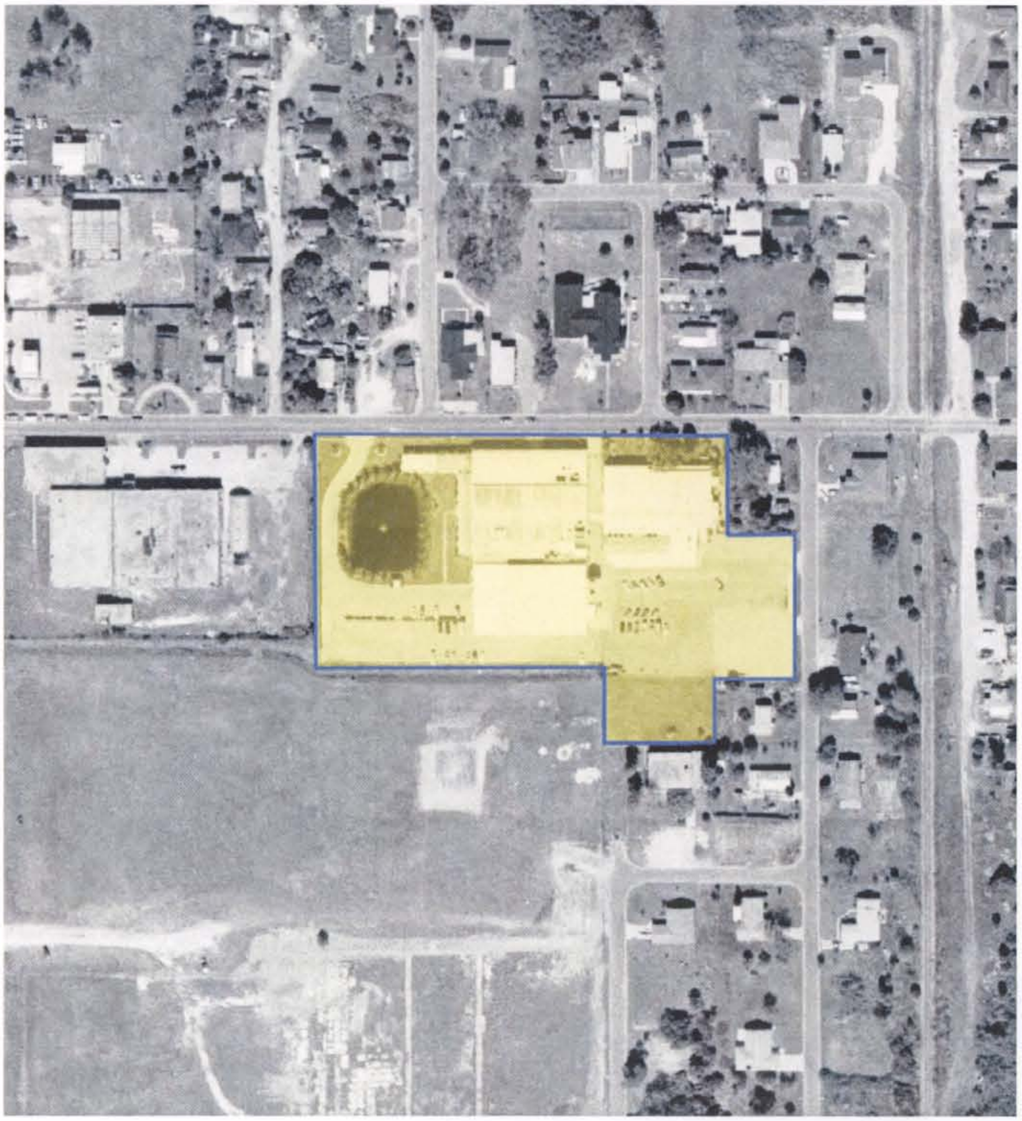
PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES

Former American Beryllium Company
1600 Tallevast Road
Tallevast, Florida



LOCKHEED MARTIN

Tetra Tech
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Preliminary Evaluation of Remedial Alternatives Former American Beryllium Company

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TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

Chlorinated volatile organic compounds (VOCs) have been identified in shallow groundwater beneath Lockheed Martin Corporation's (LMC) former American Beryllium Company (ABC) facility in Tallevast, Florida, originating from sources associated with past ABC operations. The impacted groundwater has migrated off-site in the northerly and easterly directions, and encompasses an area of approximately 212,000 ft^2 (~4.86 acres). With the investigation of VOC-impacted groundwater considered complete, the Florida Department of Environmental Protection (FDEP) issued a letter, dated July 25, 2003, requiring submittal of a remedial action plan (RAP) for the site.

On behalf of LMC, Tetra Tech, Inc. has prepared the following report that provides the initial screening of applicable technologies and remedial alternatives that could be used at the site. The primary goal of this document is two-fold: (1) present an estimation of the VOC mass in groundwater, and (2) conduct a preliminary screening process to identify appropriate approaches and technologies for RAP development. Also presented in this report are recommendations for conducting additional tasks, including site-specific treatability studies, groundwater modeling, and risk assessment, to further assist with RAP development.

Tables and figures are presented as Appendices A and B, respectively. Appendix C presents a copy of the July 25, 2003 FDEP letter requiring the RAP. Geotechnical data used in the VOC mass estimation are presented in Appendix D.

2.0 SITE DESCRIPTION

The former ABC facility is composed of 5.167 acres of land and is located at 1600 Tallevast Road in Tallevast, Manatee County, Florida. The property is bounded by Tallevast Road to the north, undeveloped and residential areas to the south, 17th Street Court East to the east, and an abandoned industrial facility (the former Spindrift facility) to the west – *see Figure 1 in Appendix B for a location map.*

The property is zoned "Heavy Manufacturing" (HM) by the County of Manatee (Tetra Tech, February 1997). The facility was formerly used as an ultra-precision machine parts manufacturing plant, where metals were milled, lathed, and drilled into various components. Some of the components were finished by electroplating, anodizing, and ultrasonic cleaning. Chemicals used and wastes generated at the facility included oils, petroleum-based fuels, solvents, acids, and metals. Operations were discontinued on September 27, 1996.

