater plume area than previously delineated. While the groundwater plume area is larger, the overall concentrations and numbers of CVOCs have been declining since the 1993 ROD due to natural attenuation. These two factors reduce the cost effectiveness and feasibility of the remedy selected in the 1993 ROD of groundwater extraction and above-ground treatment.

A large and dilute groundwater plume exists at the Anodyne Superfund Site. The groundwater plume currently consists mostly of the daughter products DCE and VC with very little TCE and PCE. The isolated areas of higher groundwater concentrations of TCE and DCE found in the "source area" during the RI have exhibited decreasing concentration trends over time. These decreases suggest a limited amount of residual CVOC mass remaining in the source area, and an absence of dense non-aqueous phase liquid (DNAPL) mass in the form of free liquids and/or pools of accumulation. Recent sampling data also show that the plume is currently stable or shrinking in size and magnitude.

As described in Section 3.0, lines of evidence exist to indicate that natural attenuation processes are occurring throughout the plume, but may be inhibited in some areas or depths by the subsurface geochemical conditions or by the apparent high groundwater velocities that exist in some subsurface zones that would result in a rapid turnover of groundwater pore volumes. This rapid turnover results in less residence time for impacted groundwater to be exposed to the microbes, and for the microbes to become acclimated to the subsurface geochemical conditions. Results from the microbial sampling conducted in 2013 and 2014 indicate the presence of a DHC microbial population capable of supporting reductive dechlorination. However, some of these measured population counts are considered marginal regarding supporting continued natural reductive dechlorination at the current low CVOC groundwater concentrations.

Based on historic empirical evidence, it is possible that higher DHC microbial population counts existed during previous periods of downward CVOC groundwater concentration trends, but have decreased given the current lower concentrations. Other abiotic natural attenuation mechanisms involving naturally occurring species present within the aquifer matrix (e.g., iron or iron sulfides) may also be working in combination with biological attenuation mechanism based on current studies. This would also account for the marginal microbial population counts that were measured during the more recent sampling events. The measured DHC microbial population counts may be subject to enhancement by amendment injections that could promote further natural bio stimulation and degradation of CVOC groundwater concentrations after a period of acclimation. However, the low CVOC concentrations now present at many of the monitoring wells may no longer be adequate to support further DHC growth to appreciably accelerate reductive dechlorination and the corresponding timeframe to attain the remediation goals.

EPA is proposing to amend the 1993 ROD to include a combination of MNA with targeted bioremediation by ERD to enhance the attenuation rates of the CVOCs. Targeted treatment of residual CVOCs would provide the most cost effective use of in-situ ERD amendment injections. This would also reduce the overall timeframe for achieving the groundwater remediation goals by MNA by treating persistent pockets of higher CVOC groundwater concentrations that continue to "feed" mass flux to the down gradient portion of the plume that create the observed plateau conditions.

The estimated cost of implementing and monitoring the improvements of the amended remedy over the next 30 years is approximately $10,000,000. The amended remedy selected in this AROD is considered to be a final remedy for groundwater that will be protective of human health and will assist in achieving the long-term RAO of restoring the aquifer to its beneficial use as a drinking water source for the City of Miami Gardens.

4.3 Remedial Action Objectives

The general RAOs developed for this site in the original FS were to adhere to applicable governing regulations (ARARs), eliminate or reduce the need for long-term management, reduce toxicity, mobility and/or volume of waste and reduce the potential risk of exposure or direct contact with contaminated media both long term and short term during remediation. The remedial actions for the shallow groundwater and soil are considered complete.

The media considered during the development of RAOs for this AROD is the deep groundwater. According to the BRA, the total current and future carcinogenic and non-carcinogenic risks to residential populations arising from exposure to the deep groundwater exceed the range of acceptable risk. The RAO action identified in the 1993 ROD for the Zone 2 groundwater was to restore the portions of the Biscayne Aquifer that have been impacted by the Anodyne Site to acceptable drinking water standards. An additional short-term RAO for the deep groundwater zone includes a reduction in the mass flux of the CVOCs migrating toward the public water supply well fields that exist both to the north and south of the site.

4.4 Cleanup Levels

The EPA Safe Drinking Water Act (SDWA) MCLs are relevant and appropriate standards that need to be met throughout the plume. The 1993 OU1 Zone 1 and 2 ROD groundwater goals are based on the EPA MCLs and FDEP groundwater GCTLs for CVOCs.

The cleanup levels for the groundwater at Anodyne Site were identified in the 1993 ROD as follows:

- PCE – 3 ug/L (FDEP)
- TCE – 3 ug/L (FDEP)
- Cis-1,2-DCE - 70 ug/L (FDEP & EPA)
- Trans-1,2- DCE – 100 ug/L(FDEP & EPA)
- 1,1- DCE – 7 ug/L(FDEP & EPA)
- VC – 1 ug/L (FDEP)

The additional groundwater sampling that has occurred since preparation of the 1993 ROD has confirmed that the deep groundwater contains CVOCs, and that the extent of the CVOCs in the groundwater is greater than identified in the 1993 ROD. Current groundwater concentrations for the CVOCs still exceed the groundwater cleanup levels listed above.

5.0 FFS REMEDIAL ALTERNATIVES

Nine criteria identified in the National Contingency Plan (NCP) were used in the FFS to evaluate the different remedial alternatives individually and against each other in order to select a remedy. Given the complexity of the site, EPA developed five remedial action alternatives comprised of combinations of the general response actions and technologies identified, screened, and retained in the FFS. Each of the remedial alternatives described in the FFS included a combination of individual technologies designed to address the deep groundwater as described in the Conceptual Site Model (CSM).

Alternative 1: No Action

Alternative 1 would have provided no additional actions or documentation to determine if the groundwater concentrations were attenuating naturally. Based on the evaluations, this alternative is not protective and does not comply with ARARs.

Alternative 2: Monitored Natural Attenuation for Entire Plume

Alternative 2 would have added monitoring to provide documentation that natural attenuation would be effective to achieve the cleanup levels.

Alternative 3: Source Area Treatment and MNA for Remainder of Plume (Selected Remedy)

Alternative 3 included two types of amendment technologies for the source area.

1. **Alternative 3A: Source Area Treatment with In-situ Anaerobic Biological Treatment Using AROD Injections and MNA for Remainder of Plume.**

   In addition to the remedial components included previously in Alternative 2, Alternative 3A would also include in-situ anaerobic biological treatment within the defined source area by in-situ injection of a hydrogen-producing substrate amendment in the source area as defined above to create a strong reducing environment for enhanced bioremediation through reductive dechlorination.

2. **Alternative 3B: Source Treatment with In-situ Aerobic Biological Treatment Using Oxygen Sparging/Diffusion and MNA for Remainder of Plume.**

   In addition to the remedial components included previously in Alternative 2, Alternative 3B would also include in-situ aerobic biological treatment within the defined base source area by oxygen sparging/diffusion.

Alternative 4: CVOC Migration Control and MNA for Entire Plume

Alternative 4 also included 2 variations based on the technology that would be utilized for migration control.

1. **Alternative 4A: Pump and Treat and MNA for Entire Plume.**

   Alternative 4A is the remedy selected in the 1993 ROD for Zone 2 Groundwater, which includes all of the components of Alternative 2 (MNA) plus a P&T system for CVOC migration control.

2. **Alternative 4B: In-situ Anaerobic Biological Treatment Barrier and MNA for Entire Plume**

   Alternative 4B would consist of all the components outlined for Alternatives 2 (MNA) and 3A with installation of two down gradient in-situ barrier walls (one each for the northern and southern lobes of the plume) that incorporate in-situ anaerobic biological treatment using amendment injections in the same manner as described for Alternative 3A. The barrier walls would serve to mitigate CVOC mass flux further down gradient at their respective locations. The influence area created by the injected amendments would create a treatment cell that would degrade the CVOC mass at that location and reduce/mitigate the mass flux further down gradient as the CVOCs within the groundwater travel through the barrier.

Alternative 5: Source Area Treatment, CVOC Migration Control, and MNA for Remainder of Plume

Alternative 5 would consist of all components outlined in Alternatives 3 and 4. This alternative combines both source area treatment and down gradient CVOC migration control. Any combination of the two source area treatment technologies described for Alternative 3 and the two CVOC migration control technologies described for Alternative 4 could be used as part of Alternative 5.

Alternative 6: Total Plume Treatment with In-Situ Anaerobic Biological Treatment Using AROD Injections and MNA as Needed to Attain RAOs

Alternative 6 represents the highest level of plume treatment of the remedial alternatives and would achieve the greatest amount of CVOC mass reduction. It is the only remedial alternative that would treat the entire plume, and therefore relies less on natural attenuation to achieve RAOs than the other remedial alternatives. This alternative also would have the highest cost.

5.1 Description of New Alternatives for Deep Groundwater

5.1.1 Alternative 1: No Action

Estimated Capital Costs: 0
Estimated Annual O&M Costs: 0
Estimate Present Worth Costs: 0
Estimated Construction Timeframe: 0
Estimate Time to Achieve RAOs and Cleanup Levels: Same estimated 50 to 60 years as for MNA, but would not be able to determine if achieved due to no action.

The no action alternative is required to be evaluated under the CERCLA process as a baseline for comparison of other alternatives. For this alternative, there would be no actions taken at this site. This alternative was addressed in the 1993 ROD also, and was included in the FFS to satisfy NCP requirements.

This alternative would have not provide the public any level of protection from exposure to groundwater contaminated with CVOCs. Groundwater would not be actively treated to reduce CVOC concentrations, nor would CVOC migration control be included to mitigate continuing mass flux throughout the plume or possible further down gradient migration of the plume. The BRA identified unacceptable potential human exposure risks associated with impacted groundwater. Based on this evaluation, this remedial alternative would not be protective of human health nor restore the groundwater during the length of time that it would take for the natural processes to attain RAOs. Groundwater restoration would not be able to be verified due to the nature of the no action alternative.

5.1.2 Alternative 2: Monitored Natural Attenuation for Entire Plume

Estimated Capital Cost: $100,000
Estimated Annual O&M Cost: $293,156
Estimated Present Work Cost: $4,606,525

Estimated Construction Timeframe: 1 year
Estimated Time to Achieve RAOs and Cleanup Levels: 50 to 60 years

Alternative 2 would consist of MNA, long-term groundwater monitoring (LTM) and the implementation of administrative measures (referred to in broad context as ICs throughout the remainder of this AROD). The plume would attain RAOs by natural attenuation. Under Alternative 2, ICs would implemented to restrict the use of groundwater to protect human health. No active remedial technology would be implemented to reduce the volume or concentrations of CVOCs within the plume. MNA would be monitored through a LTM program to monitor and document the changes in CVOC concentrations and distribution over time and progress towards achieving cleanup levels and the RAOs. Selected wells would be monitored periodically for CVOCs and natural attenuation parameters to document the rate of attenuation until cleanup levels and RAOs are achieved. In addition, ICs, such as restricting groundwater access for consumption and irrigation and property owner notification. Natural attenuation is considered to be effective in reducing low concentrations of contaminants to acceptable levels if the source material has been removed, and if the geochemical and hydrological conditions in the subsurface continue to be conducive to the degradation of CVOCs at the site.

Alternative 2 would consist of the following components:

- Natural attenuation of CVOCs;
- LTM and periodic progress reporting;
- ICs; and
- Five-year site reviews.

Historical sampling data indicates that natural attenuation is occurring at the site, with more recent sampling data collected during 2012, 2013, and 2014 showing RAOs already being met or almost met at several monitoring locations that previously exhibited elevated DCE and VC concentrations. The projected timeframe for natural attenuation to attain RAOs is 50-60 yrs, which is consistent with other CERCLA sites that have CVOC groundwater plumes with similar concentrations. The results from the most recent sampling events suggest that the timeframe to achieve MCLs throughout the plume would be consistent with or less than this projection. The key ARARs for this alternative are the EPA MCLs and the FDEP GCTLs and chemical ARARs discussed in Section 8.2.

5.1.3 Alternative 3: Source Area Treatment and MNA for Remainder of Plume (Selected Remedy)

Alternative 3 would consist of all the components from Alternative 2 plus:

- In-situ bioremediation by Enhanced Reductive Dechlorination (ERD).

The ERD technology would consist of injecting an amendment into the subsurface at the elevations where the CVOCs are located. The amendment would enhance the subsurface conditions to make the conditions favorable for the DHC microbes that exist in the subsurface to flourish, thereby accelerating the dechlorination processes of the CVOCs.

This alternative includes treatment of the source area within and/or in close proximity of the property boundaries of the Anodyne Site, and will be focused in the areas of the highest measured CVOC groundwater concentrations around monitoring well RDA-31E (@ 400 ug/L for DCE) and areas to the southeast and northeast. The defined groundwater middle zone (100 – 140 ft bgs) would be the primary depth interval targeted for source area treatment, while the defined deeper zone (170-180 ft bgs) will also be targeted for treatment in the area of the former injection well(s) and monitoring well RDA-31E.

Source area treatment would be performed to reduce the continued mass flux of CVOCs feeding the groundwater plume, which in turn should accelerate natural attenuation rates and reduce attenuation timeframes throughout the remainder of the groundwater plume. Two separate types of treatment technologies (aerobic and anaerobic) were evaluated for the source area treatment component of this Alternative.

The EPA has modified the source treatment component of Alternative 3 from the FFS (i.e., would not be utilizing a grid throughout the identified source area described in the FFS for Alternative 3) for purposes of this AROD to include more localized targeted active treatment at selected locations identified as having consistently higher CVOC groundwater concentrations (TCE @ 100 ug/L, DCE @ 300 ug/L and VC @ 150 ug/L on average). The concentrations of the CVOCs in these locations are persistent and which could be a result of the subsurface groundwater geochemistry or may be suspected as being a residual CVOC source mass area or where immobilized CVOC residual mass may reside. This could include down gradient plume locations, which also differs from Alternative 3 of the FFS. The locations for the targeted active treatment would be identified based on their persistent elevated CVOC concentrations as described above during the remedial design/remedial action phase.

The continuing decreasing trends in CVOC groundwater concentrations since the original ROD and preparation of the FFS has demonstrated the efficacy of natural attenuation, while also reducing the area of higher concentrations warranting active treatment. As previously discussed, a point of diminishing returns is often realized for ERD treatment, where low CVOC groundwater concentrations will not support DHC microbial growth that would appreciably reduce the remediation timeframe versus MNA.

Remedial timeframe estimates for Alternative 3 ranged between 20-30 years for portions of the plume influenced by the source area treatment and 30-40 years for down gradient portions of the plume beyond the influence of the source treatment area. Since the selected remedy has modified Alternative 3, where active treatment would be performed on a more targeted basis but at any location throughout the plume, the projected remediation timeframe to attain the remediation goals throughout the plume ranges between 20 and 40 years. ICs would remain in place until RAOs would be achieved. Key ARARs are the MCLs, GCTLs and the chemical specific ARARs listed in Section 8.2.

- **Alternative 3A: Source Area Treatment with In-situ Anaerobic Biological Treatment Using Amendment Injections and MNA for Remainder of Plume**

Estimated Capital Costs: $15,943,527

Estimated Annual O&M Costs: $315,306
Estimate Present Worth Costs: $20,789,550
Estimated Construction Timeframe: 1 year
Estimate Time to Achieve RAOs and Cleanup Levels: Estimated 30 – 40 years.

In addition to the remedial components included previously in Alternative 2, Alternative 3A would also include in-situ anaerobic biological treatment within the defined source area by in-situ injection of a hydrogen-producing substrate amendment in the source area as defined above to create a strong reducing environment for enhanced bioremediation through reductive dechlorination.

- **Alternative 3B: Source Treatment with In-situ Aerobic Biological Treatment Using Oxygen Sparging/Diffusion and MNA for Remainder of Plume.**

Estimated Capital Costs: $10,393,378
Estimated Annual O&M Costs: $624,056
Estimate Present Worth Costs: $17,270,075
Estimated Construction Timeframe: 2 years
Estimate Time to Achieve RAOs and Cleanup Levels: Estimated 30 to 40 years.

In addition to the remedial components included previously in Alternative 2, Alternative 3B would also include in-situ aerobic biological treatment within the same defined source area for Alt. 3 A by oxygen sparging/diffusion.

5.1.4 Alternative 4: CVOC Migration Control and MNA for Entire Plume

CVOC migration control should prevent down gradient CVOC mass flux from continuing to feed further plume migration, which in turn should accelerate natural attenuation of CVOCs in the dissolved phase plume that may extend beyond the influence of the migration control system and the current monitoring well network. Technologies identified for CVOC migration control would be performed at down gradient locations and focus on reducing further mass flux of the CVOCs. Two CVOC migration control technologies/process options were evaluated for Alternative 4. These were Pump and Treat (P&T), the selected remedy from the 1993 ROD, and an in-situ anaerobic barrier wall treatment.

- **Alternative 4A: CVOC Migration Control Using Pump and Treat and MNA for Entire Plume**

Estimated Capital Costs: $3,595,500
Estimated Annual O&M Costs: $1,591,256
Estimate Present Worth Costs: $28,057,003
Estimated Construction Timeframe: 2 years
Estimate Time to Achieve RAOs and Cleanup Levels: Estimated 30 to 40 years.

Alternative 4A is the remedy selected in the 1993 ROD for Zone 2 Groundwater, which includes all of the components of Alternative 2 plus a P&T system for CVOC migration control. Pump and Treat systems remove the groundwater from the subsurface and treat the water above ground. The treated water is then injected back into the subsurface, at a location down gradient of the treatment area. ICs would remain in place until RAOs are achieved. Key ARARs are those listed as the chemical and monitoring/injection well ARARs in Table 8.2.