The property contains five primary buildings that cover a total surface area of approximately 66,335 ft^2 (1.523 acres). During LMC's occupancy, Building #1, the main building structure, was comprised of office space and machining areas. Buildings #2 and #3 contained machining areas and inspection rooms. Building #4 housed a wood working shop and non-hazardous material storage area. Building #5 contained plating and anodizing rooms, a wastewater treatment system and hazardous materials storage areas. Further historical information is provided in the Phase I Environmental Assessment (EA) Report, dated February 7, 1997.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The former ABC facility is located on a gently sloping plain at an elevation of about 30 feet above mean sea level (amsl). The site is inland from Sarasota Bay and approximately $1^3/_4$ miles from the Gulf of Mexico. The ground surface around the site has very low relief and slopes gently towards the south to southwest.

The uppermost 40 feet are comprised of undifferentiated surficial deposits consisting of variably clayey quartz sand and slightly phosphatic, iron-stained sand. From the surface to a depth of 20 feet bgs, these sands are fine to medium grained and unconsolidated. From 20 to 30 feet bgs, the sands are poorly consolidated with clay cement. At approximately 30 feet bgs, very tight clay or dense, cemented sands were encountered. During past site investigations, soil borings could not be advanced deeper than 30 feet bgs using direct-push technology (DPT).

The surficial deposits unconformably overlie approximately 45 feet of relatively pure clay (known as the "Venice Clay"). The clay sequence represents the upper confining beds of the intermediate aquifer system. The contact between the Venice Clay and the underlying Early Miocene undifferentiated Arcadia Formation occurs at approximately 85 feet bgs at the site. Based on lithologic data collected from on-site monitoring well DW-1, fractured limestone was observed in samples collected from 85 to 95 feet bgs. Clay was observed from 95 to 105 feet bgs, the maximum drilled depth at the site. Regionally, the Arcadia Formation extends to a depth greater than 300 feet bgs (SFWMD, 1995).

3.2 Site Hydrogeology

Exploratory drilling and sampling at the site have identified the surficial aquifer system (SAS) and the intermediate aquifer system (IAS). The IAS includes the uppermost confining clay beds and upper semi-confining carbonates (Tetra Tech, 2003).

Groundwater elevations measured from SAS monitoring wells in October 2003 reported depth-to-water values ranging from 2.02 to 3.90 feet bgs across the project area. The corresponding relative groundwater elevations ranged from 25.03 to 28.09 feet amsl. The results of previous monitoring show that groundwater flows generally from southwest to northeast. However, the overall groundwater flow regime appeared radial, as shown by northerly groundwater flow at the northern portion of the project area, and southeasterly flow at the southeastern portion of the project area. In addition, the gradient appears to be slightly greater at the southeast portion of the former ABC property. Groundwater gradient throughout most of the project area was relatively flat, at approximately 0.001, but at the southeastern portion of the property, the gradient is slightly greater, at 0.004 (Tetra Tech, 2003). One explanation for the flow patterns may be that groundwater mounding is occurring at the nearby golf course, which is probably being irrigated on a frequent basis. Groundwater patterns may also be impacted by the on-site pond, as well as an adjacent pond on the golf course property. Figure 2 shows the groundwater elevation contours based on data collected on October 15, 2003.

The IAS includes all water-yielding units and confining units between the overlying SAS and the underlying Floridan Aquifer System. Groundwater was encountered in the IAS at approximately 85 feet. The water table was later measured at approximately 12 feet bgs, confirming that the IAS occurs under confined conditions. The IAS is composed of upper confining and semi-confining beds that occurs between approximately 40 and 85 feet bgs. These confining beds generally consist of a continuous sequence of dense, non-plastic clays, with intermittent sandy clay zones (Tetra Tech, 2003). Figure 3 shows a cross-sectional view of site lithology.

A step down test was conducted in March 2003 to estimate the hydraulic conductivity, transmissivity, and average linear velocity of the SAS. These groundwater parameters are estimated as follows:

Hydraulic Conductivity of the aquifer = 20 ft/day;
Transmissivity = 400 ft^2/day;
Average Linear Velocity = 0.2 ft/day

4.0 SITE HISTORY

This section provides a brief chronological history of investigation and remedial action activities that have been implemented at the site:

- January 2000: Initial Leak Discovery – Groundwater impacts were initially discovered during a preliminary groundwater sampling program conducted in January 2000 around the former sumps in Building #5. On behalf of LMC, Tetra Tech prepared a contamination discovery report (CDR), dated July 7, 2000, documenting the preliminary assessment activities conducted at the former ABC facility. In response to the CDR, the FDEP submitted a letter dated August 24, 2000 requiring an assessment to delineate the chemicals detected at the site.

- February 2001: Initial Subsurface Assessment – In February 2001, a subsurface assessment program was conducted to evaluate the extent of chemicals previously detected in the soil and groundwater (i.e., VOCs, beryllium and chromium). Beryllium and chromium appeared to be limited primarily to the immediate vicinity of the former sumps. However, VOCs were detected above GCTLs in groundwater samples collected near the southeastern, northern, and northeastern property boundaries. Based on the analytical data, VOCs appeared to be migrating off-site of the former ABC facility. Findings from the assessment are presented in the Contamination Assessment Report, dated April 30, 2001.

- September 2001: Source Remediation – As a source removal measure, a remedial excavation was completed to remove soil impacted with TPH, VOCs, and metals in this area. Further details of the soil removal program are presented in Tetra Tech's Initial Remedial Action Report, December 12, 2001.

- December 2001: Supplemental Groundwater Assessment – In December 2001, additional temporary monitoring wells were installed and sampled at on-site and off-site to assess the extent of VOCs in groundwater. A total of 23 temporary wells were used to evaluate the vertical distribution of VOCs. All groundwater samples from the wells were analyzed for VOCs and selected samples were also analyzed for beryllium and chromium. VOCs were detected in each of the 23 groundwater samples that were collected both on-site and off-site, prompting the requirement for further investigation of VOCs. TPH and beryllium were not detected in any of the groundwater samples analyzed.

- January 2002: Installation of Deep Monitoring Well – In accordance with FDEP's letter dated August 27, 2001, a permanent monitoring well was installed to evaluate the presence of VOCs in the deeper IAS. In January 2002, a dual-cased well (DW-1) was installed to a depth of 92 feet bgs southeast of the Building #5 sump area, a location specified by FDEP.

- December 2002 through September 2003: Delineation Investigation – Additional on-site and off-site groundwater delineation investigation was conducted from December 2002 through September 2003. The delineation investigation was conducted in accordance with Tetra Tech's Contamination Assessment Plan Addendum #2 (CAPA), dated September 13, 2002, and FDEP's guidelines outlined in Corrective Actions for Contamination Site Cases. Approval letters were obtained from FDEP prior to conducting the field work. The primary intent of the program was to complete the delineation of VOCs in groundwater at the site. Data collected from the grab groundwater samples and the monitoring well samples showed that the extent of VOCs has been delineated both on-site and off-site – *see Figures 4 and 5 in Appendix B.*

In its July 25, 2003 letter, the FDEP concurred that the investigation was considered completed, and requested submittal of a RAP for the site – *see Appendix C.* Quarterly groundwater monitoring is currently being conducted to evaluate seasonal groundwater flow patterns and VOC concentration trends. In addition to sampling for VOCs, samples are being analyzed for unfiltered beryllium using EPA Method 6010B. Selected samples are being collected for various parameters to evaluate biodegradation potential and natural attenuation of VOCs. The most recent quarterly monitoring report was submitted in December 2003.

5.0 PRIMARY CHEMICALS OF CONCERN

Based on data collected during the assessment program, a total of five VOCs were detected in groundwater above their GCTLs throughout the investigation area. The VOCs include 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride. For the most part, these five VOCs were detected above GCTLs in both grab groundwater samples and monitoring well samples. During the initial assessment programs, the metals chromium and beryllium were detected above GCTLs in a very localized area around the former Building 5 sumps. Because the lateral extent of these metals was not extensive, these chemicals were not assessed further.

6.0 VOC MASS ESTIMATION

As shown in Figures 4 and 5, the groundwater plumes of the primary chemicals of concern (COCs) have been delineated through the existing monitoring well network. The VOC mass for the chemicals TCE, PCE, 1,1-DCA and 1,1-DCE was estimated using the following equation:

$$\mathit{Mass\ of\ Chemical} = VC_l(n + K_d\rho_b)$$

where,

C_l = chemical concentration in groundwater (μg/L)

n = total effective soil porosity

ρ_b = soil dry bulk density (g/cm^3)

K_d = distribution coefficient for soil-water partitioning (cm^3/g)

V = volume of saturated soil impacted by the chemical

In order to quantify and calculate the VOC mass, the following procedures and assumptions were used:

- Thickness of the saturated aquifer is 30 feet - *see Figure 3*;
- VOC iso-concentrations of the chemical plumes were based on data collected in September and October 2003, as presented in Figures 4 and 5;
- The graphical plume depictions (Figures 4 and 5) represent depth (vertical) averages of the chemicals in the aquifer;
- Site-specific parameters of the surficial aquifer, such as soil bulk density, total effective soil porosity and soil organic carbon content (used for estimating K_d) were based on the laboratory test results of thirteen soil samples. The average values of the parameters were used in chemical mass estimation. Copies of the geotechnical laboratory reports are presented in Appendix D.
- Based on near-surface groundwater conditions (< 5 feet), VOC mass in the vadose zone is anticipated to be negligible. The September 2001 remedial excavation successfully removed most of the impacted soils at the Building #5 source area.

Based on the calculations, a total of 86 kilograms (kg), or 189 pounds (lb), of VOCs are estimated to be present in groundwater. The bulk of the VOC mass is TCE and PCE, each comprising approximately 40% of the total mass. TCE mass is estimated at approximately 35 kg, and PCE is estimated at approximately 34 kg. Results of the VOC plume mass estimations are presented in Table 1 – *see Appendix A*.

7.0 EVALUATION OF NATURAL ATTENUATION DATA

During the September / October 2003 quarterly monitoring event, groundwater samples were tested for various parameters to evaluate biodegradation potential and natural attenuation of VOCs. Parameters that were monitored in all the wells included pH, dissolved oxygen, and oxidation reduction potential (ORP). In addition, groundwater samples from six monitoring wells (MW-3, MW-4, MW-7S, MW-10, MW-15S, and MW-16S) were monitored for alkalinity, ferrous iron (Fe^{+2}), hydrogen sulfide, methane, dissolved metals (iron, manganese), general chemistry (chlorides, nitrates, nitrites, orthophosphates, sulfates, sulfides, and total organic carbon), and light volatiles (ethane, ethane). Geotechnical data were also obtained from selected soil samples throughout the investigation area, including dry density, porosity, and total organic carbon (TOC). A summary of the natural attenuation data is presented in Table 2, and a summary of the geotechnical data is presented in Table 3 – *see Appendix A.*

Natural attenuation data was evaluated in two ways. First, a score for the source area was developed based on the screening method described in "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water" (USEPA, 1998, EPA/600/R-98/128). Using this method, the concentrations of various natural attenuation parameters are compared to benchmarks and assigned a score. The individual parameter scores are added together, and the total can be used for screening. A second way to evaluate the data is by qualitatively analyzing the changes in concentrations or levels of the natural attenuation parameters upgradient of the site, at the source, and downgradient of the source. These trends can be used as indicators of anaerobic activity at a site.

EPA Scoring for Natural Attenuation

For this site, MW-10 can be considered a source well, based on its location and relatively high concentrations of chlorinated VOCs. Parameters that yielded positive scores for the source well were dissolved iron (assumed to be primarily ferrous iron), ethane, ethene, ORP, dissolved oxygen, cis-1,2-DCE, and vinyl chloride. These components yield a total score of 13 to 14, which falls into the category of "limited evidence of anaerobic biodegradation". The absence of a significant carbon source most likely slows the rate of anaerobic reduction of the chlorinated compounds.

Qualitative Analysis of VOC Concentrations and Bio-Parameters

Based on the groundwater flow direction and the presence or absence of contaminants, MW-3 can be considered as a background well. As discussed, MW-10 is a source well based on its location and the relatively high VOC concentrations consistently detected in this well. MW-4 and possibly MW-7 are the closest downgradient wells, followed by MW-15S, MW-16S, and MW-17S.

In this case, the trends of many parameters were consistent with anaerobic degradation; however, some parameter trends were indicators against anaerobic degradation. Parameter trends that suggest anaerobic degradation are the increase in chloride, specific conductivity, methane, ethane, and ethene from background through the source and downgradient. Dissolved oxygen concentrations were less than 1 mg/L in most wells, which suggest anaerobic conditions. The presence of cis-,1,2-DCE and vinyl chloride in the source well also suggests anaerobic activity.