- **Alternative 4B: CVOC Migration Control Using In-situ Anaerobic Biological Treatment Barrier and MNA for Entire Plume**

Estimated Capital Costs: $11,347,470
Estimated Annual O&M Costs: $257,543
Estimate Present Worth Costs: $15,306,537
Estimated Construction Timeframe: 1 year
Estimate Time to Achieve RAOs and Cleanup Levels: Estimated 30 to 40 years

Alternative 4B would consist of all the components outlined for Alternatives 2 and 3A, with the CVOC migration control component consisting of two down gradient in-situ barrier walls (one each for the northern and southern lobes of the plume) that incorporate in-situ anaerobic biological treatment using amendment injections in the same manner as described for Alternative 3A. The barrier walls would facilitate the growth of the DHC bacteria within the location of the barrier wall that provide reductive dechlorination as the CVOCs pass through the wall. This would serve to mitigate CVOC mass flux further down gradient at their respective locations. The influence area created by the injected amendments would create a treatment cell that would degrade the CVOC mass at that location and reduce/mitigate the mass flux further down gradient.

Alternative 4B and 4A would provide migration control to reduce or cut off mass flux of CVOCs to the areas of the plume located down gradient of the influence of the containment system, thereby providing a method intended to prevent further plume migration. Active treatment to satisfy the NCP preference is represented by the CVOC migration control technologies, but would not be as robust as the source treatment or total plume treatment technologies represented by the other remedial alternatives with the exception of Alternative 2. Key ARARs are those listed as the chemical and monitoring/injection well ARARs in Table 8.2.

5.1.6 Alternative 5: Source Area Treatment, CVOC Migration Control, and MNA for Remainder of Plume

Estimated Capital Costs: $13,988,878
Estimated Annual O&M Costs: $2,215,312
Estimate Present Worth Costs: $45,327,078
Estimated Construction Timeframe: 2 years
Estimate Time to Achieve RAOs and Cleanup Levels: 30 – 40 years

Alternative 5 would consist of all components outlined in Alternatives 3 and 4. This alternative combines both source area treatment of the in-situ injections of a bioremediation amendment and the down gradient CVOC migration control of either a barrier wall or pump and treat system.

Any combination of the two source area treatment technologies described for Alternative 3 and the two CVOC migration control technologies described for Alternative 4 could be used as part of Alternative 5. This alternative would reduce both the CVOC mass within the source area and the mass flux of CVOCs from the source area to the down gradient parts of the plume, while also cutting off down gradient mass flux at the point of the CVOC migration control.

Alternative 5 would provide source area treatment, which would be consistent with the NCP preference for active treatment. Treating the source area should result in accelerating the degradation of the residual CVOC mass, thus increasing the overall level and rate of CVOC mass removal and reducing mass flux from the source area. Source area treatment could accelerate natural attenuation rates, which in turn would reduce the remediation timeframe versus natural attenuation alone for certain hydraulic characteristic scenarios in the down gradient portions of the plume. The overall result of source area treatment would be an acceleration of the reduction in the CVOC groundwater concentrations within the treatment zones. Key ARARs are those listed as the chemical and monitoring/injection well ARARs in Table 2 in Section 8.2.

5.1.7 Alternative 6: Total Plume Treatment with In-Situ Anaerobic Biological Treatment Using Amendment Injections and MNA as Needed to Attain RAOs.

Estimated Capital Costs: $77,745,660
Estimated Annual O&M Costs: $326,565
Estimate Present Worth Costs: $80,265,693
Estimated Construction Timeframe: 2 years
Estimate Time to Achieve RAOs and Cleanup Levels: Estimated 15 - 20 years

Alternative 6 would consist of the following components:

- In-situ anaerobic biological treatment of the "total groundwater plume" using amendment injections;
- LTRA and periodic progress reporting; and
- Five-year site reviews.

Alternative 6 represents the highest level of plume treatment of the remedial alternatives and would achieve the greatest amount of CVOC mass reduction. It is the only remedial alternative that would involve total plume treatment, and thus has a much lower reliance on natural attenuation to achieve RAOs than the other remedial alternatives. This alternative would satisfy the NCP preference for active treatment. Because of the incorporation of total plume treatment, this alternative also represents the highest level of protectiveness of the remedial alternatives and would achieve RAOs in the shortest remediation timeframe. Because this alternative offers the greatest amount of plume treatment and reduction of CVOCs, it represents the best chance to achieve RAOs and would also result in accelerating the timeframe projected to meet the RAOs.

5.2. Recommended Alternative: Modified Alternative 3A MNA for Entire Plume Plus Targeted In-situ Anaerobic Biological Treatment Using Amendment Injections for Selected Zones within Plume.

A modified version of Alternative 3A (See Figure 14 in Appendix A) is recommended as the final remedy in this AROD. This remedial alternative has been evaluated against the 9 criteria (see Section 6.0 below) and would address the current site conditions in an expeditious and cost effective manner once the data gaps are filled and the treatment areas can be targeted to address only those zones that are transmitting the CVOCs. Site conditions favoring the choice of Alternative 3A include the large size of the plume, the shrinking or stable CVOC groundwater concentrations, the complex hydrogeology, and the documentation that microbial populations exist at some levels that would support reductive dechlorination. Alternative 3A would be scaled back to address targeted areas of sustained higher CVOC groundwater concentrations(TCE @ 100 ug/L, DCE @ 300 ug/L and VC @ 150 ug/L on average) that are showing plateau conditions after further evaluation. The addition of an amendment to enhance the subsurface conditions that will allow the DHC microbes to flourish will result in the acceleration of the dechlorination processes that will reduce the CVOC concentrations in the source area. The reduction in CVOC groundwater concentrations in many areas within the source area negates the need for total source area treatment as described in Alternative 3A or 3B in the FFS.

Targeted in situ treatment of residual CVOCs would also provide the most effective use of in-situ amendments, and reduce the overall timeframe for achieving RAOs through MNA by treating persistent pockets of higher CVOC groundwater concentrations that continue to "feed" mass flux to the remainder of the plume that create the observed plateau conditions. Any amendment selected should be designed for applications in bedrock and for long-acting rebound applications (e.g., longer acting amendments designed to cling to rock surfaces and not be flushed out by high groundwater velocities). Lines of evidence exist to indicate that natural attenuation processes are occurring in some parts of the plume, but may be inhibited by the subsurface geochemical conditions or by the apparent high groundwater velocities that exist in some subsurface zones that would result in a rapid turnover of groundwater pore volumes. This rapid turnover results in less residence time for impacted groundwater to be exposed to the microbes, and for the microbes to become acclimated to the subsurface geochemical conditions.

6.0 COMPARISON OF SELECTED AMENDED REMEDY AND ALTERNATIVES

This section compares the relative performance of the original selected remedy, with the amended remedy selected in this AROD and the other alternatives that were considered but not selected against the nine criteria, noting how both the original and the new amended remedy compare to the other options under consideration. The more complete comparative analysis of all six remedial alternatives is presented in the FFS, which is part of the Administrative Record.

The nine criteria are in three categories; threshold, primary balancing, and modifying criteria. Threshold criteria must be met by an alternative for an alternative to be eligible for selection. Primary balancing criteria are used to weigh major trade-offs among eligible alternatives. Modifying criteria by their nature are fully considered after comments are received on the Proposed Plan.

The nine evaluation criteria are summarized below:

TABLE 1: EVALUATION CRITERIA FOR SUPERFUND REMEDIAL ALTERNATIVES
Threshold Criteria
Overall Protectiveness of Human Health and the Environment requires that an alternative adequately eliminates, reduces, or controls threats to public health, welfare or the environment through all the means it selects, including institutional controls (ICs).
Compliance with ARARs requires that an alternative meets all federal and stricter state environmental statutes and regulations, or that such requirements be formally waived.
Primary Balancing Criteria
Long Term Effectiveness and Permanence compares the capacity of alternatives to maintain protection of human health, welfare and the environment over time.
Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment compares the use of treatment to reduce the harmful effects, ability to move in the environment, and quantity of principal contaminants of concern.
Short-term Effectiveness compares the length of time needed to implement alternatives and the risks to workers, residents, and the environment during implementation.
Implementability compares the technical and administrative feasibility of implementing alternatives, including factors such as relative availability of goods and services.
Cost compares estimated capital and annual operation and maintenance (O&M) costs expressed as present-worth costs. Present-worth is the total cost of an alternative over time in terms of current value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
Modifying Criteria
State/Support Agency Acceptance compares state/support agency preferences/views on EPA's remedy selection and analyses as compiled in the Proposed Plan.
Community Acceptance compares affected community preferences/views as reflected in public comments on EPA's remedy selection and analyses as compiled in the Proposed Plan.

6.1 Threshold Criteria

6.1.1 Overall Protection of Human Health and Environment.

The selected remedy (Modified Alternative 3A) would provide overall protection of human health and the environment by a combination of the targeted treatment of selected areas where the matrix diffusion and high transmissivities have created "plateau" conditions within the plume and by natural attenuation for the remainder of the plume. Monitoring and reporting would confirm that treatment and attenuation were progressing towards the attainment of RAOs.

ICs would add another layer of protection and would notify residents of the potential risks for using groundwater from within the plume and would restrict groundwater use in the area, also providing for the protection of human health. The Site is located within an FDEP "Delineated Area" which does not allow the installation of groundwater wells without FDEP approval. In order to ensure continued protectiveness of ICs at this Site, the EPA may consider additional administrative measures, including: (1) following procedures for information sharing and assistance in implementation of ICs, as outlined in the Memorandum of Agreement signed between EPA and the South Florida Water Management District on March 11, 2010; (2) identifying parcels within the plume boundary that would be entered in Miami-Dade County's "tickler system" and alert the EPA to any well permit requests; and (3) sending individual notifications of potential groundwater contamination to affected property owners.

The 5-year reviews would confirm that the ICs were in place, and that the CVOC concentrations were being reduced by natural attenuation. Targeted treatment of plateau areas would result in the overall reduction of CVOC concentrations by both enhanced bioremediation and natural attenuation processes. A reduction in the CVOC concentrations within these areas would translate to less mass flux in the dissolved phase moving down gradient. The overall result would be the protection of human health and the environment.

Alternatives 1 and 2 would provide far less protection of human health as would Alternative 4 and 5, which provides for containment outside the source area. The combined source area treatment and CVOC migration control provided by Alternative 5 could result in increased overall protectiveness that may also reduce the timeframe for achieving the RAOs throughout the plume. Alternatives 5 and 6 would provide a similar or greater level of protectiveness; however, the selected remedy would be much less intrusive and would leave a much smaller footprint (after implementation) which makes it overall comparatively more protective of human health. Alternative 5 would then be more protective of overall human health and the environment than Alternatives 2, 3, and 4, but not provide total plume treatment that is included with Alternative 6.

6.1.2 Compliance with ARARs

All of the alternatives evaluated in the FFS are expected to comply with ARARs; however the timeframes for each are difficult to project with a high degree of confidence, given the uncertainties involved. Alternatives 1 and 2 would take the longest time to achieve RAOs. The difference between Alternatives 1 and 2 is that for Alternative 1 there would be no provision for documentation of the RAOs being achieved. Alternative 4 would also be expected to have an extremely long timeframe before achieving RAOs in the source area.

The selected Remedy (a modification of Alternative 3A) would comply with ARARs in a shorter timeframe than Alternatives 1, 2 and 4 and would provide documentation that the ARARs have been achieved. Alternative 5 would be expected to achieve RAOs in a similar timeframe as Alternative 3A, while Alternative 6 was designed to take the least amount of time to achieve RAOs than the other alternatives through treatment of the CVOCs within the entire plume.

6.2 Balancing Criteria

6.2.1 Long-Term Effectiveness and Permanence

The historical groundwater sampling data shows a decreasing trend in CVOC concentrations throughout the plume as a result of natural attenuation mechanisms and have documented subsurface conditions that are conducive to anaerobic dechlorination. Biological parameters measured during the pilot study and during the recent groundwater sampling events indicate that the appropriate microbes (i.e., DHCs) exist in the subsurface for the reductive dechlorination of DCE and VC; therefore, natural attenuation by biological degradation is projected to be effective in reducing CVOCs to eventually attain RAOs.

Both Alternatives 1 and 2 would provide long-term effectiveness as eventually the concentrations of the CVOCs in the groundwater would degrade, and RAOs would be achieved by natural attenuation processes. The effects of these processes would be permanent. The long-term reliability of Alternative 2 would also be dependent on maintaining the ICs.

For Alternatives 3, 5 and 6, the aerobic or anaerobic degradation of CVOCs for the source area treatment would be irreversible; therefore, these alternatives would have long-term effectiveness and permanence. Monitoring would provide evidence of the effectiveness of the treatment. Alterative 3 is designed only to treat the source area due to the extremely large size of the plume and the complex geology documented for the Biscayne Aquifer. The higher transmissivities of some of the aquifer units would transport the amendments down gradient of the source area (as the CVOCs were originally transported from the source), which should also increase the protectiveness of the treatment down gradient of the application area for this alternative. This down gradient transport of the amendments may also create a stronger reducing environment in the down gradient direction for the anaerobic biological treatment alternative (in the case of Alternative 3A), which should also result in an enhanced attenuation rate away from the source area. However, matrix diffusion processes could occur within the source area or down gradient areas that may induce some uncertainty in the timeframe to achieve RAOs.

Alternative 4 would include CVOC migration control barriers, but no source area treatment. If the rates of attenuation are such that the plume is receding, as appears to be the case, then a CVOC migration control approach may only provide a marginal incremental benefit to the effectiveness of natural attenuation to attain RAOs throughout the plume. Therefore, there is a high level of uncertainty that RAOs and cleanup levels would be achieved with alternative 4. The primary function of a CVOC migration control system is to reduce the mass flux of CVOCs down gradient and corresponding expansion of a plume. Alternative 5 would provide some long-term effectiveness and permanence in the source area and down gradient areas as both the source area would be targeted for active treatment and the down gradient barriers would reduce the CVOC concentrations as the groundwater passes through the barriers. Alternative 6 would provide the highest level of long-term effectiveness and permanence as the entire plume would be actively treated.

6.2.2 Reduction of Contaminant Toxicity, Mobility and Volume through Treatment

Alternatives 1 and 2 provide no active treatment for the CVOCs in the groundwater; therefore, no reduction of toxicity, mobility, or volume would result from any treatment. These alternatives would eventually result in the reduction of mass and, therefore, toxicity of the CVOCs through natural attenuation processes, but without treatment.

Alternative 3 (including 3A and 3B) would provide treatment that is designed to reduce the toxicity and volume of the CVOCs in the source area of the groundwater through biological degradation by reductive dechlorination. As such, Alternative 3 involves source mass reduction that would be considered consistent with the NCP's preference for treatment. Treating the source area typically results in accelerating the degradation of the residual CVOC mass, thus increasing the overall level and rate of CVOC mass removal and reducing mass flux from the source area. The mobility of the CVOCs would not be reduced by this alternative, but the concentrations and mass of CVOCs migrating with the groundwater would be reduced. Source area treatment can facilitate and accelerate natural attenuation rates, which in turn can reduce the remediation timeframe. The overall result of source area treatment would be an acceleration of the reduction of concentrations of CVOC within the treatment zones.

One advantage of Alternative 3 is that the use of amendment additions in the source area to enhance biodegradation processes would result in a shifting of the subsurface redox state that could tend to increase the rate of desorption and diffusion of the CVOCs from the areas of lower permeability and increase the level of CVOC mass reduction in the source area. This effect would also result in a greater increase in the overall CVOC mass removal rate in the source area, and serve to reduce the effects of matrix diffusion within the treated area. These types of CVOC mass reduction enhancements resulting from treatment amendment additions in the source area would not occur under Alternatives 2 or 4. Alternatives 5 and 6 would provide the same level of source area treatment as Alternative 3.

Alternative 4 evaluated two different options for CVOC migration. CVOC migration control would serve to reduce the mass flux of CVOCs in the groundwater toward the down gradient portions of the plume. The mobility of the contaminants would not be reduced by this alternative, but the removal of the CVOCs through treatment would result in a reduction of the CVOC mass and toxicity migrating with the groundwater down gradient of the influence of the CVOC migration control systems. Containment alternatives do not meet the statutory requirement of preference for treatment and the NCP's preference for treatment of principal threats.

Alternative 5 would result in a greater reduction of contaminant mass and volume than Alternatives 1 thru 4, since it combines the treatment elements of Alternatives 3 and 4. As with Alternative 3, this alternative includes treatment to reduce the toxicity and volume of the CVOCs in the groundwater through biological degradation by reductive dechlorination. Alternative 5 involves source mass reduction that would be considered consistent with the NCP's preference for treatment of principal threats. The mobility of the CVOCs would not be reduced by this alternative, but would reduce the concentrations and mass of CVOCs in the groundwater. The CVOCs within the area treated would have the greatest rate of reduction of mass (and therefore toxicity), while the remainder of the plume would experience a reduction at a slower rate as natural attenuation progresses.

Because of the uncertainty concerning the effects of matrix diffusion of CVOCs that have previously diffused into the rock matrix back into the groundwater, the CVOC migration control provided by Alternatives 4 and 5 may not provide incremental benefits versus Alternatives 2 and 3. The back diffusion of CVOCs from the matrix could provide low levels of CVOCs to the groundwater that would affect the CVOC mass flux and the timeframes estimated for reducing or stable plume size scenarios that are likely to exist at the Anodyne Site by natural attenuation.

Alternative 6 reduces the toxicity and volume of the CVOCs in the groundwater through biological degradation by reductive dechlorination through the entire plume, which is on a much larger scale than the other alternatives. Alternative 6 involves source mass reduction that would be considered consistent with the NCP's preference for treatment. The mobility of the CVOCs would not be reduced by this alternative, but the concentrations and mass of CVOCs would be reduced throughout the entire plume. This alternative is intended to treat the entire plume and does not rely on natural attenuation to achieve cleanup levels and RAOs.