Although the ORP values are negative, suggesting anaerobic activity, the source well ORP is greater than the background and downgradient values, whereas a significantly lower ORP compared to the background would be expected at the source. Similarly, the carbon dioxide concentration is lower at the source compared to background, and anaerobic activity would tend to increase the concentration of carbon dioxide. However, it is possible that the higher concentrations are occurring somewhat further downgradient.

Organic carbon concentrations are relatively low, but not absent. A carbon source is required for the anaerobic reduction of chlorinated VOCs. The lack of organic carbon slows down the progress of biological degradation.

The trends of several parameters were indeterminate. The concentration of sulfate increases from the background through the source. Under anaerobic conditions, sulfate concentrations would be expected to decrease. Sulfide concentrations were not consistently observed and could not be evaluated. There was very little change in alkalinity, but alkalinity would be expected to increase in the source area where biological activity would be the highest. The trend of the alkalinity is not consistent with the carbon dioxide concentration trend. Nitrate and nitrite concentrations were typically very low or absent and cannot be evaluated. Ferrous iron was not detected using the field kits, but laboratory-measured dissolved iron concentrations were relatively high. However, iron is poorly soluble except in its ferrous form and the laboratory-measured dissolved iron has been assumed to be ferrous iron.

The observation of inconsistent trends of some natural attenuation parameters at a site is not uncommon. Variations in groundwater flow directions, uncertain contaminant sources, and sporadically occurring carbon sources can lead to unusual observations. Overall, especially considering the low dissolved oxygen concentrations and the presences of TCE–degradation compounds, the site characteristics are consistent with anaerobic biological degradation of chlorinated compounds. The bio-parameter data will be collected quarterly as the RAP is being prepared. The RAP will include a detailed presentation and evaluation of bio-parameter data.

8.0 EVALUATION OF GROUNDWATER REMEDIATION ALTERNATIVES

The following summarizes the primary relevant characteristics of the site used in the preliminary screening process:

- The site was a manufacturing facility and is surrounded by undeveloped and residential areas;
- The site is underlain by a 30-foot thick surficial aquifer. The uppermost 20 to 30 feet is sand, followed by a hard sand/silt/clay layer, and a dense, cemented sand layer. The surficial aquifer is underlain by an intermediate aquifer system consisting a 45-foot thick clay layer over a 10-foot thick limestone layer;
- Chemicals of concern (COCs) identified in the surficial aquifer at concentrations greater than GCTLs are 1,1-DCA, 1,1-DCE, PCE, TCE, and vinyl chloride. The maximum COC concentration observed in a monitoring well was TCE at 820 ug/L. No VOCs were detected at concentrations greater than GCTLs in the intermediate aquifer;
- Two sources were identified. Using the most recent data and based on a 100 ug/L TCE isoconcentration line, the source areas are about 6,000 ft^2 and 28,000 ft^2. Based on the 3 ug/L TCE isoconcentration line, the area of the entire plume is about 212,000 ft^2 (~4.86 acres).
- The screening score of natural attenuation parameters suggested limited evidence of anaerobic biological degradation of chlorinated VOCs. The lack of organic carbon is probably limiting the progress of degradation.

The selection of a remedial system must consider the following important components for its implementation:

- The areal extent of the plume;
- The residential setting, with private properties within or adjacent to the VOC plume area;
- Time required to remediate the groundwater;
- Cost to remediate the groundwater;
- Degree of treatment at source areas and at downgradient portions of the plume.

A total of twelve (12) technologies were considered relevant for this preliminary screening process. In-situ technologies that were evaluated include enhanced bioremediation, electron donor addition, phytoremediation, chemical oxidation, air sparging / soil vapor extraction, and natural attenuation. Groundwater extraction was evaluated as a source reduction and plume control measure. Ex-situ treatment alternatives evaluated include biological treatment, oxidation, air stripping, and activated carbon. Table 3 summarizes and evaluates the technologies – *see Appendix A*.

Factors that eliminated certain technologies included cost, treatment time, difficulty to employ (with respect to existing buildings, both on-site and off-site), uncertainty in effectiveness, and potential impacts to adjacent residential properties. Ex-situ extraction and treatment alternatives were generally not favored based on the possibility of not being able to install optimum recovery wells at off-site locations. However, groundwater extraction may be used in conjunction with other technologies as a plume control measure. This approach will be evaluated further during the RAP development.

In-situ phytoremediation was not considered further because of site development and land use considerations. In-situ well circulation, and air sparging / soil vapor extraction, were both eliminated from further consideration based on the potential for air emissions to migrate to residential areas. Similarly, in-situ chemical oxidation uses hazardous reagents and may cause heat / vapor generation, and therefore was also eliminated as a remedy. In-situ thermal treatment methods, such as six-phase heating, were not retained based on high capital costs and long-term power requirements.

Based on the screening, the following technologies have been retained as viable potential remedial alternatives and will be evaluated in the RAP:

- In-Situ Electron Donor (ED)
- In-Situ Enhanced Bioremediation (Bioaugmentation)
- In-Situ Zero-valent iron (ZVI)
- Natural Attenuation
- Groundwater Extraction for Plume Control

Further description and evaluation of these technologies are presented in the following subsections.

8.1 In-Situ Electron Donors

Description

Electron donors (EDs) generally enhance anaerobic biological activity and can degrade chlorinated VOCs under anaerobic, reducing conditions. ED compounds are injected into the groundwater to enhance the biological activity. These compounds can be added either at the source or as a barrier across the path of the plume, or both. Further, these compounds fall into two general categories: slow-release and aqueous.

Slow-release EDs include Hydrogen Release Compound (HRC™), vegetable oil, and chitin. HRC (a proprietary compound by Regenesis) is a polymeric compound that slowly releases lactic acid into the groundwater. The lactic acid is metabolized by microorganisms that reduce the chlorinated compounds. Vegetable oil and chitin are naturally occurring materials that can be similarly used by microorganisms during the reduction of chlorinated compounds. Many of these EDs persist for months before being exhausted.

Aqueous EDs include lactate, ethanol, and similar short-chain hydrocarbons. These materials dissolve in water and typically used quickly by the microorganisms.

EDs have been applied and demonstrated at numerous sites. As noted, some compounds like HRC™ are proprietary, while other compounds are available on the open market. There are many drilling companies with experience in applying the compounds.

Application of EDs can occur in different ways, depending on the remedial goals. For example, the compounds can be injected in a series of points across the plume, perpendicular to the groundwater flow, both near the source and downgradient. Then, remediation takes place as the groundwater flows through the injected material. Injection points can also be made at the source so that the high-concentration areas are treated within a shorter timeframe. A combination of injection locations, both at the source and downgradient can be considered. Injection points could be installed along rights-of-way to minimize disruption in the neighborhood.

The injection point spacing for EDs must be determined through a pilot/treatability test. Injection point spacings of 5 to 10 feet are typical for viscous materials, while spacings of 15 to 25 feet have been observed for the more soluble materials. In general, the injection points spacing is a function of the subsurface conditions.

In addition, multiple injections are often required. The initial injection may not sufficient to completely degrade all of the contaminants, so follow-up injections may need to be conducted.

Site-Specific Considerations

A final design for this approach would require additional sampling for geochemical parameters to evaluate the biological activity at the site. If source treatment is to be part of the remediation, then additional monitoring wells and sampling to improve the delineation of the source may be required.

For on-site use, there are a few considerations. First, buildings and utilities may be in the way of optimum injection locations in the high-concentration source areas. In addition, the private residence that borders the site to the northeast is located partially within the source area, and direct injection at that location may not be possible. Thus, to treat the source, a flow-through "barrier" arrangement may be required along the road right-of-way (ROW) along the northern and eastern sides of the private lot.

For off-site use, there are additional restrictions. Because most of the areas are privately owned residences, barrier arrangements would have to be used along the road and railroad ROWs. Depending on the actual groundwater velocity, multiple injection events may be required.

8.2 In-Situ Enhanced Bioremediation (Bioaugmentation)

Description

Bioaugmentation consists of injecting microorganisms into the groundwater that are efficient at degrading specific VOCs. These microorganisms are typically applied along with nutrients and/or other substrates (such as HRC™) to co-metabolize the VOCs. The initial increase in the microbial population also serves to speed up the remedial process.

Chemical-specific microorganisms have been applied and demonstrated at numerous sites. Several companies can provide the microorganism cultures and nutrient/substrate mixtures. The organisms are mixed in water and applied using conventional DPT equipment.

There are several variations of the application. One method involves injection of the microorganisms, nutrients, and substrate directly into the groundwater, usually at the source. A combination of injection locations, both at the source and downgradient can be considered. Injection points could be installed along rights-of-way to minimize disruption in the neighborhood. A second variation withdraws groundwater, mixing in microorganisms, nutrients, and substrate above ground and then reinjecting the water. Finally, a permeable barrier can be installed across the path of the groundwater where the growth of contaminant-specific microorganisms is promoted. For this particular site, the injection method would me most applicable.

The injection point spacing for microorganisms must be determined through a pilot/treatability test. Injection point spacings of 15 to 25 feet would be expected in this case. In general, the injection points spacing is a function of the subsurface conditions.

In addition, multiple injections are often required. The initial injection may not sufficient to completely degrade all of the contaminants, so follow-up injections may need to be conducted.

Site-Specific Considerations

A final design for this approach would require additional sampling for geochemical parameters to evaluate the biological activity at the site. If source treatment is to be part of the remediation, then additional monitoring wells and sampling to improve the delineation of the source may be required.

For on-site use, there are a few considerations. First, buildings and utilities may be in the way of optimum injection locations in the high-concentration source areas. In addition, the private residence that borders the site to the northeast is located partially within the source area, and direct injection at that location may not be possible.

For off-site use, there are additional restrictions. Because most of the areas are privately owned residences, barrier arrangements would have to be used along the road and railroad ROWs. Depending on the actual groundwater velocity, multiple injection events may be required.

8.3 In-Situ Zero-Valent Iron

Description

Zero-valent iron (ZVI), through several mechanisms, allows for hydrogen to replace chlorine in chlorinated compounds. Thus, for example, TCE is converted to ethene. ZVI can be brought into contact with VOC-impacted groundwater in two ways, barriers and injection.

ZVI permeable reactive barriers (PRBs) are made by excavating trenches across the plume, perpendicular to the flow, and filling them with porous iron material. This can be the form of iron filings, pellets, and iron-coated sand. Often, impermeable barriers are placed on either side of the iron to funnel the impacted groundwater through the PRB. The time of treatment is limited by the velocity of the groundwater. Barriers can be placed near the source, downgradient, or both.

ZVI injection is a more recent development. Micrometer to nanometer sized ZVI particles are slurried with water and injected into the groundwater. The particles radiate out from the injection point. This method allows for treatment of the source directly, rather than waiting for the source plume to flow through a barrier. Alternatively, injection points can be placed close together to create a barrier in places where trenching is limited due to depth or interferences. Injection points could be installed along rights-of-way with minimum disruption in the neighborhood.

Similar to ED technology, ZVI application can occur in different ways, depending on the remedial goals. ZVI can be injected in a series of points, or PRBs can be installed across the plume, both near the source and/or downgradient. Then, remediation takes place as the groundwater flows through the injected material. Injection points can also be made at the source so that the high concentration areas are treated in a shorter time. A combination of injection locations, both at the source and downgradient can be considered.

Site-Specific Considerations

The injection points spacing for ZVI must be determined through a pilot/treatability test. Depending on the subsurface conditions, the spacing can vary from 5 to 25 feet. If source treatment is to be part of the remediation, then additional monitoring wells and sampling to improve the delineation of the source may be required.

On-site application considerations of this technology are similar to ED addition. First, buildings and utilities may be in the way of optimum injection locations in the high-concentration source areas. PRBs might be installed at the site, along the property boundaries. In addition, the private residence that borders the site to the northeast is located partially within the source area, and direct injection at that location may not be possible. Thus, to treat the source, PRBs may be required along the road ROW along the northern and eastern sides of the private lot.

Off-site application considerations of this technology are similar to ED addition. Because most of the area is privately owned, lines of injection points would have to be used along the road and railroad ROWs. Off-site PRBs would probably be prevented by property owners and buried utilities.

8.4 Natural Attenuation

Description

Natural attenuation allows for physical processes, such as dispersion, sorption, and dilution, to reduce chemical concentrations, and for biological processes to degrade contaminants. Chlorinated compounds can be biologically degraded by anaerobic microorganisms. However, this process requires a carbon source. Often, naturally-occurring carbon is present in sufficient quantities to sustain the biological activity. In many cases, a coincidental fuel release contributes the carbon.