6.2.3 Short-Term Effectiveness

With Alternative 1 there would be no treatment to increase the rate of degradation; therefore, this alternative would provide no short-term benefit or enhancements to the short-term effectiveness. This alternative would also offer no improvement for short-term effectiveness with respect to human health and the environment, but would not pose any safety issues to workers or the public.

Since no active treatment is involved for Alternative 2, the short-term effectiveness would also be minimal as natural attenuation represents a long term remedial process. Historical sampling data indicate that natural attenuation is occurring. This alternative relies solely on natural attenuation to achieve cleanup levels and RAOs. As the degradation of DCE progresses by natural attenuation, concentrations of VC in the dissolved phase may increase in the short term. The VC that is generated from the reductive dechlorination could migrate quickly down gradient within the higher velocity/transmissivity aquifer units, resulting in increased concentrations in the down gradient portions of the plume. VC accumulation could occur in portions of the plume that are highly anaerobic and an insufficient DHC population exists to complete the degradation process.

Alternative 3 relies on anaerobic or aerobic enhanced bioremediation. A pilot study was conducted using technologies to be applied for the purpose of enhanced bioremediation. Results indicated that the subsurface environment responded as expected to these amendments within the six-month timeframe that the study was conducted. The injection of a hydrogen producing amendment would transform the groundwater from a mildly reducing environment to a strongly reducing environment in the area where the amendment is injected within six months to one year after injection. This aerobic biological treatment option would result in increasing the DO concentration in the subsurface as soon as the system was started, immediately having an effect on the environment. The system would operate continuously to provide a source of DO that would continuously migrate with the groundwater or diffuse into the formation. Therefore, Alternative 3 provides a reasonable level of short-term effectiveness for the environment. Similarly, it is believed that Alternative 5 would provide a reasonable level of short-term effectiveness for the environment.

Due to the depth of the affected groundwater at this site, any on-site workers or construction workers in the area would not be at risk of contact with the CVOCs; therefore, any treatment would not significantly affect the short-term effectiveness of the alternative with respect to potential human receptors. There could be potential safety issues for the public and for site workers during installation of injection points, because of the likely location of wells in right-of-ways along roads or in roadways where high concentrations of vehicle traffic would occur. The safety issues would also be a consideration during operation and maintenance activities.

Alternative 4, which utilizes CVOC migration control technologies, may yield minimal mass removal in the source area or throughout the up gradient portion of the plume. It would not have any impact on the natural attenuation timeframe to achieve RAOs within the current boundaries of the delineated plume and therefore very little short term effectiveness.

Due to the depth of the aquifer and affected groundwater, any on-site workers or construction workers in the area would not be at risk of contact with the CVOCs; therefore, any treatment would not significantly affect the short-term effectiveness of the alternative with respect to potential receptors. The construction activities for both CVOC migration control options, as with the other alternatives, may have potential safety issues for the public and for site workers during installation of wells and piping (as well as long-term maintenance activities), because of the likely location of wells in right-of-ways along roads or in roadways where high concentrations of vehicle traffic would occur. The P&T option poses a greater level of potential public and safety issues during construction and O&M activities, because of the amount of subsurface trenching and piping installation that would also be involved and the higher likelihood that extraction wells may need to be located closer to roadways. P&T also poses potential safety issues to the public and the environment because of the potential for subsurface and above-grade releases during operation.

Alternative 6 would provide the greatest short-term impact as most or all of the plume area would be subject to treatment. Since natural attenuation would not solely be relied upon to attain RAOs, Alternative 6 would offer the most aggressive level of short-term effectiveness for the environment.

Short-term effectiveness benefits associated with CVOC mass reduction and attainment of RAOs within the source area would be achieved by Alternative 3, which would not occur for Alternatives 2 or 4. Alternative 3 may be more effective toward achieving a long-term permanence in a shorter time frame than Alternatives 2 and 4, especially in the source area, but would not be as effective as Alternative 6. The untreated areas immediately down gradient of the source area may also benefit from a reduced mass flux of CVOCs from the treated areas and depths, as well as some enhancements to the redox conditions from the migration of the amendments with the groundwater. As discussed above, the treatment of the source area would likely only minimally influence the down gradient portions of the plume, and would not likely provide a reduction in the remediation timeframe projected for natural attenuation to achieve the RAOs in the plume further down gradient from the source area.

6.2.4 Implementability

Alternative 1 involves no action; therefore there would be no implementability issues associated with this alternative. Alternative 2 is also readily implementable; no construction would be required except for additional monitoring wells that would be added to the monitoring well network. Monitoring and reporting are readily implementable, as are ICs limiting the use of groundwater for drinking and irrigation.

There would be more implementability issues for Alternative 3 than for Alternative 2, but far less than for Alternatives 4, 5, and 6. Implementability issues for the treatment technologies mostly involve access for the injection/treatment points that would need to be located within utility right-of-ways and corridors. These access issues would be minimal for source area treatment on the Anodyne Site associated with Alternative 3. For the sparging/diffusion treatment option (Alternative 3B), the small areas of the Anodyne Site where the treatment equipment would be located, would be occupied for the lifetime of the treatment period (which has been projected to be five years), and, therefore, would not be available for other uses by current or future property owners until the treatment was completed. Rights of entry may be necessary to place new wells or perform injections on private property. Lack of access to property may also affect the implementation of this alternative.

The implementability of Alternative 3B would be inhibited by the accessibility of areas not within the public rights-of-way, locations of utilities, and access agreements to private properties. The implementability of this alternative would also be subject to obtaining applicable permits and access agreements to private property that would be needed. If the source treatment area is limited to the property that surrounds the Anodyne building and adjacent buildings to the east, then these implementability issues would be minimal. A majority of the work for this alternative would be performed in public right-of-ways, but access to private property around the Anodyne building and nearby buildings would be necessary.

Both options for Alternative 4 are also readily implementable subject to obtaining needed access agreements. Equipment, product, and labor for the treatment can be readily acquired and installed. Time to acquire the access agreements would take longer than for Alternatives 2 and 3 due to the larger areas that these alternatives would need to occupy.

The P&T option poses the greatest implementability issues of all of the remedial alternatives, given the need for property access and off-site disturbance associated with trenching/piping and extraction wells. Provisions would need to be made to accommodate the treatment plant(s) on or around the Anodyne Site. The design itself will be much larger than that originally proposed in the 1993 ROD, and implementation will greatly hinge on obtaining rights of access agreements to the areas necessary for the installation of the equipment and piping.

If the re-injection wells cannot be located within the area of groundwater capture, then additional work and trenching would need to be performed for the installation of these wells. Areas of the

Anodyne Site where the treatment building and equipment are located would be occupied for an extended operational timeframe and not available for use or re-development, which may pose a concern to the current or future property owners. There could also be a potential for release of contaminated groundwater to the environment on private or public property, and possible response delays due to unmanned operations. The P&T system would require security needs for unmanned operations. There could also be potential difficulties in identifying feasible discharge options for the treated effluent by re-injection or direct discharge; and ongoing O&M needs would extend over a prolonged period of operation.

Because of the complex geology and depth requiring treatment, the barrier wall option may or may be not capable of totally cutting off mass flux if unable to uniformly deliver amendments and contact dissolved phase CVOCs. The injected amendments could also be prematurely used up or flushed away by high groundwater velocities.

Alternative 5 is readily implementable subject to obtaining applicable access agreements to private property that would be needed. Most work would be performed in public right-of-ways. The equipment, product, and labor for this treatment alternative can be easily acquired from commercial vendors. As with the previous alternatives, rights of entry may be necessary to place new wells or perform injections on private property. The time to obtain access agreements for the installation of the injection points in both the source and CVOC migration control treatment areas would take longer to implement than Alternatives 1 thru 4, as this alternative would have more areas needing access agreements. Only Alternative 6 would involve more access agreements and use of right-of-ways.

Alternative 6 and the large scale use of in-situ injection of amendments represents the best treatment option for this large of a plume area, especially within an urban/industrial setting without posing difficult implementability constraints. The injection approach is the most flexible and would present the least amount of disturbance and intrusion into the areas utilized. Also, there would be no permanent structures left in place with this alternative.

Rights of entry may be necessary to place new wells or perform injections on private property; therefore, lack of access to property may also affect the implementation of this technology. Also, the size of the plume and industrial/urban nature of the locations where the injection points would need to be located may not allow for the optimal injection locations and spacing required to achieve adequate amendment distribution to effectively access the entire plume area targeted for treatment. As with the other in-situ alternatives, the ability to uniformly deliver and distribute the amendment within the subsurface to effectively contact the CVOC mass could be an impediment to its implementability.

6.2.5 Cost

A cost comparison, in Table 1, provides a summary of the costs for each alternative.

By definition, Alternative 1 has no costs associated with it because there are no actions. Alternative 2 represents the lowest cost alternative besides no action. This alternative has the lowest present value cost of the remedial alternatives, and is less likely to be as variable over time as the costs of the other four alternatives besides no action. Because of the costs associated with active treatment technologies, Alternative 2 represents the lowest estimated present value cost of the remedial alternatives besides no action. The costs projected for this alternative are less likely to exhibit sensitivity to various variables and uncertainties, since there are fewer unknowns compared to the other remedial alternatives.

Three source area options were defined for Alternative 3 involving in-situ anaerobic amendment injections for FS costing purposes. Figures 15, 16 and 17 in Appendix A show the location of each treatment area. In addition, Alternative 3B involves in-situ aerobic biological treatment by oxygen sparging/diffusion using the same treatment area as Alternative 3A. Costs for Alternative 3A could vary greatly depending on the extent of the area targeted for treatment both horizontally (3A vs 3A-Alt) and vertically (3A-Deep Zone), as well as the type of amendment utilized (3B). Capital costs (direct and indirect) for Alternative 3 range from $10.4 million to $26.3 million for the four possible source treatment options. Annual O&M costs range from $315,000 for Alternatives 3A and 3A-Alt to $624,000 for 3B. The present value costs estimated for 10 years of O&M range from $15.2 to $28.7 million for Alternatives 3A-3B. Present value costs for 30 years of O&M range from $17.2 to $31.1 million. The 10- and 30-year present value costs for Alternative 3A for aerobic biological treatment were somewhat less than Alternative 3A that involved the smaller base source area for anaerobic biological treatment. The incremental additional 10-and 30-year present value costs to include the deeper aquifer zone treatment for Alternative 3A were $1.26 and $1.28 million, respectively.

Alternative 4 represents a mid-level cost remedial alternative. Alternatives 4A and 4B represent a higher estimated present value cost than Alternative 2, but is somewhat less than Alternative 3, if assuming the shorter 10-year treatment timeframe for natural attenuation. However, groundwater sites involving CVOCs often require remediation timeframes more than 10 years, where the estimated present value cost is greater for Alternative 4A than Alternative 3 and not considered technically practicable or cost effective for Alternative 4B. The estimated present value cost for Alternative 4 is much less than Alternatives 5 and 6. Both Alternatives 4A and 4B are susceptible to a high level of cost variability and sensitivity versus Alternatives 2 and 3. A number of various design parameters are unknown and still need to be determined. Also, the site conditions and locations for equipment to be placed are also unknown. There are many factors involved with construction for this alternative that are difficult to predict.

Total capital costs for Alternative 4 are estimated to range from $3.6 million for the P&T option to $11.6 million for the barrier wall option. Annual O&M costs are estimated to range from $258,000 for the barrier wall option to $1.6 million for the P&T option. The present value cost for 10 years of O&M ranges from $13.3 million for the barrier wall option to $15.9 million for the P&T option; while at the present value cost assuming 30 years of O&M range for the P&T option is $28.0 million. It was not considered technically practicable to operate the barrier wall option for 30 years, so only LTRA costs were included for the 30-year present value cost for Alternative 4B. Consequently, the 30-year O&M present value cost of $15.3 million for Alternative 4B was based on only 10 years' worth of treatment, with the remaining 20 years of O&M including strictly LTRA costs.

Since Alternative 5 is a combination of Alternatives 3 and 4, the respective capital, O&M, and present value costs would reflect the sum of the specific design that would be selected from the source area technology options associated with Alternatives 3A and 3B and the CVOC migration control technology options associated with Alternatives 4A and 4B.

Costs for Alternative 6 could vary greatly depending on the extent of the area targeted for treatment both horizontally and vertically, as well as the type of amendment utilized. Capital costs (direct and indirect) for Alternative 6 are estimated at $77.7 million. Annual O&M costs are estimated at $326,000. A present value cost for ten years of O&M is estimated at $80.2 million, which includes five years of treatment and five years of LTRA for either natural attenuation and/or rebound. Alternative 6 has a higher present value cost versus the other alternatives by more than a factor of two.

Alternative 3 represents a mid-level cost remedial alternative. Alternatives 3A and 3B (all options presented) represent a higher estimated present value cost than both Alternatives 2 and 4, if assuming the shorter 10-year treatment timeframe for natural attenuation. However, its estimated present value cost is much less than Alternatives 5 and 6. Because of the higher level of certainty associated with the timeframe and costs for source area treatment than CVOC migration control and total plume treatment, the estimated present value cost for Alternative 3 is not as sensitive to variables and uncertainty as Alternatives 4 thru 6.

The selected remedy is a modification of Alternative 3A and would include the costs for treatment of the deep zone if needed (identified in Table 1 as 3A-Deep Zone). For the modified version of Alternative 3A, the areas targeted for in situ bioremediation would be smaller than the area used to determine the cost estimate of 3A listed in Table 1; therefore the total cost of the modified 3A remedy would be less than the cost estimate in the FFS. Costs for the modified 3A Alternative are also shown in Table 1. Capital costs (direct and indirect) for the Modified Alternative 3A are estimated to be $4.4 million for the 3 treatment areas. Annual O&M costs range from $315,000 as for the other Alternatives. The present value costs estimated for 10 years of O&M are $6.8 million and the present value costs estimated for 30 years of O&M range is $9.9 million. In order to define these areas both horizontally and vertically, additional subsurface data would need to be obtained that could be used to define these zones of CVOC transport.

In the absence of significant matrix diffusion influence, the inclusion of source area treatment should accelerate the timeframe to attain RAOs by natural attenuation throughout the untreated down gradient portion of the plume. If the groundwater velocities are found to be at the higher end of the projected range, then attaining the RAOs in the source area by in-situ treatment could also translate into an accelerated timeframe for the attainment of RAOs throughout the entire plume due to the relatively rapid turnover of the volume of groundwater in the higher transmissivity aquifer units, where the highest CVOC concentrations are believed to exist. The uncertainty associated with the identification and locations of these thin aquifer zones/strata of higher transmissivities are also critical barriers to the refinement of the CSM regarding the primary accumulation and migration zones for the CVOC mass. These two factors also affect the ability to project the timeframes to achieve RAOs for Alternative 2.

CVOC migration control (Alternative 4) would prevent further down gradient migration of the plume. For these scenarios, the reduction or elimination of further down gradient mass flux would accelerate the rate of natural attenuation for these further down gradient areas, which in turn would result in the shrinking of the plume extent over time and decrease the timeframe to achieve RAOs down gradient of the CVOC migration control influence. However, more recent groundwater sampling results suggest the plume is currently shrinking at an appreciable rate, so it is not expected that CVOC migration control would provide any appreciable benefits regarding prevention of further down gradient migration.

Alternative 3 would likely have a similar overall remediation timeframe as Alternatives 2, 4, and 5, since each of these remedial alternatives involve natural attenuation of the majority of the plume, and CVOC dissolved phase concentrations are similar throughout the entire plume (i.e., not decreasing with distance from the source area). The projected natural attenuation timeframe for the remainder of the plume to attain RAOs following source area treatment is 20 to 30 years versus 30 to 40 years for natural attenuation. The timeframe to achieve RAOs in the source area would be expected to be much less given the CVOC mass reduction that would be achieved. The projected timeframe for the active treatment for Alternative 3 is 5 years.

Only the treatment of the full plume by Alternative 6 would definitively offer a much shorter timeframe to attain the RAOs. Except for Alternative 6, natural attenuation is the primary remedial component for the majority of the plume for each of the remedial alternatives.

6.3. Modifying Criteria

6.3.1. State/Support Agency Acceptance

The Florida Department of Environmental Protection (FDEP) supports the amended remedy selected in this AROD. A verbal concurrence was provided by FDEP on April 12, 2016. A formal concurrence letter is being drafted for signature and is expected to be signed in fiscal year 2016.

6.3.2. Community Acceptance

A public meeting was held on February 25, from 5:30 PM to 7:30 PM at the St. Thomas University Library. At that meeting the proposed plan was presented that selected a modified Alternative 3A, comprised of monitoring natural attenuation plus on site bioremediation at selected areas.

After completion of the thirty day comment period and public meeting provided by EPA, no comments from the public were received.

7.0 SUPPORT AGENCY COMMENTS

The Florida Department of Environmental Protection (FDEP) has reviewed this AROD and supports its conclusions. The FDEP has provided verbal concurrence with this AROD at this time.

8.0 STATUTORY DETERMINATIONS

Pursuant to Section 121 of CERCLA and the NCP, the lead Agency (EPA) must select remedies that are protective of human health and the environment, comply with ARARs, are cost effective, and utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes.

Pursuant to 40 C.F.R. § 300.430(f)(5)(ii), the following sections discuss how the amended remedy selected in this AROD meets these statutory requirements.