These natural processes take a long time, on the order of several years. Groundwater modeling is often performed to estimate the time to reach cleanup goals throughout the plume. When natural attenuation is used as a remedial approach, long-term monitoring is required to track the changes in contaminant concentrations and to evaluate changes in geochemical conditions.

Site-Specific Considerations

A final design for this approach would require additional sampling for geochemical parameters to evaluate the biological activity at the site. However, existing data shows the presence of cis-1,2-DCE and vinyl chloride, which are intermediate products of the biological degradation of TCE. Existing geochemistry data suggests limited evidence of natural attenuation, based on the USEPA guidance document for natural attenuation. At the site, the limited available carbon source is most likely inhibiting the biological process. The time frame to meet cleanup goals can be estimated using public domain groundwater models.

Florida regulations have default maximum concentrations for sites where natural attenuation can be applied as a remedial alternative. For TCE, the default value is 300 ug/L; for 1,1-DCA, the value is 700 ug/L; for 1,2-DCA, the value is 300 ug/L; for cis-1,2-DCE, the value is 700 ug/L, and for PCE, the value is 300 ug/L. The TCE concentrations at the source are higher than the default value; however, the concentrations of TCE downgradient are less than the default value. Thus, natural attenuation can be considered for the downgradient portions of the plume in conjunction with an active treatment system at the source.

For off-site applications, the concentrations are all relatively low, and the existing natural attenuation data suggests that biological reduction is occurring. The approach can be used in conjunction with another source treatment technology.

8.5 Groundwater Extraction for Plume Control

Description

In this alternative, groundwater would be pumped to divert and/or control the movement of the plume. The groundwater would be modeled to identify the optimum locations and flow rates for extraction wells. Extracted groundwater would be diverted to an on-site infiltration field, a surface water discharge, or to a publicly owned treatment works (POTW). If the extracted groundwater is impacted, treatment may be required using granular activated carbon, air stripping unit or other viable treatment alternative, prior to discharge. Low VOC concentrations might be discharged to the POTW without treatment. If the water is discharged to surface water or to a POTW, the flow rate would need to be measured and recorded.

Site Specific Considerations

A pump-and-treat pilot test was conducted at the site in March 2003. The pilot study showed that the aquifer system is able to produce high rates of water [at least 10 gallons per minute (gpm)]. The pilot study included use of an air stripper and activated carbon for treatment of VOCs in groundwater. During the study, influent samples to the treatment system reported average total VOC concentrations of approximately 1,000 µg/L. *Note: the pilot test data is being further evaluated through groundwater flow and transport modeling. A detailed presentation of the pilot test results will be provided in the forthcoming RAP.*

As discussed previously, groundwater pump-and-treat is not expected to be used solely as the remedy for VOC removal. If a groundwater recovery system with a flow capacity of 10 gpm is used to treat average total VOC concentrations of 1,000 µg/L, only 1.5 pounds of VOCs would be removed per year. Low VOC recovery rates, long treatment time, and relatively high O&M costs preclude using pump-and-treat as an effective technology for VOC mass removal. However, groundwater recovery may be applied to control groundwater flow and prevent further VOC migration. As part of the RAP process, groundwater flow and transport modeling will be conducted to further evaluate this option.

Since recovery wells installed in the SAS can be expected to produce high rates of water, disposal of the water will require important considerations. If recharge is selected, then a relatively high capacity infiltration field will be needed. For a discharge to a POTW, the capacity of the sewer lines and the capacity of the plant must be considered and evaluated and a permit must be obtained from the POTW. In addition, the costs for a discharge of a high flow rate to the POTW may be significant. Discharge to surface water, such as a storm water ditch, will require treatment (possibly greater than that for groundwater recharge), a permit, and routine monitoring and reporting. However, the area is flat, and the flow capacity of existing storm water conveyance ditches may need to be evaluated.

For on-site application, the extraction wells, treatment system, and discharge can be installed as needed and kept secure. However, for offsite applications, the private properties may interfere with well locations and piping routes. The extraction well and pipelines would need to be located on right-of-ways (ROWs). A treatment system, if needed, and discharge point may need to be located on-site for security.

9.0 PROPOSED TASKS TO SUPPORT RAP DEVELOPMENT

Various actions will be conducted to support RAP development. In March 2003, a pilot test using an air stripper system was performed to determine groundwater characteristics and to evaluate the potential use of a pump and treat system as an effective technology. Data from the pumping tests and pilot test will be further evaluated during RAP development. In addition, other tasks are being performed as part of the remedial planning, including the following:

1) Treatability studies to evaluate the effectiveness of electron donor and bioaugmentation methods;
2) Preliminary two-dimensional fate and transport modeling to further understand groundwater flow conditions and evaluate potential migration of the existing chemical plumes;
3) Risk assessment to evaluate indoor air pathway for VOCs;
4) Quarterly sampling of the wells to evaluate VOC concentration trends, and monthly water level gauging of the wells to evaluate groundwater flow patterns; and
5) Preparation of RAP and remedial design.

Task 1: Electron Donor and Bioaugmentation Treatability Studies

Based on the initial screening of remedial alternatives, in-situ methods that appear applicable at the site include ED and bioaugmentation methods. Two treatability studies will be conducted to evaluate the effectiveness of these methods at the site. The first treatability study will consist of injecting a proven electron donor, HRC™, in an effort to enhance unanaerobic biological activity at the site. In the second treatability study, the microorganism *dehalococcoides ethenogenes* will be added to evaluate whether increasing the microbial population will expedite remediation. The treatability studies will be conducted at the suspected VOC source areas, spaced apart so they will not interfere with each other – *see Figure 6 for treatability study areas.* Data collected from the treatability studies will be evaluated as part of the RAP / design process.

The treatability studies may last approximately four to six months to appropriately evaluate their effectiveness. To monitor progress and effectiveness, groundwater sampling will be conducted within and just outside the treatment plots.

During the meeting with Florida Department of Environmental Protection (FDEP) on September 26, 2003, a request was made by FDEP to collect groundwater and soil samples near the base of the SAS at 30 feet bgs (i.e., at the location where cemented sands occur) to aid in the remedial design process. Tetra Tech proposes to collect a maximum of three soil and three groundwater samples to accomplish this task. The samples will be collected prior to conducting the treatability studies. Samples will be analyzed for VOCs using EPA Method 8260B.

Electron Donor Treatability Study

Chlorinated VOCs can be degraded under anaerobic, reducing conditions. Demonstrated methods to enhance anaerobic bioremediation include HRC™, a proprietary compound by Regenesis. HRC™ is a polymeric compound that slowly releases lactic acid into the groundwater. The lactic acid is metabolized by microorganisms that reduce chlorinated VOCs in groundwater.

A total of eight injection points will be completed for the HRC™ treatability study. The injection points will be spaced at approximately 10-foot centers in a staggered array. Each injection point will be drilled using direct-push technology to a depth of approximately 30 feet below ground surface (bgs). The thickness of the saturated zone will be backfilled with the HRC™ slurry, and the remaining annulus will be backfilled with bentonite chips to the surface.

To monitor the progress and effectiveness of HRC™ at the site, groundwater sampling will be conducted within and just outside the treatment plot. Four new monitoring wells (¾-inch diameter pre-packed screen) will be installed (source, up-gradient, down-gradient, and cross-gradient) to monitor and sample the groundwater. The up-gradient, down-gradient and cross-gradient wells will be installed about 10 to 15 feet from the injection points so as to be out of the immediate influence of the injected fluids. Samples will be collected prior to injection (baseline), one month after injection, and four months after injection. After four months of monitoring data, the treatability study will be re-evaluated to determine if additional monitoring and sampling may be necessary. All samples will analyzed for VOCs using EPA Method 8260B, and various bioparameters.

Bioaugmentation Treatability Study

Using chlorinated ethenes as the electron acceptor, some microorganisms can gain energy from reductive dechlorination which involves the sequential replacement of chlorine atoms by hydrogen atoms on the alkene molecule. *Dehalococcoides ethenogenes* is the only microorganism that is currently known to completely dechlorinate TCE. At sites where *dehalococcoides ethenogenes* is not present or active, bioaugmentation can stimulate the desired complete dechlorination.

A total of eight injection points will be completed for the *dehalococcoides ethenogenes* bioaugmentation study. The injection points will be spaced at approximately 10-foot centers in a staggered array. Each injection point will be drilled using direct-push technology to a depth of approximately 30 feet below ground surface (bgs). An electron donor, such as HRC™, will also be injected with the microorganisms.

To monitor the progress and effectiveness of bioaugmentation at the site, groundwater sampling will be conducted within and just outside the treatment plot. Four new monitoring wells (¾-inch diameter pre-packed screen) will be installed (source, up-gradient, down-gradient, and cross-gradient) to monitor and sample the groundwater. The up-gradient, down-gradient and cross-gradient wells will be installed about 10 to 15 feet from the injection points so as to be out of the immediate influence of the injected fluids. Samples will be collected prior to injection (baseline), one month after injection, and four months after injection. After four months of monitoring data, the treatability study will be re-evaluated to determine if additional monitoring and sampling may be necessary. All samples will be analyzed for VOCs using EPA Method 8260B, and various bioparameters. Bioassays may also be performed to monitor bioaugmentation.

Task 2: Groundwater Modeling

Groundwater flow and fate and transport modeling will be conducted to predict groundwater flow and chemical migration in the remediation area. As discussed in Section 3.2, a complex, radial groundwater flow regime is apparent at the site. Groundwater modeling will be conducted to fully understand groundwater conditions and aid in remedial design. The modeling effort will consist of three primary components:

(1) Site Conceptual Model – A three-dimensional conceptual model will be developed that simplifies the field problem and organizes and interprets the associated field data (e.g., chemical concentrations for delineating chemical plumes and quantifying chemical mass, groundwater elevations for determining groundwater contours, and aquifer parameters such as hydraulic conductivity, soil porosity, and bulk density).

(2) Numerical Groundwater Flow Model – Based on the site conceptual model, a three-dimensional numerical groundwater flow model (MODFLOW) will be developed and utilized to simulate the unconfined aquifer groundwater flow systems. MODFLOW 2000 (the latest version) simulates groundwater flow in aquifer systems using the finite-difference method. A variety of features and processes, such as rivers, springs, reservoirs, lakes, wells, evapo-transpiration, and recharge from precipitation and irrigation also can be simulated.

(3) Numerical Fate and Transport Model - A three-dimensional chemical fate and transport model (MOC3D) will then be developed and used to predict migration of chemicals in groundwater. It is a solute-transport program that is integrated with MODFLOW and has the capability to calculate change in concentration of a single solute as affected by processes of advection, dispersion, fluid sources, decay, and retardation.

Task 3: Risk Assessment for Indoor Air Evaluation

The initial indoor air evaluation will consist of applying a predictive model, the Johnson and Ettinger model (J&E), dated 1998 and revised November 2002, to estimate the potential VOC concentrations in the air inside residences. The model will incorporate site-specific geotechnical properties of soil at the site. The highest VOC concentrations detected in the groundwater will be used as an initial conservative evaluation. If the highest detected concentration results in an unacceptable level of risk, then the data that would be deemed representative of the exposure area will be identified. The 95% upper confidence limit (UCL) of this data set will be used subsequently to estimate the indoor air concentrations.

Task 4: Quarterly Well Sampling and Monthly Water Level Measurements

As part of the RAP development process and to evaluate potential seasonal fluctuations in groundwater flow and VOC concentrations, quarterly sampling of the monitoring wells will continue to be conducted. Sampling activities will be conducted in accordance with FDEP's Standard Operating Procedures for Field Activities (DEP-SOP-001/01). Groundwater samples will be collected from a total of 26 monitoring wells at the site using low-flow sampling method. Prior to purging and sampling, water level measurements will be recorded from all monitoring wells. The samples will be analyzed for VOCs using EPA Method 8260 and unfiltered beryllium using EPA Method 6010B. Selected samples will also be collected for various parameters to evaluate biodegradation potential and natural attenuation of VOCs. Monthly water level gauging of the wells and the on-site pond will be conducted to evaluate groundwater flow patterns

Task 5: Preparation of Remedial Action Plan / Design

Following completion of the treatability studies, modeling, and risk assessment, a detailed remedial action plan (RAP) will be prepared that summarizes the data and outlines the basis for selecting the remedial technology for the site. The RAP will also include a detailed presentation and evaluation of bio-parameter data. An initial design will be prepared that provides basis for design, well configurations, treatment method, equipment layout and components, and technical specifications.