8.1 Protection of Human Health and the Environment

The modified remedy selected in this AROD will adequately protect human health and the environment through treatment, engineering controls, and/or institutional controls. Groundwater will be treated through Enhanced Anaerobic Biodegradation (EAB) in the highly contaminated areas which will substantially reduce the mass transport of COCs to the groundwater in the down gradient parts of the plume. All of these measures will reduce the risks to human receptors to protective levels for the long term. They are not expected to cause unacceptable short-term risks or cross-media impacts. This is expected to be the final remedy and will restore the groundwater of the Biscayne Aquifer for use as a primary drinking water source.

The size and depth of the plume and fractured flow geology pose certain complexities to the remediation process, as well as potential technical barriers to the removal of the remaining residual CVOC mass. One of those potential technical barriers involves the unknown amount of immobilized CVOC residual mass that resides both within difficult to access secondary fractures and directly absorbed into the solid matrix. This immobilized residual CVOC mass could be slowly released back into the dissolved phase (i.e., matrix diffusion). In general, studies and case study information for complex groundwater remediation sites has shown that matrix diffusion influences could either significantly extend the projected timeframe to attain groundwater remediation goals, or worst-case pose a technical impracticability barrier to their attainment.

8.2 Compliance With ARARS

TABLE 2: Chemical Specific ARARs			
Action/Media	**Requirement**	**Prerequisite**	**Citation**
Classification of ground water	All ground water of the state is classified according to the designated uses and includes the following: Class G-I – Potable water use, ground water in single source aquifers which has total dissolved solids content of less than 3,000 mg/l. Class G-II – Potable water use, ground water in single source aquifers which has total dissolved solids content of less than 10,000 mg/l, unless otherwise classified by the Florida Environmental Regulation Commission.	Groundwater within the state of Florida -- **Applicable**	F.A.C. 62-520.410
Restoration of ground water as a potential drinking water source	All ground water (except for Class G-IV) shall meet the minimum criteria for ground water specified in F.A.C. 62-520.400(1)(a)-(f).	Ground water within the state of Florida with designated beneficial use(s) of Class G-I or Class G-II – **Relevant and Appropriate**	F.A.C. 62-520.400 Minimum Criteria for Ground Water
	Class I and Class II ground water shall meet the primary drinking water standards listed in FAC 62-550.310 for public water systems, except as otherwise specified.		F.A.C. 62-520.420(1) Standards for Class - I and Class – II Ground Water
	Shall not exceed the maximum contaminant level (MCL) listed in Table 4 VOLATILE ORGANIC CONTAMINANTS. (These standards may also apply as ground water quality standards as referenced in Chapter 62-520, F.A.C.)	Supply of water to public water system, as defined in F.A.C. 62-550.200 (17) – **Relevant and Appropriate**	F.A.C. 62-550.310 Primary Drinking Water Standards
Restoration of groundwater as a potential drinking water source	Specifies Groundwater Cleanup Target Levels (CTLs) for site rehabilitation. FAC 62-777.170 Table I lists the default Groundwater Criteria. • Tetrachloroethene (PCE) – 3ug/L • Trichloroethene (TCE) –3ug/L • Cis- 1, 2-Dichloroethene (Cis- 1, 2-DCE) –70ug/L • 1,1- Dichloroethylene –7ug/L • Trans – 1, 2-Dichloroethene –100ug/L • Vinyl Chloride (VC) –1ug/L	Rehabilitation (i.e., remediation) of site contaminated groundwater – **Relevant and Appropriate**	F.A.C. 62-780.150(5) F.A.C. 62-777.170(1)(a)

	Requires that a lifetime excess cancer risk level of 1.0E-6 and a hazard index of 1 or less shall be used in establishing alternative contaminant cleanup target levels for groundwater or soil.	Establishment of Alternative cleanup target levels (CTLs) for contaminants of concern at the Site – **Relevant and Appropriate**	F.A.C. 62-780.650(1)(d)

ARAR = applicable *or* relevant and appropriate requirement
CFR = Code of Federal Regulations
F.A.C. = Florida Administrative Code, Chapters as specified
F.S. = Florida Statutes
TBC = To Be Considered guidance

TABLE 3: Action Specific ARARs

Action	Requirement	Prerequisite	Citation
	General Construction Standards — All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.)		
Control of storm water runoff from soil disturbing activities	Must comply with the substantive provisions in the "Generic Permit for Storm water Discharge from Large and Small Construction Activities," document number 62-621.300(4)(a), issued by the FDEP and effective February 17, 2009. Requires development storm water pollution prevention plan and implementation of best management practices and erosion and sedimentation controls for storm water runoff to ensure protection of the surface waters of the state. Note: Plan would be part of CERCLA document such as Remedial or Removal Action Work Plan.	Storm water discharges from large and small construction activities to surface waters of the State as defined in Section 403.031, F.S. – Applicable	F.A.C. 62-621.300(4)(a) Generic Permit for Storm water Discharge from Large and Small Construction Activities
Control of storm water runoff from soil disturbing activities	No discharge from a storm water discharge facility shall cause or contribute to a violation of water quality standards in waters of the state.	Construction activity (e.g., alteration of land contours or land clearing) that results in creation of storm water	F.A.C. 62-25.025 Regulation of Storm water Discharge

TABLE 3: Action Specific ARARs			
Action	**Requirement**	**Prerequisite**	**Citation**
		management system as defined in F.AC. 62-25.020(15) – Applicable	
	Erosion and sediment control best management practices shall be used as necessary during construction activity to retain sediment on site. These practices shall be designed by an engineer or other competent professional experienced in the fields of soil conservation or sediment control according to specific site conditions and shall be shown or noted on the plans of the storm water management system. Note: Plan would be part of CERCLA document such as Remedial or Removal Action Work Plan.		F.A.C. 62-25.025 (7)
Control of Fugitive Dust	No person shall cause, let, permit, suffer or allow the emissions of unconfined particulate matter from any activity, including vehicular movement; transportation of materials; construction, alteration, demolition or wrecking; or industrially related activities such as loading, unloading, storing or handling; without taking reasonable precautions to prevent such emissions.	Land disturbing activity that has potential for unconfined emissions of particulate matter – Applicable	F.A.C. 62-296.320(4)(c) General Pollutant Emission Limiting Standards
Monitoring and Injection Wells – Installation, Operation, and Abandonment			
Groundwater Monitoring Well Installation	Before construction of new ground water monitoring wells, a soil boring shall be made at each new monitoring well location to properly determine monitoring well specifications such as well depth, screen interval, screen slot, and filter pack.	Installation of groundwater monitoring well to detect migration of contaminants – Relevant and Appropriate	F.A.C. 62-532.600(6)(g)

TABLE 3: Action Specific ARARs			
Action	**Requirement**	**Prerequisite**	**Citation**
	Provides detailed guidance to assist in monitoring well design and material specifications for construction of groundwater monitoring well.	Installation of groundwater monitoring well to detect migration of contaminants – **To Be Considered**	FDEP, Monitoring Well Design and Construction Guidance Manual (2008)
Construction and repair of groundwater well	Well casing. Well liner shall be in accordance with the substantive requirements specified in F.A.C. 62-532.500(1)(a) through(i) as appropriate	Installation of water well as defined in F.A.C. 62-532.200 – Relevant and Appropriate.	F.A.C. 62-532.500(1)
	Wells shall be constructed to meet the following criteria specified in F.A.C. 62-532.500(2)(a), (b), and (d)		F.A.C. 62-532.500(2)
Plugging and Abandonment of Groundwater Monitoring Wells	All abandoned wells shall be plugged by filling them from bottom to top with neat cement grout or bentonite and capped with a minimum of one foot of neat cement grout. An alternate method providing equivalent protection shall be approved by the Department and EPA.	Abandonment of water well as defined in F.A.C. 62-532.200 – Relevant and Appropriate	F.A.C. 62-532.500(4)

Groundwater Monitoring for Monitored Natural Attenuation (MNA) remedy	A minimum of two monitoring wells is required1: At least one well shall be located at the down gradient edge of the plume; and At least one well shall be located in the area(s) of highest groundwater contamination or directly adjacent to it if the area of highest groundwater contamination is inaccessible (for example, under a structure).	Groundwater monitoring as part of the remedy relying on natural attenuation – Relevant and Appropriate	F.A.C. 62-780.690(8)(a) Natural Attenuation with Monitoring
	The designated monitoring wells shall be sampled for analyses of applicable contaminants no more frequent than quarterly. [1]	Groundwater monitoring as part of the remedy relying on natural attenuation – **Relevant and Appropriate**	F.A.C. 62-780.690(8)(b)
	Water-level measurements in all designated wells and piezometers shall be made within 24 hours of initiating each sampling event. [1]	Groundwater monitoring as part of the remedy relying on natural attenuation – **Relevant and Appropriate**	F.A.C. 62-780.690(8)(c)
Injection of In-Situ Chemical Precipitation agents into groundwater	An injection activity cannot allow the movement of fluid containing any contaminant into USDWs, if the presence of that contaminant may cause a violation of the primary drinking water standards under 40 CFR part 141, other health based standards, or may otherwise adversely affect the health of persons. This prohibition applies to well construction, operation, maintenance, conversion, plugging, closure, or any other injection activity.	Class V wells [as defined in 40 CFR § 144.6(e)] – Relevant and Appropriate	40 CFR § 144.82(a)(1)
Abandonment for Class V wells	Wells must be closed in a manner that complies with the above prohibition of fluid movement. Also, any soil, gravel, sludge, liquids, or other materials removed from or adjacent to the well must be disposed or otherwise managed in accordance with substantive applicable Federal, State, and local regulations and requirements.	Class V wells [as defined in 40 CFR § 144.6(e)] – Relevant and Appropriate	40 CFR § 144.82(b)
General Criteria for Class V well used for underground injection (e.g., In-Situ Chemical Precipitation agents)	A well shall be designed and constructed for its intended use, in accordance with good engineering practices.	Operation of Class V well Group 4 (wells associated with aquifer remediation projects) – Relevant and Appropriate	F.A.C. 62-528.605(1)

	May not cause or allow fluids to migrate into underground source of drinking water which may cause a violation of a primary or secondary drinking water standard contained in Chapter 62-550, F.A.C., or minimum criteria contained in Rule 62-520.400, F.A.C., or may cause fluids of significantly differing water quality to migrate between underground sources of drinking water.		F.A.C. 62-528.605(2)
Construction of Class V well used for underground injection (e.g., In-Situ Chemical Precipitation agents)	Shall be constructed so that their intended use does not violate the water quality standards of Chapter 62-520. F.A.C., at the point of discharge, except where specifically allowed in subsection65-522.300(2), F.A.C.	Operation of Class V well Group 4 (wells associated with aquifer remediation projects) – Relevant and Appropriate	F.A.C. 62-528.605(3)
	All drilled wells shall, at a minimum, meet the casing and cementing requirements for water well construction set forth in Chapter 62-532, F.A.C.		F.A.C. 62-528.605(7)
Operation of Class V well used for underground injection (e.g., In-Situ Chemical Precipitation agents)	Shall be used or operated in a manner that it does not present a hazard to an underground source of water.	Operation of Class V well Group 4 (wells associated with aquifer remediation projects) – Relevant and Appropriate	F.A.C. 62-528.610(1)
	Pretreatment for fluids injected through existing wells shall be performed if necessary to ensure the injected fluid does not violate applicable water quality standards in Chapter 52-520, F.A.C.		F.A.C. 62-528.610(3)
Monitoring of Class V well used for underground injection (e.g., In-Situ Chemical Precipitation agents)	The need for monitoring shall be determined by the type of well, nature of injected fluid, and the water quality of the receiving and overlying aquifers. Note: The monitoring parameters and frequency will be specified in a CERCLA document such as Remedial or Removal Action Work Plan.	Operation of Class V well Group 4 (wells associated with aquifer remediation projects) – Relevant and Appropriate	F.A.C. 62-528.615(1) and (2)

Plugging and abandonment of Class V well used for underground injection (e.g., In-Situ Chemical Precipitation agents)	Prior to abandoning Class V wells, the well shall be plugged with cement in a manner that will not allow movement of fluids between underground sources of water. Placement of the cement shall be accomplished by any recognized and approved method.	Operation of Class V well Group 4 (wells associated with aquifer remediation projects) – Relevant and Appropriate.	F.A.C. 62-528.625(3)
Post-Active Remediation Monitoring for groundwater treatment system	Unless otherwise provided in CERCLA Remedial/Removal Action Work Plan, the following shall be performed as follows: A minimum of two monitoring wells is required with at least one located at the down gradient edge of the plume; and at least one located in the area(s) of highest groundwater contamination or directly adjacent; Designated monitoring wells shall be sampled quarterly for contaminants that were present[1]; Water-level measurements in all designated wells and piezometers shall be made within 24-hour of initiating each sampling event. 1	Operation of an active remediation system – Relevant and Appropriate.	F.A.C. 62-780.750(4)(a) through (c)
Waste Characterization – Primary Waste (e.g., excavated soils from well cuttings, purge water) and Secondary Wastes (e.g., contaminated equipment or treatment residuals)			
Characterization of ***solid waste*** (all primary and secondary wastes)	Must determine if solid waste is a hazardous waste using the following method: • Should first determine if waste is excluded from regulation under 40 CFR 261.4; and Must then determine if waste is listed as a hazardous waste under subpart D 40 CFR Part 261.	Generation of solid waste as defined in 40 CFR 261.2 – **Applicable**	40 CFR 262.11(a) and (b) F.A.C. 62-730.160
	Must determine whether the waste is (characteristic waste) identified in subpart C of 40 CFR part 261by either: (1) Testing the waste according to the methods set forth in subpart C of 40 CFR part 261, or according to an equivalent method approved by the Administrator under 40 CFR 260.21; or	Generation of solid waste which is not excluded under 40 CFR 261.4(a) – **Applicable**	40 CFR 262.11(c) F.A.C. 62-730.160

	(2) Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used.		
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste which is determined to be hazardous waste – **Applicable**	40 CFR 262.11(d) F.A.C. 62-730.160
Characterization of ***hazardous waste*** (all primary and secondary wastes)	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.	Generation of RCRA hazardous waste for storage, treatment or disposal – **Applicable**	40 CFR 264.13(a)(1) F.A.C. 62-730.180(1)
Determinations for management of hazardous waste	Must determine each EPA Hazardous Waste Number (waste code) applicable to the waste in order to determine the applicable treatment standards under 40 CFR 268 et seq. Note: This determination may be made concurrently with the hazardous waste determination required in Sec. 262.11 of this chapter.	Generation of hazardous waste for storage, treatment or disposal – **Applicable**	40 CFR 268.9(a) F.A.C. 62-730.183
	Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the characteristic waste.	Generation of RCRA characteristic hazardous waste (and is not D001 non –wastewaters treated by CMBST, RORGS, or POLYM of Section 268.42 Table 1) for storage, treatment or disposal – **Applicable**	40 CFR 268.9(a) F.A.C. 62-730.183
Determinations for management of hazardous waste	Must determine if the hazardous waste meets the treatment standards in 40 CFR 268.40, 268.45, or 268.49 by testing in accordance with prescribed methods or use of generator knowledge of waste. Note: This determination can be made concurrently with the hazardous waste determination required in 40 CFR 262.11.	Generation of hazardous waste for storage, treatment or disposal – **Applicable**	40 CFR 268.7(a) F.A.C. 62-730.183

	Must comply with the special requirements of 40 CFR 268.9 in addition to any applicable requirements in CFR 268.7.	Generation of waste or soil that displays a hazardous characteristic of ignitability, corrosivity, reactivity, or toxicity for storage, treatment or disposal – **Applicable**	40 CFR 268.7(a) F.A.C. 62-730.183
Waste Storage – Primary Waste (e.g., excavated soil from well cuttings and purge water) and Secondary Wastes (e.g., contaminated equipment or treatment residuals)			
Temporary on–site storage of hazardous waste in containers	A generator may accumulate hazardous waste at the facility provided that: • waste is placed in containers that comply with 40 CFR 265.171 –173; and • the date upon which accumulation begins is clearly marked and visible for inspection on each container; • container is marked with the words "hazardous waste"; or	Accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10 – **Applicable**	40 CFR 262.34(a); 40 CFR 262.34(a)(1)(i); 40 CFR 262.34(a)(2) and (3) F.A.C. 62-730.160
	• container may be marked with other words that identify the contents.	Accumulation of 55 gal. or less of RCRA hazardous waste or one quart of acutely hazardous waste listed in 261.33(e) at or near any point of generation – **Applicable**	40 CFR 262.34(c)(1) F.A.C. 62-730.160
Use and management of hazardous waste in containers	If container is not in good condition (e.g. severe rusting, structural defects) or if it begins to leak, must transfer waste from this container to a container that is in good condition.	Storage of RCRA hazardous waste in containers – **Applicable**	40 CFR 265.171 F.A.C. 62-730.180(2)
	Must use container made or lined with materials compatible with waste to be stored so that the ability of the container to contain is not impaired.		40 CFR 265.172 F.A.C. 62-730.180(2)
	Containers must be closed during storage, except when necessary to add/remove waste.		40 CFR 265.173(a) and (b) F.A.C. 62-730.180(2)

	Container must not opened, handled and stored in a manner that may rupture the container or cause it to leak.		
Storage of hazardous waste in container area	Area must have a containment system designed and operated in accordance with 40 CFR 264.175(b)	Storage of RCRA hazardous waste in containers with free liquids – **Applicable**	40 CFR 264.175(a) F.A.C. 62-730.180(1)
	Area must be sloped or otherwise designed and operated to drain liquid resulting from precipitation, or Containers must be elevated or otherwise protected from contact with accumulated liquid.	Storage of RCRA–hazardous waste in containers that do not contain free liquids (other than F020, F021, F022, F023,F026 and F027) – **Applicable**	40 CFR 264.175(c)(1) and (2) F.A.C. 62-730.180(1)
Closure of RCRA container storage unit	At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soils containing or contaminated with hazardous waste and hazardous waste residues must be decontaminated or removed. [Comment: At closure, as throughout the operating period, unless the owner or operator can demonstrate in accordance with 40 CFR 261.3(d) of this chapter that the solid waste removed from the containment system is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of parts 262 through 266 of this chapter].	Storage of RCRA hazardous waste in containers in a unit with a containment system – **Applicable**	40 CFR 264.178 F.A.C. 62-730.180(1)
Storage and processing of non-hazardous waste	No person shall store, process, or dispose of solid waste except as authorized at a permitted solid waste management facility or a facility exempt from permitting under this chapter. No person shall store, process, or dispose of solid waste in a manner or location that causes air quality standards to be violated or water quality standards or criteria of receiving waters to be violated.	Management and storage of solid waste – **Applicable**	F.A.C. 62 701.300(1)(a) and (b)

Waste Treatment and Disposal – Primary Waste (e.g., excavated soil from well cuttings, purge water) and Secondary Wastes (e.g., contaminated equipment or treatment residuals)			
Disposal of RCRA hazardous waste in a land-based unit	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted RCRA waste – **Applicable**	40 CFR 268.40(a) F.A.C. 62-730.183
	All underlying hazardous constituents [as defined in 40 CFR 268.2(i)] must meet the UTS, found in 40 CFR 268.48 Table UTS prior to land disposal	Land disposal of restricted RCRA characteristic wastes (D001 – D043) that are not managed in a wastewater treatment system that is regulated under the CWA, that is CWA equivalent, or that is injected into a Class I nonhazardous injection well – **Applicable**	40 CFR 268.40(e) F.A.C. 62-730.183
Disposal of RCRA – *hazardous waste soil* in a land–based unit	Must be treated according to the alternative treatment standards of 40 CFR 268.49(c) <u>or</u> according to the UTSs specified in 40 CFR 268.48 applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal	Land disposal, as defined in 40 CFR 268.2, of restricted hazardous soils – **Applicable**	40 CFR 268.49(b) F.A.C. 62-730.183
Disposal of RCRA hazardous waste in a land-based unit	To determine whether a hazardous waste identified in this section exceeds the applicable treatment standards of 40 CFR 268.40, the initial generator must test a sample of the waste extract or the entire waste, depending on whether the treatment standards are expressed as concentration in the waste extract or waste, or the generator may use knowledge of the waste. If the waste contains constituents (including UHCs in the characteristic wastes) in excess of the applicable UTS levels in 40 CFR 268.48, the waste is prohibited from land disposal, and all requirements of part 268 are applicable, except as otherwise specified.	Land disposal of RCRA toxicity characteristic wastes (D004 – D011) that are newly identified (i.e., wastes, soil, or debris identified by the TCLP but not the Extraction Procedure) – **Applicable**	40 CFR 268.34(f) F.A.C. 62-730.183
Waste Transportation – Primary and Secondary Wastes			

Transportation of hazardous waste *on–site*	The generator manifesting requirements of 40 CFR 262.20–262.32(b) do not apply. Generator or transporter must comply with the requirements set forth in 40 CFR 263.30 and 263.31 in the event of a discharge of hazardous waste on a private or public right–of–way.	Transportation of hazardous wastes on a public or private right–of–way within or along the border of contiguous property under the control of the same person, even if such contiguous property is divided by a public or private right–of–way – **Applicable**	40 CFR 262.20(f) F.A.C. 62-730.160
Transportation of hazardous waste *off–site*	Must comply with the generator standards of Part 262 including 40 CFR 262.20–23 for manifesting, Sect. 262.30 for packaging, Sect. 262.31 for labeling, Sect. 262.32 for marking, Sect. 262.33 for placarding,	Preparation and initiation of shipment of hazardous waste off–site –**Applicable**	40 CFR 262.10(h); F.A.C. 62-730.160
Transportation of *hazardous materials*	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 CFR 171–180 related to marking, labeling, placarding, packaging, emergency response, etc.	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material – **Applicable**	49 CFR 171.1(c)
Transportation of samples (i.e. contaminated soils and wastewaters)	Are not subject to any requirements of 40 CFR Parts 261 through 268 or 270 when: • the sample is being transported to a laboratory for the purpose of testing; or • the sample is being transported back to the sample collector after testing • the sample is being stored by sample collector before transport to a lab for testing	Samples of solid waste or a sample of water, soil for purpose of conducting testing to determine its characteristics or composition – **Applicable**	40 CFR 261.4(d)(1)(i)–(iii) F.A.C. 62-730.030

ARAR = applicable *or* relevant and appropriate requirement
CFR = Code of Federal Regulations
CWA = Clean Water Act
F.A.C. = Florida Administrative Code, Chapters as specified
F.S. = Florida Statutes
HAP =hazardous air pollutant
HMTA = Hazardous Materials Transportation Act
HMR = Hazardous Materials Regulations
RCRA = Resource Conservation and Recovery Act
TCLP = toxicity characteristic leaching procedure

UHCs = underlying hazardous constituents
USDW = Underground Sources of Drinking Water
UTS = Universal Treatment Standards
VOC = volatile organic compound

[1] The designated number of wells, sampling time frames/frequency, and specific parameters for analyses will be provided in a Monitoring Plan that is included in a CERCLA post-ROD document prepared as part of the Remedial Design or Remedial Action which is approved by the EPA and the FDEP.

8.3 COST EFFECTIVENESS

The amended remedy selected in this AROD is considered to be the most cost effective of the FFS remedial alternatives. The post-ROD groundwater sampling has shown significant decreasing CVOC groundwater concentration trends already attaining or coming close to attaining the remediation goals at many monitoring wells. Because of the size and depth of the plume, complex fractured flow geology, and location in an active urban area, it would not be technically feasible or cost effective to attempt to implement active treatment throughout the plume. The CSM has identified the potential for very high transmissivities through narrow flow paths that has accounted for the plume migration. Targeted in-situ bioremediation by ERD at select locations of higher CVOC concentrations should be able to accelerate the timeframe to attain the groundwater remediation goals because of the rapid turnover in pore volumes that occur in these highly transmissive thin units (i.e., reduction in source concentrations should propagate down gradient relatively quickly).

The selected amended remedy provides the best overall protection in proportion to cost, and meets all other requirements of CERCLA. Section 300.430(f)(1)(ii)(D) of the NCP requires EPA to evaluate the cost-effectiveness by comparing all of the alternatives which meet the threshold criteria, overall protection of human health and the environment, and compliance with ARARs, against three additional balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; and short-term effectiveness. Based on this evaluation, the amended remedy selected is the most cost-effective alternative. The estimated present worth cost for the recommended remedy presented in this AROD will be less than the estimated costs for Alternative 3A of $22,077,376 (also includes costs for remediation of the deepest zone shown in Table 1 as Alternative 3A-Deep Zone) but more than the estimated costs for Alternative 2 (natural attenuation alone) of $4,606,525.

8.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to Maximum Extent Practicable

The amended remedy selected in this AROD represents the maximum extent to which permanent solutions and treatment technologies can be utilized for Zone 2, while providing the best balance among other evaluation criteria. Of those alternatives that are protective of human health and the environment and that comply with ARARs, EPA has determined that the amended remedy selected in this AROD is the most efficient and effective alternative when evaluated using the five balancing criteria, while also considering (1) the statutory preference for treatment as a principal element, (2) cost effectiveness, and (3) state and community acceptance.

The recommended remedy in this AROD offers long-term effectiveness, permanence, and an acceptable reduction of volume and mobility through treatment and natural attenuation. Application of EAB should result in a mass contaminant flux reduction and reduced contaminant concentrations in the groundwater. Ongoing groundwater monitoring will document that RAOs are met and will be evaluated during the five-year reviews.

8.5 Preference for Treatment

The recommended remedy in this AROD is intended to address the principal threat waste (PTW) comprised of residual source material in the form of residual mass adsorbed to the subsurface formations matrix. The COCs are found at concentrations that pose an unacceptable risk for potential future groundwater exposure pathways identified in the BRA (e.g., direct ingestion if future potable wells are installed within the plume). In addition, down gradient migration of dissolved phase CVOCs in groundwater represents a potential long-term threat to two municipal water supplies for the City of Miami/Dade. As such, the amended remedy will take a more aggressive and timely action to address this PTW in order to accelerate groundwater restoration. A combination of targeted active treatment using in-situ bioremediation by ERD with ongoing natural attenuation that has been demonstrated by post-ROD groundwater sampling results will accelerate degradation of CVOC in groundwater within the source area and down gradient dissolved phase plume. This treatment is expected to reduce the mass flux from the dissolved phase plume to the areas impacted down gradient of the site. The statutory preference for remedies that employ treatment as a principal element is satisfied by the active bioremediation through the ERD component of the remedy. Ultimately, the long-term RAO for the remedy is complete groundwater restoration to allow for unrestricted use as a drinking water source for the City of Miami Gardens.

8.6 Five-Year Review Requirement

The amended remedy selected in this AROD will address hazardous contaminants within the Deep Groundwater of Zone 2 above levels that allow for unlimited use and unrestricted exposure. A policy review will be conducted within five years after initiation of the remedial action to ensure the remedy is and will be protective of human health and the environment. The five-year review process will begin after the initiation of the remedial action and will continue until site goals are met.

9.0 PUBLIC PARTICIPATION COMPLIANCE

EPA published a Proposed Plan to Amend the Record of Decision on February 16, 2016. The public was provided a 30 day comment period to submit a response to EPA after review of the Proposed Plan.

A public meeting was held on February 25, 2016 at the St. Thomas University Library between the hours of 5:30pm and 7:30pm. The meeting provided a historical review of activities and the current site status that reflects the groundwater impact from site contaminants. The Proposed Plan presented the selected modified alternative 3A for addressing current site conditions.

Prior to this opportunity for public participation, the EPA solicited public comment on the remedial alternatives during the period of December 8, 1992 through January 7, 1993. No comments were received from the communities in proximity to the Site. Some comments were received from legal counsel for the Potentially Responsible Party, legal counsel for the adjacent property owner and a local water works director.

EPA opened another comment period between April 29, 1993 and May 28, 1993, based on comments received from the FDER, now known as FDEP. All comments and responses are contained in the Responsiveness Summary of the 1993 Record of Decision.

10.0 RESPONSIVENESS SUMMARY

EPA published a Proposed Plan to Amend the Record of Decision on February 16, 2016. A public notice was issued in a local newspaper informing the public of EPA's plan. The public was provided a 30 day comment period to submit a response to EPA after review of the Proposed Plan.

On February 25, 2016 EPA held a public meeting at the St. Thomas University Library in Opa Locka, Florida. The Proposed Plan was presented to the public. A transcript of the proceedings was prepared and submitted to EPA.

EPA did not receive any comments from the public or State of Florida in response to the Proposed Plan. The Proposed Plan presented the selected alternative that is a Modified 3A alternative for addressing current site conditions. Monitored natural attenuation of the deep zone aquifer along with selected treatment areas is the proposed remedy.

Table 4: Comparison Costs of Remedial Alternatives

Alternative			Capital Costs	Annual O&M	10-Year Present Value Cost	30-Year Present Value Cost	Remarks
	1	No Action					
	2	MNA for Entire Plume	$100,000	$293,156*	$2,363,672	$4,606,525	
HOT SPOT TREATMENT	Modified 3A	Identified in Proposed Plan	$3,283,491	$315,306*	$6,818,170	$9,230,486	Includes in-situ treatment in source area of 60 inj pts from 100 to 140 ft bgs plus the deeper zone at 180 ft bgs, plus two additional hot spots identified in down gradient locations with 20 inj pts each
SOURCE AREA TREATMENT	3A	In-situ Anaerobic Source Treatment Involving "Anodyne Release Area" with MNA for Remainder of Plume	$15,943,527	$315,306*	$18,377,235	$20,789,550	Smaller base source area w/ 220 inj pts to 140 ft
	3A-Alt	Source Treatment Option Involving "Plume Core Source Area"	$26,278,072*	$315,306*	$28,712,781	$31,125,097	Larger plume mass area with 283 inj pts to 140 ft
	3A-Deep Zone	Treatment of Deep Zone Aquifer-RDA-31E Area	$1,227,874*	$3,900*	$1,257,989	$1,287,826	Deeper gwater zone w/ 50 inj pts to 180 ft
	3B	In-situ Aerobic Treatment with MNA for Remainder of Plume	$10,393,378*	$624,056*	$15,212,172	$17,270,075	Oxygen diffusion systems, 357 inj pts to 120 ft

CVOC MIGRATION CONTROL	4A	Pump & Treat with MNA for Entire Plume	$3,595,500*	$1,591,256*	$15,882,756	$28,057,003	
	4B	In-situ Anaerobic Barrier Wall with MNA for Entire Plume	$11,347,470*	$257,543*	$13,336,149	$15,306,537	Two barrier lines of inj pts; one north and one south; 149 pts to 140 ft; injections over first 5 years only
	5	Source Area Treatment, CVOC Migration Control with MNA for Remainder of Plume	$13,988,878	$2,215,312*	$31,094,928	$45,327,078	Costs reflect pairing of Alts 3B and 4A
	6	Entire Plume Treatment with In-situ Anaerobic Injections, & MNA as Needed	$77,745,660*	$326,565*	$80,265,693		Entire plume treatment with 675 inj pts to 140 ft

***30% added to costs for contingencies; inj pts – injection point; ft - feet**

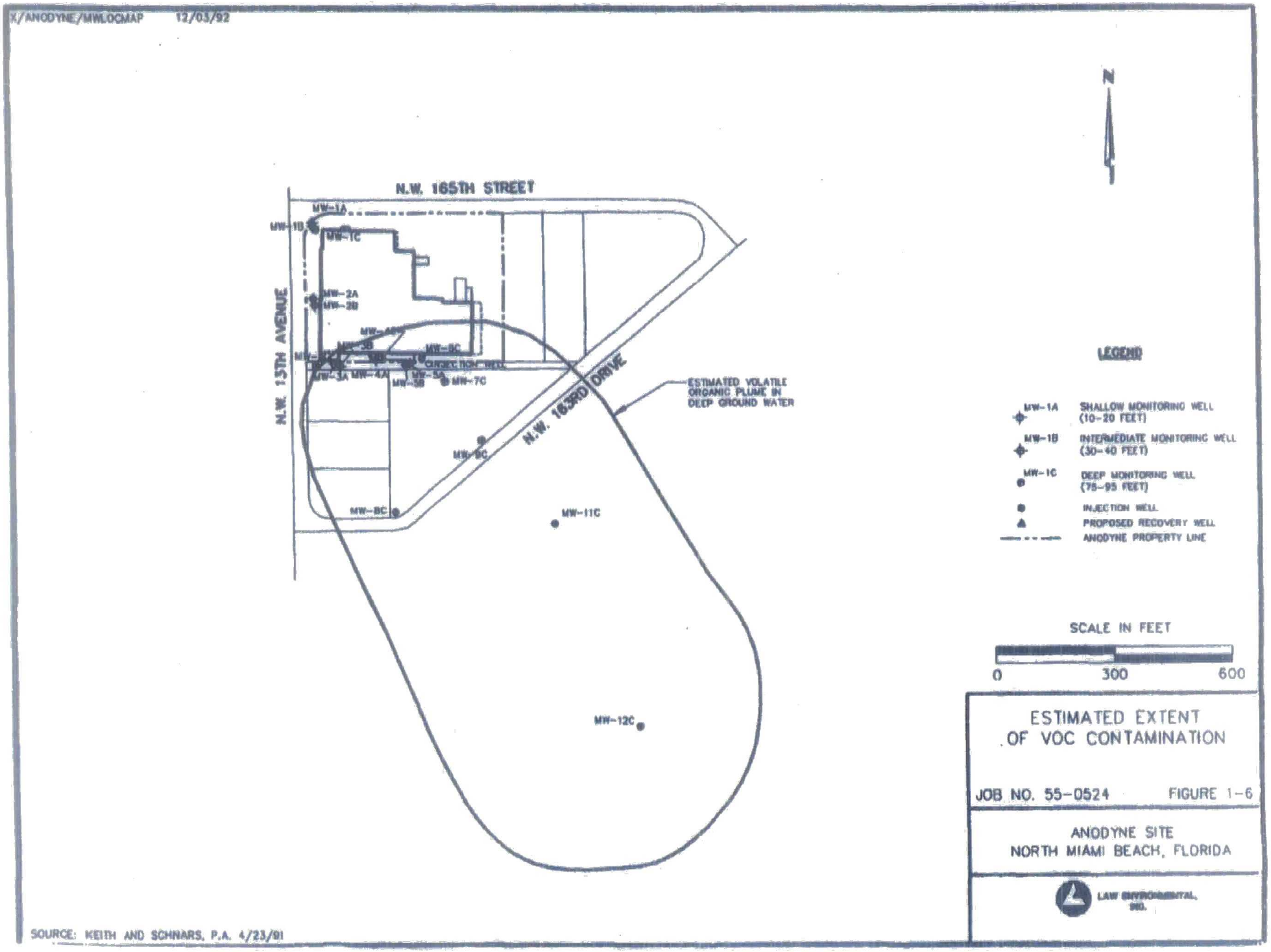
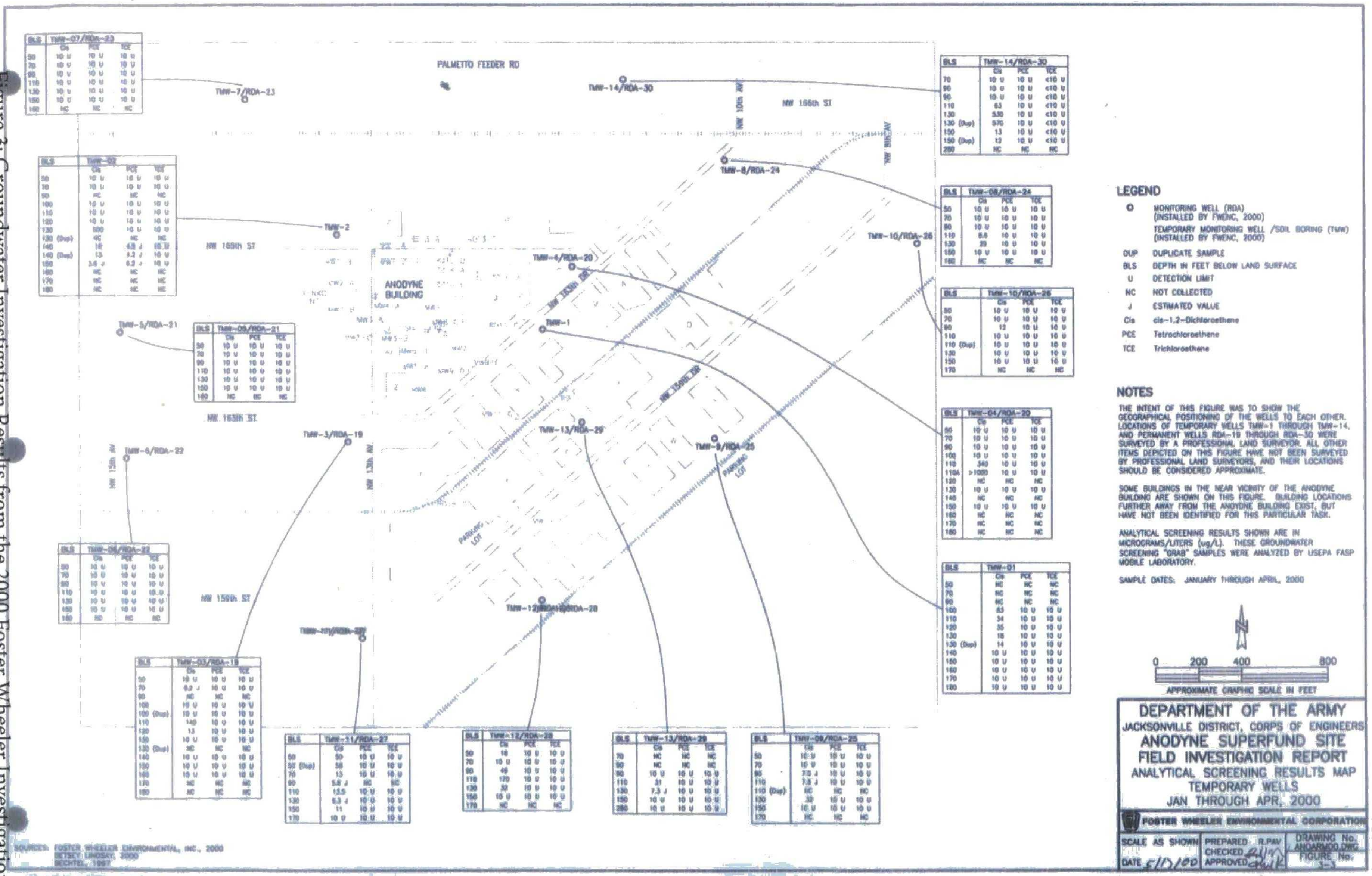


Figure 2: Extent of Plume as defined in the 1993 ROD



BLS	TMW-07/RDA-23 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	10 U	10 U	10 U
110	10 U	10 U	10 U
130	10 U	10 U	10 U
150	10 U	10 U	10 U
160	NC	NC	NC

BLS	TMW-02 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	NC	NC	NC
100	10 U	10 U	10 U
110	10 U	10 U	10 U
120	10 U	10 U	10 U
130	500	10 U	10 U
130 (Dup)	NC	NC	NC
140	18	4.8 J	10 U
140 (Dup)	13	4.2 J	10 U
150	3.6 J	6.2 J	10 U
160	NC	NC	NC
170	NC	NC	NC
180	NC	NC	NC

BLS	TMW-05/RDA-21 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	10 U	10 U	10 U
110	10 U	10 U	10 U
130	10 U	10 U	10 U
150	10 U	10 U	10 U
160	NC	NC	NC

BLS	TMW-06/RDA-22 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	10 U	10 U	10 U
110	10 U	10 U	10 U
130	10 U	10 U	10 U
150	10 U	10 U	10 U
160	NC	NC	NC

BLS	TMW-03/RDA-19 Cis	PCE	TCE
50	10 U	10 U	10 U
70	6.2 J	10 U	10 U
90	NC	NC	NC
100	10 U	10 U	10 U
100 (Dup)	10 U	10 U	10 U
110	140	10 U	10 U
120	13	10 U	10 U
130	10 U	10 U	10 U
130 (Dup)	NC	NC	NC
140	10 U	10 U	10 U
150	10 U	10 U	10 U
160	10 U	10 U	10 U
170	NC	NC	NC
180	NC	NC	NC

BLS	TMW-11/RDA-27 Cis	PCE	TCE
50	50	10 U	10 U
50 (Dup)	58	10 U	10 U
70	13	10 U	10 U
90	5.8 J	NC	NC
110	15.5	10 U	10 U
130	6.3 J	10 U	10 U
150	11	10 U	10 U
170	10 U	10 U	10 U

BLS	TMW-12/RDA-28 Cis	PCE	TCE
50	18	10 U	10 U
70	10 U	10 U	10 U
90	49	10 U	10 U
110	170	10 U	10 U
130	32	10 U	10 U
150	10 U	10 U	10 U
170	NC	NC	NC

BLS	TMW-13/RDA-29 Cis	PCE	TCE
70	NC	NC	NC
90	NC	NC	NC
90	10 U	10 U	10 U
110	31	10 U	10 U
130	7.3 J	10 U	10 U
150	10 U	10 U	10 U
200	10 U	10 U	10 U

BLS	TMW-09/RDA-25 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	7.0 J	10 U	10 U
110	7.5 J	10 U	10 U
110 (Dup)	NC	NC	NC
130	32	10 U	10 U
150	10 U	10 U	10 U
170	NC	NC	NC

BLS	TMW-14/RDA-30 Cis	PCE	TCE
70	10 U	10 U	<10 U
90	10 U	10 U	<10 U
90	10 U	10 U	<10 U
110	63	10 U	<10 U
130	530	10 U	<10 U
130 (Dup)	570	10 U	<10 U
150	13	10 U	<10 U
150 (Dup)	12	10 U	<10 U
200	NC	NC	NC

BLS	TMW-08/RDA-24 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	10 U	10 U	10 U
110	8.6	10 U	10 U
130	29	10 U	10 U
150	10 U	10 U	10 U
160	NC	NC	NC

BLS	TMW-10/RDA-26 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	12	10 U	10 U
110	10 U	10 U	10 U
110 (Dup)	10 U	10 U	10 U
130	10 U	10 U	10 U
150	10 U	10 U	10 U
170	NC	NC	NC

BLS	TMW-04/RDA-20 Cis	PCE	TCE
50	10 U	10 U	10 U
70	10 U	10 U	10 U
90	10 U	10 U	10 U
100	10 U	10 U	10 U
110	340	10 U	10 U
110A	>1000	10 U	10 U
120	NC	NC	NC
130	10 U	10 U	10 U
140	NC	NC	NC
150	10 U	10 U	10 U
160	NC	NC	NC
170	NC	NC	NC
180	NC	NC	NC

BLS	TMW-01 Cis	PCE	TCE
50	NC	NC	NC
70	NC	NC	NC
90	NC	NC	NC
100	63	10 U	10 U
110	34	10 U	10 U
120	35	10 U	10 U
130	18	10 U	10 U
130 (Dup)	14	10 U	10 U
140	10 U	10 U	10 U
150	10 U	10 U	10 U
160	10 U	10 U	10 U
170	10 U	10 U	10 U
180	10 U	10 U	10 U

Figure 3: Groundwater Investigation Results from the 2000 Foster Wheeler Investigation

Figure 4: PCE Isopleths from the 2000 Foster Wheeler Groundwater Investigation

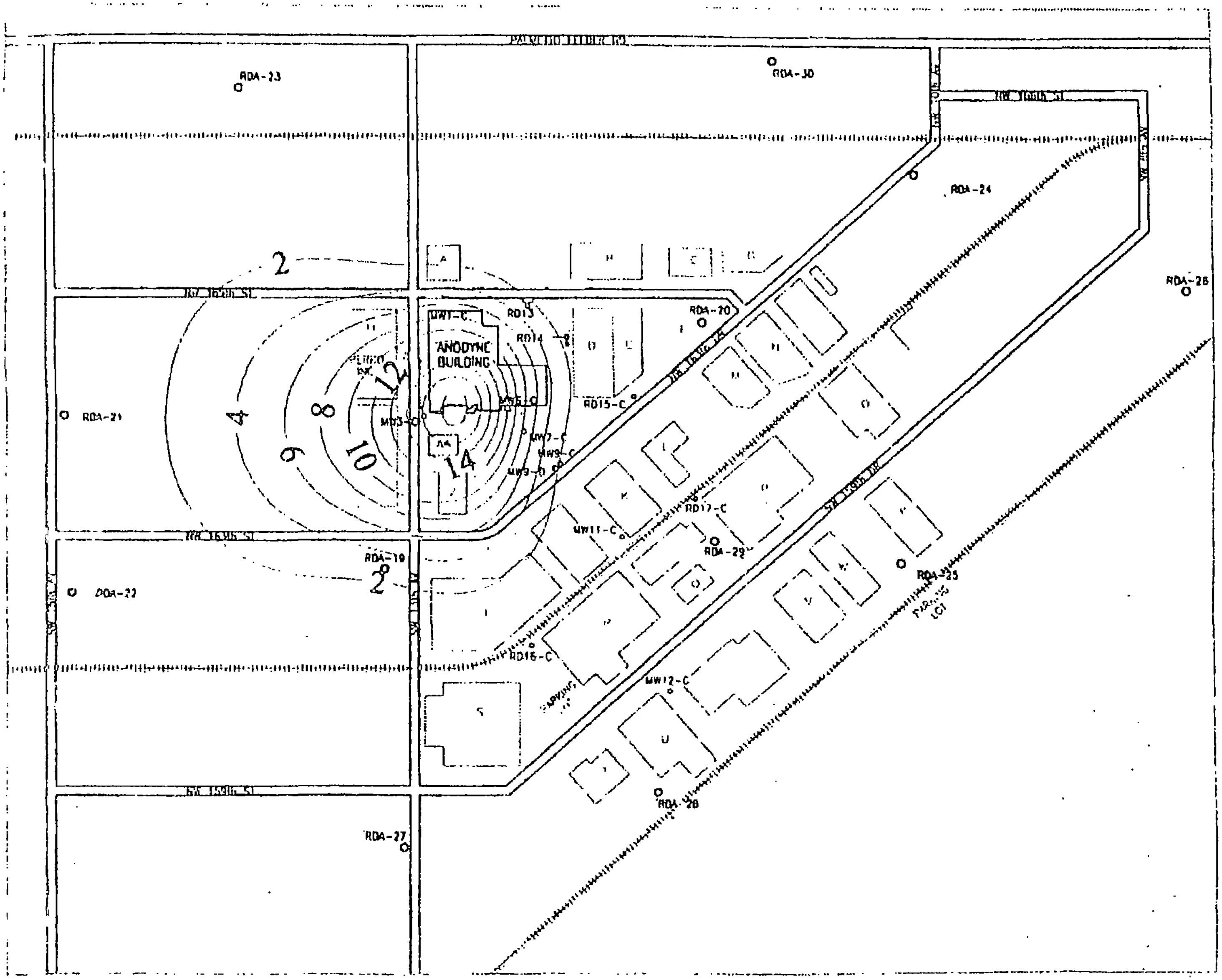


Figure 6: tetrachloroethene (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 5: TCE Isopleths from the 2000 Foster Wheeler Groundwater Investigation

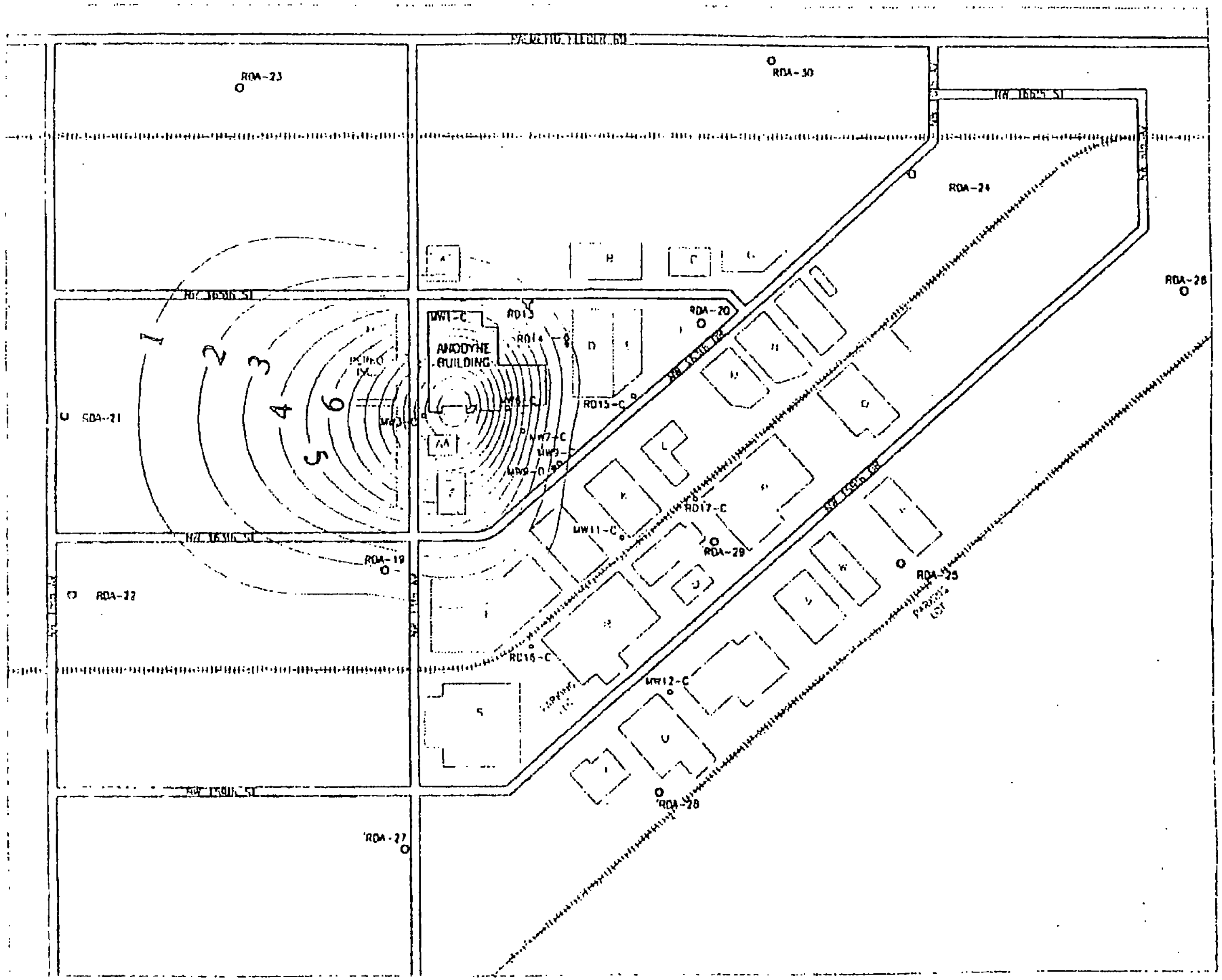


Figure 7: trichloroethene (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 6: 1,1-DCE Isopleths from the 2000 Foster Wheeler Groundwater Investigation

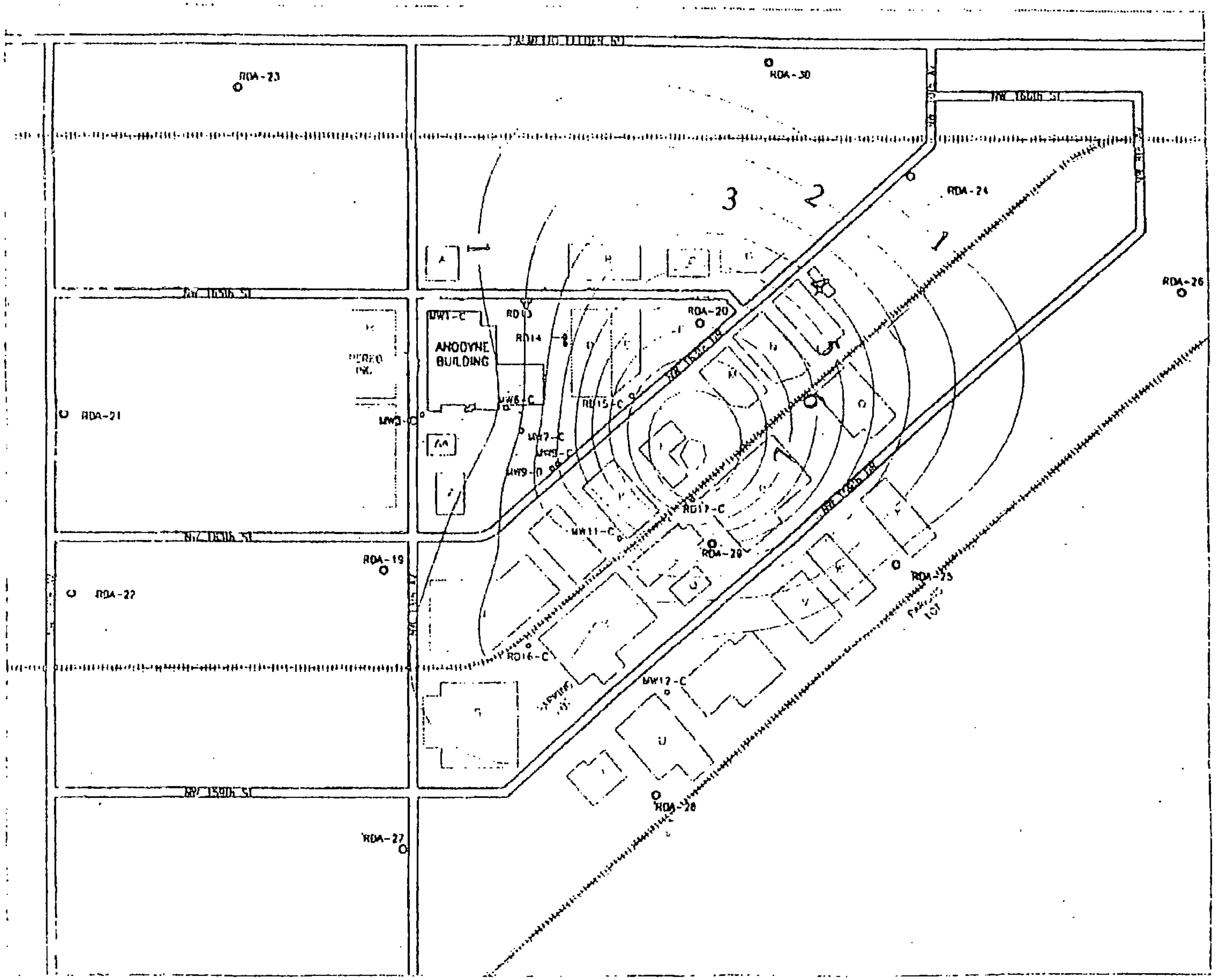


Figure 8: 1,1-dichloroethene (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 7: Cis-1,2-DCE Isopleths from the 2000 Foster Wheeler Groundwater Investigation

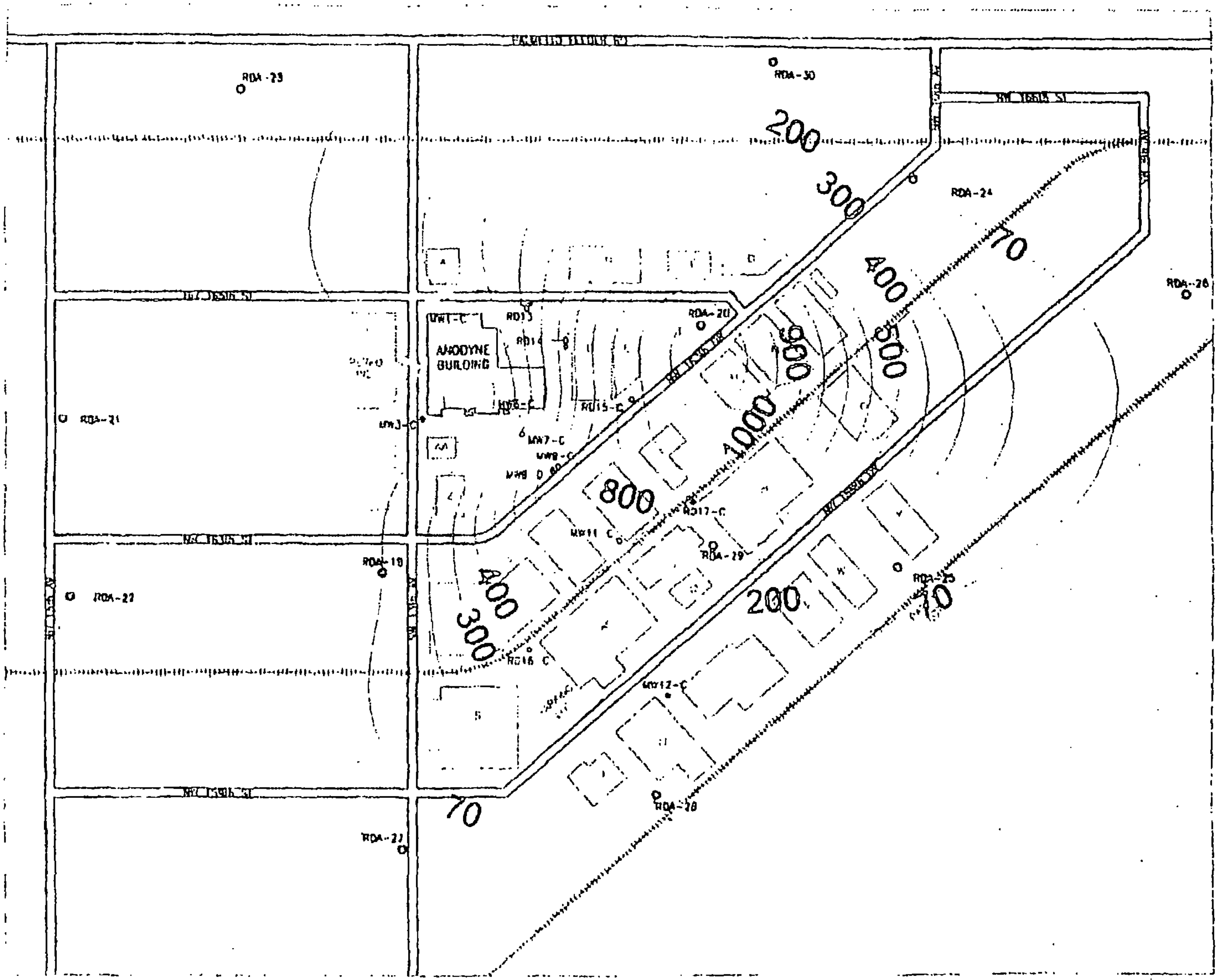


Figure 3: cis-1,2-trichloroethene (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 8: Trans-1,2-DCE Isopleths from the 2000 Foster Wheeler Groundwater Investigation

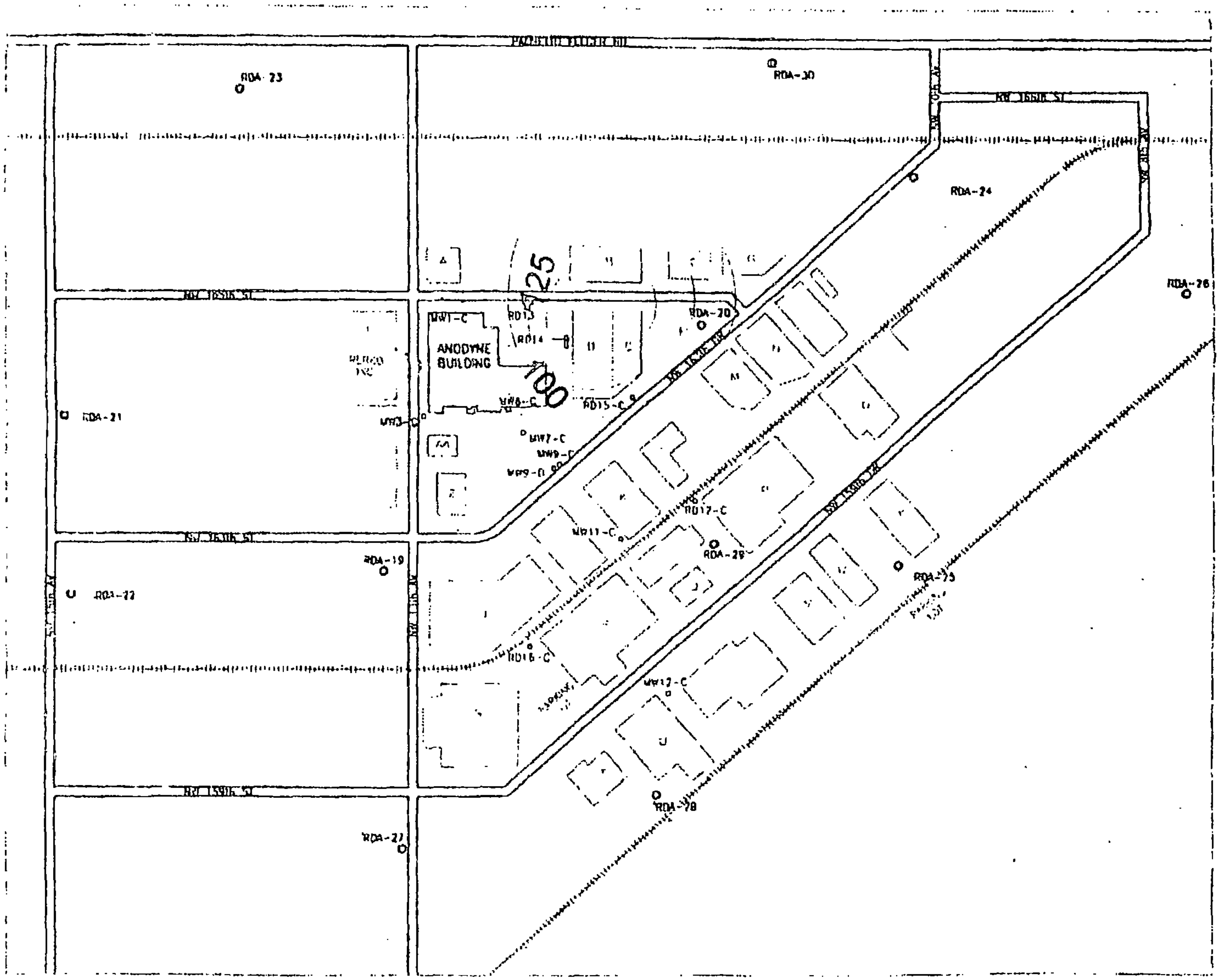


Figure 4: trans-1,2-dichloroethene (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 9: Vinyl Chloride Isopleths from the 2000 Foster Wheeler Groundwater Investigation

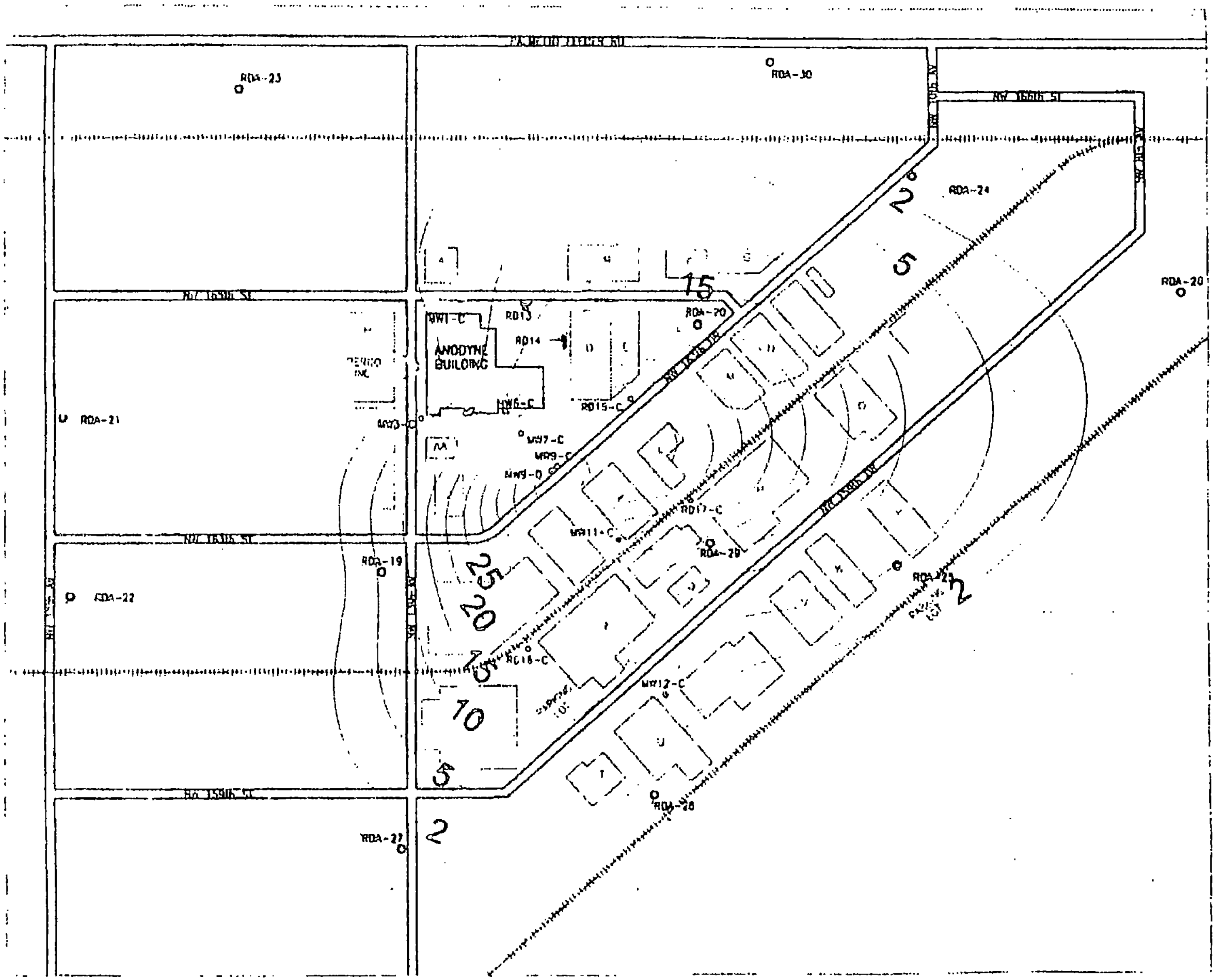


Figure 5: vinyl chloride (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

Figure 10: Total VOC Conentrations from the 2000 Foster Wheeler Groundwater Investigation

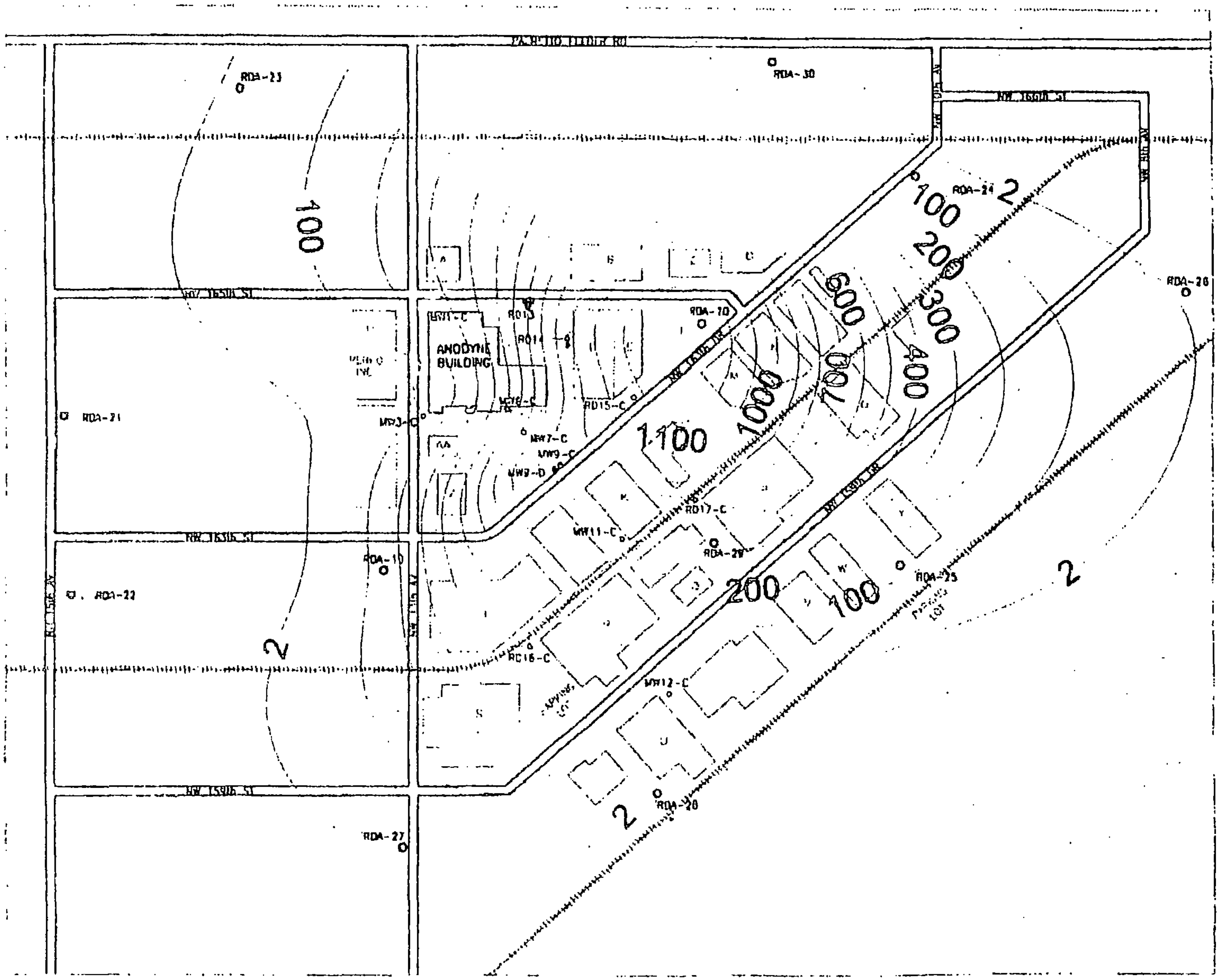


Figure 9: Total VOA (ug/l) Concentration Isopleth Map
Anodyne Superfund Site, North Miami Beach, Florida

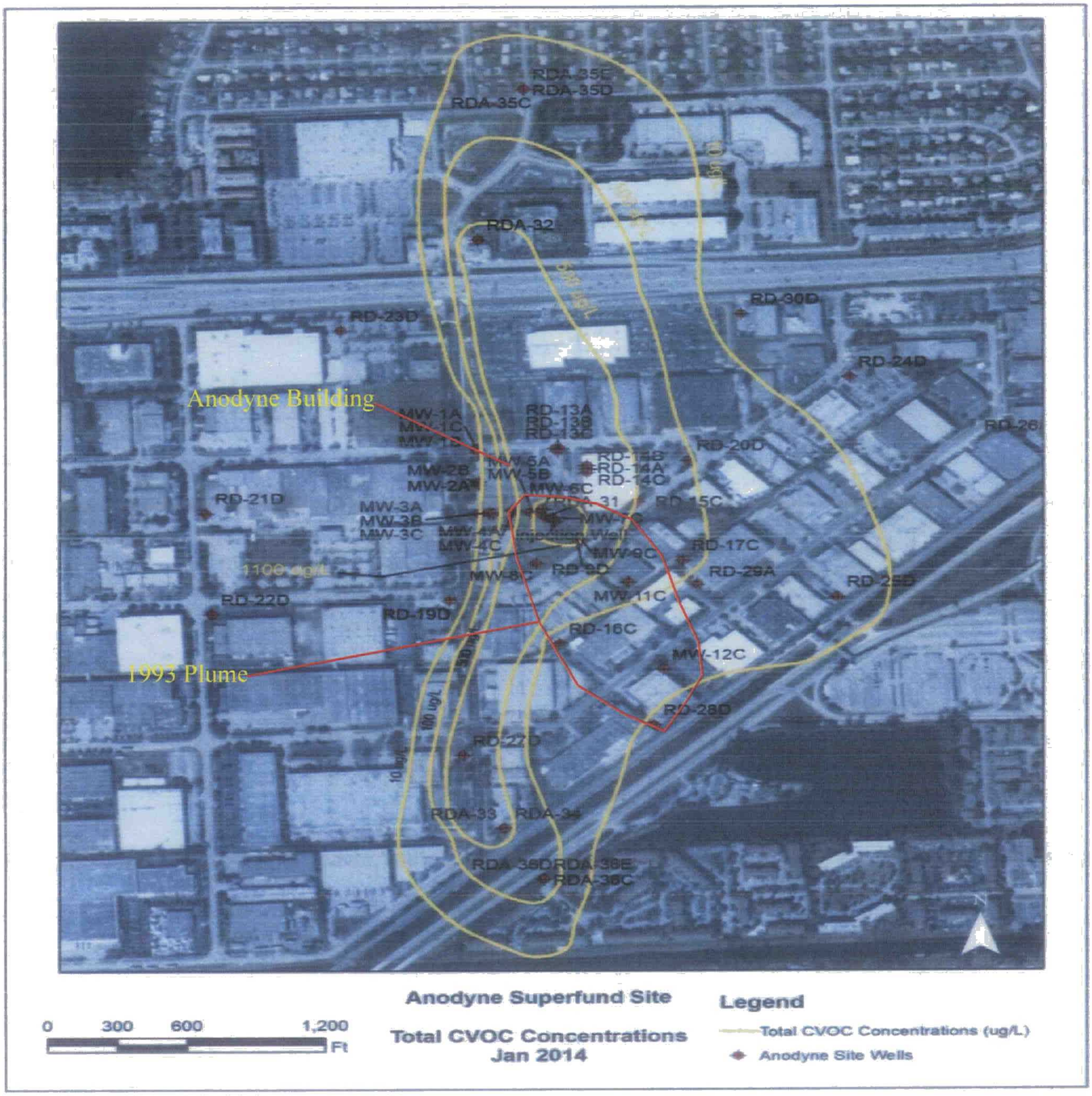
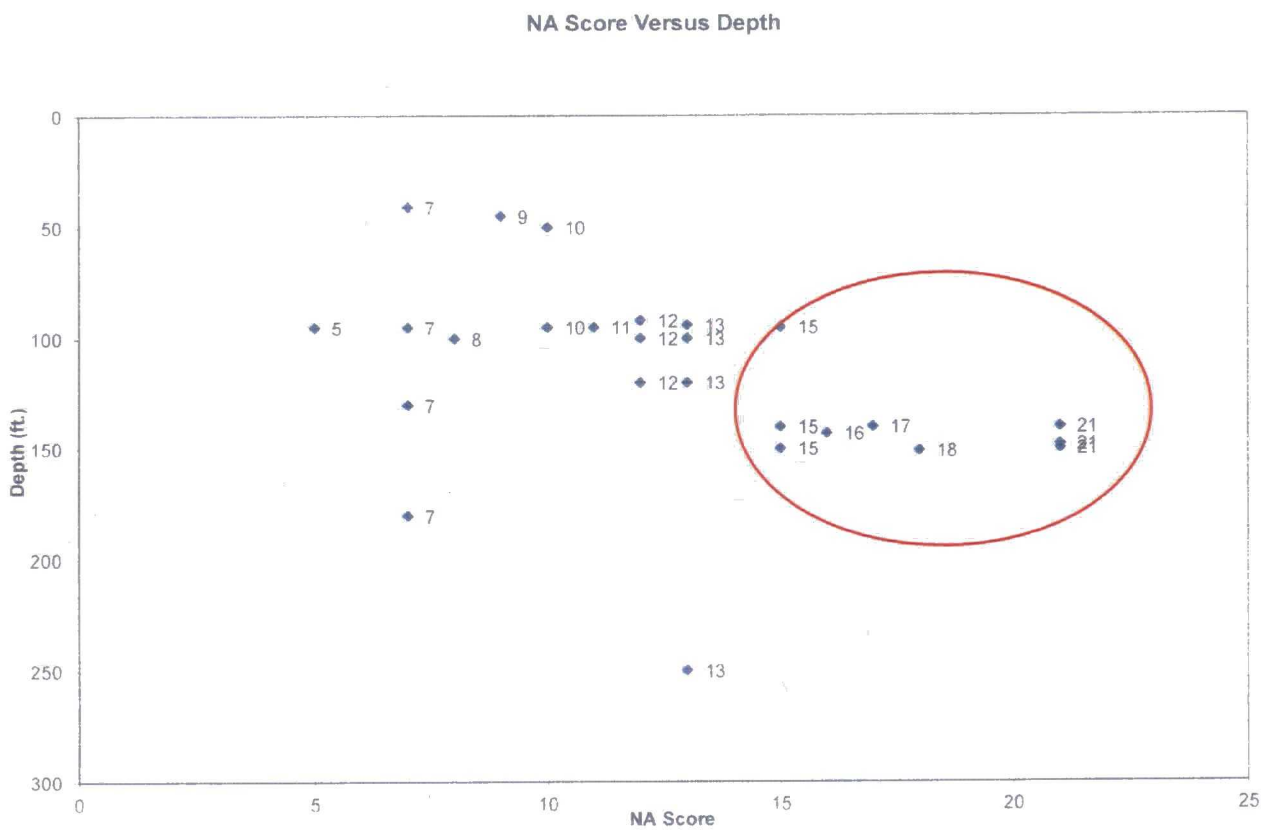


Figure 11: Extent of Plume as defined in 2014

Figure 12: Natural Attenuation Scores from 2005 MicroPact Report

Well ID	Well Depth	Score By Well
IW (MW-10C)	100	8
MW11-C	95	7
MW12-C	95	11
MW1-B	45	9
MW1-C	95	10
MW2-B	41	7
MW3-B	45	9
MW3-C	92	12
MW4-C	95	7
MW5-B	41	7
MW6-C	95	15
MW7-C	94	13
MW8-C	95	5
MW9-C	95	15
MW9-D	140	15
RD13-C	100	13
RD14-C	100	8
RD15-C		
RD16-C	100	12
RD17-C	100	12
RDA-31	180	7
RDA-32	130	7
RDA-33	120	13
RDA-34	50	10
TMW-10/RDA-26	150	21
TMW-11/RDA-27	151	18
TMW-12/RDA-28	140	21
TMW-13/RDA-29	250	13
TMW-14/RDA-30	150	15
TMW-3/RDA-19	143	16
TMW-4/RDA-20	120	12
TMW-5/RDA-21	148	21
TMW-6/RDA-22		
TMW-7/RDA-23		
TMW-8/RDA-24	150	15
TMW-9/RDA-25	140	17

Figure 13: Natural Attenuation Scores for Selected Wells Plotted by Depth from 2005 MicroPact Report



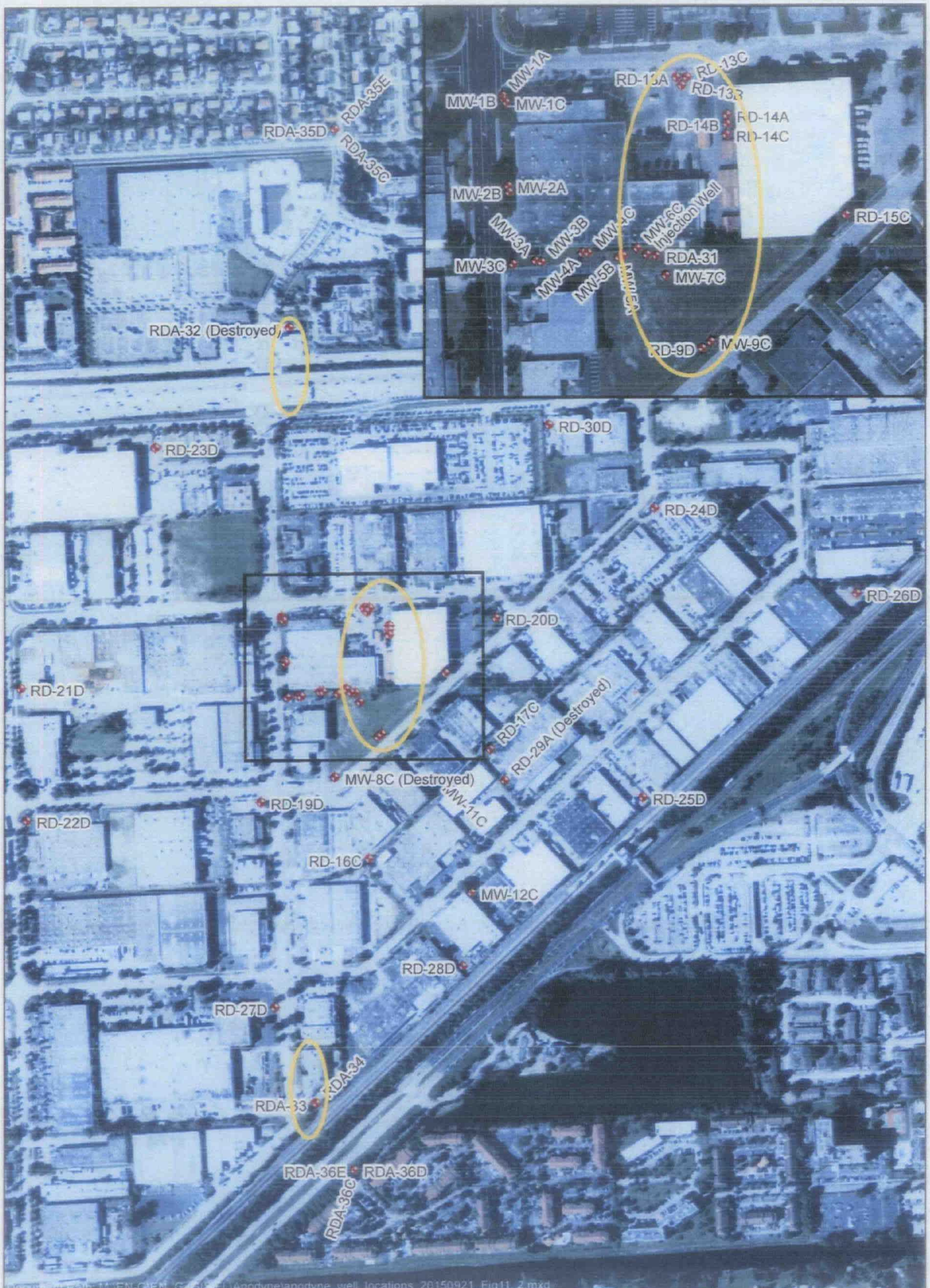


Figure 14: Modified Alterative 3A Proposed Remediation Loctations

N

0 250 500 1,000 Feet

0 0.125 0.25 Miles

Legend

Monitoring Well

U.S. Army Corps of Engineers
Savannah District
Savannah, Georgia

Anodyne Superfund Site

Proposed Remediation Areas

N. Miami, Florida

Date: Sept 2015 | Figure: 4

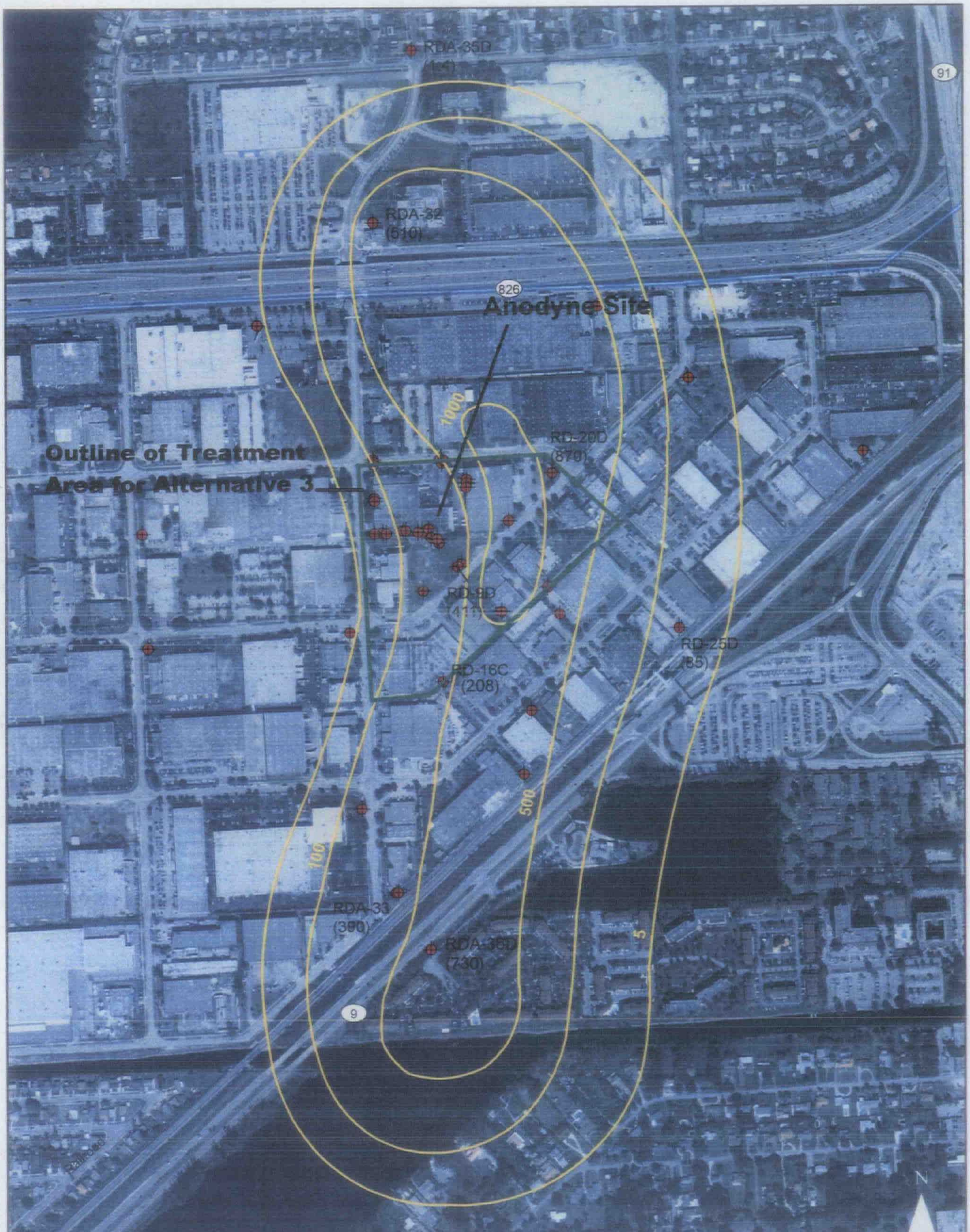


Figure 15: Location of Treatment Area for Alternative 3A-Alt. from 2011 FFS

Anodyne Superfund Site
Total CVOCs: 90 to 140 ft
Alternative 3

February 2012

Note: Total CVOC concentrations shown in parenthesis under well label

0 350 700 1,400 Ft

Legend

Total CVOC Concentrations (ug/L)

Anodyne Site Wells

Figure 16: Location of Treatment Area for Alternative 3 A from 2011 FFS

Note: Total CVOC concentrations shown in parenthesis under well label

Anodyne Superfund Site
Total CVOCs: 90 to 140 ft
Alternative 3
(Reduced Treatment Zone)

0 350 700 1,400 Ft

February 2012

Legend

Total CVOC Concentrations (ug/L)

Anodyne Site Wells

Figure 17: Location of Treatement aAre for Deep Zone @ RDA-31 E from 2011 FFS

Anodyne Superfund Site
Alternate 3
Grid Area for RDA-31E
50 injection points -20 ft spacing
February 2012

Legend

Anodyne Site Wells