10.0 REFERENCES

1. Florida Department of Environmental Protection, Water Well Permitting and Construction Requirements, Chapter 62-532, F.A.C., December 9, 1996.

2. Florida Department of Environmental Protection, Development of Soil Cleanup Criteria, Chapter 62-777, F.A.C., May 26, 1999.

3. Florida Department of Environmental Protection, Drinking Water Standards, Monitoring and Reporting, Chapter 62-550, F.A.C., August 1, 2000.

4. Jianzhong, He., et. al., Detoxification of Vinyl Chloride to Ethene Coupled to Growth of an Anaerobic Bacterium, Nature, Volume 424, 3 July 2003, Pages 62 – 65.

5. Lendvay, F., et. al., Bioreactive Barriers: A Comparison of Bioaugmentation and Biostimulation for Chlorinated Solvent Remediation, Environmental Science & Technology, Volume 37, No. 7, 2003, Pages 1422-1431.

6. Major, David, et. al., Discussion of Environment vs. Bacteria and "Oxygen Revisited", Groundwater Monitoring & Remediation, Volume 23, No. 2, Spring 2003, Pages 32-48.

7. Southwest Florida Water Management District, Final Report, ROMP TR7-2 ONECO Monitor Well Site, Manatee County, Florida, Drilling and Testing, January 1995.

8. Tetra Tech, Inc., Final Phase I Environmental Assessment, Former American Beryllium Company. February 7, 1997.

9. Tetra Tech, Inc., Final Preliminary Site Investigation Report, Former American Beryllium Company. October 20, 1997.

10. Tetra Tech, Inc., Contamination Discovery Report, Building #5, Former American Beryllium Company. July 7, 2000.

11. Tetra Tech, Inc., Initial Remedial Action Report, Former American Beryllium Company, December 12, 2001.

12. Tetra Tech, Inc., Interim Data Report and Contamination Assessment Plan Addendum #2, Former American Beryllium Company, September 13, 2002.

13. Tetra Tech, Inc., Final Contamination Assessment Report, Former American Beryllium Company, May 2003.

APPENDIX A

TABLES

Table 1
Estimate of VOC Mass in Groundwater

Chemical Name: TCE

	Parameters			Aquifer				Groundwater Concentration			Chemical Mass	
	Bulk Density	Porosity	Kd	Layer Thickness	Covering Area	Impacted Soil Volume	Aquifer Weight	Low	High	Average	Total Concentration (Soil + Water)	Mass
Chemicals	(g/cm^3)			ft	ft^2	ft^3	(kg)	(µg/L)	(µg/L)	(µg/L)	(µg/kg)	(Kg)
TCE	1.54	0.42	1.3	30	142,977	4,289,310	186,825,873	3	50	27	42	8
TCE	1.54	0.42	1.3	30	27,346	820,380	35,732,603	50	100	75	120	4
TCE	1.54	0.42	1.3	30	6,962	208,860	9,097,140	50	100	75	120	1
TCE	1.54	0.42	1.3	30	28,349	850,470	37,043,207	100	500	300	481	18
TCE	1.54	0.42	1.3	30	5,885	176,550	7,689,840	100	500	300	481	4
											Sub-total (kg) =	**35**
											Sub-total (lb) =	**77**

Chemical Names: PCE, DCA, DCE

	Parameters			Aquifer				Groundwater Concentration			Chemical Mass	
	Bulk Density	Porosity	Kd	Layer Thickness	Covering Area	Impacted Soil Volume	Aquifer Weight	Low	High	Average	Total Concentration (Soil + Water)	Mass
Chemicals	(g/cm^3)			ft	ft^2	ft^3	(kg)	(µg/L)	(µg/L)	(µg/L)	(µg/kg)	(Kg)
PCE	1.54	0.42	5.3	30	62,045	1,861,350	81,073,258	3	150	77	425	34
DCA	1.54	0.42	0.2	30	53,495	1,604,850	69,901,103	70	300	185	95	7
DCE	1.54	0.42	0.3	30	92,346	2,770,380	120,667,115	7	300	154	82	10
											Sub-total (kg) =	**51**
											Sub-total (lb) =	**112**

Total (kg) =	**86**
Total (lb) =	**189**

TABLE 2a
SUMMARY OF GEOCHEMICAL AND BIOPARAMETER DATA
OCTOBER 2003

Chemical Parameter	Well Number					
	MW-3	MW-4	MW-7S	MW-10	MW-15S	MW-16S
Methane (µg/L)	8.2	11	46	49	115.6	160
Dissolved Iron (mg/L)	0.087	0.91	0.34	2.4	0.49	3.2
Dissolved Manganese (mg/L)	ND	0.012	0.025	ND	0.02	ND
Chloride (mg/L)	1.1	14	67	26	7.7	51
NO_3 (mg/L)	ND	1.5	ND	ND	0.27	ND
NO_2 (mg/L)	ND	ND	ND	ND	ND	ND
Orthophosphate (mg/L)	ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	16	100	340	210	12	57
Sulfide (mg/L)	ND	ND	ND	ND	ND	ND
TOC (mg/L)	2.5	9.6	8.0	3.4	13	9.3
Ethane (µg/L)	ND	ND	ND	0.10	0.01	0.03
Ethene (µg/L)	0.08	0.05	0.03	0.33	0.05	0.14
ORP (Eh) (+/- mv)	-274		-81	-82	-200	-131
DO (mg/L)	0.5		0.7	0.5	0.5	0.5
Alkalinity (mg/L)	25		<10	15	<10	30
CO_2 (mg/L)	40		225	25	70	170

TABLE 2b
SUMMARY OF PURGE DATA
SEPTEMBER AND OCTOBER 2003

Well Number	pH (no units)	DO (mg/L)	ORP (mV)
September Data			
MW-4	6.26	0.84	134
MW-5	6.66	0.91	28
MW-6	7.01	0.50	-106
MW-7D	4.61	0.64	221
MW-8S	6.40	0.61	-32
MW-8D	4.73	1.01	199
MW-9S	7.14	0.49	-96
MW-9D	3.92	0.49	268
MW-11	5.42	0.44	38
MW-12	5.82	1.40	-71
MW-13S	6.29	0.62	107
MW-13D	5.16	0.91	23
MW-14S	6.89	0.43	-164
MW-14D	5.07	0.33	114
October Data			
MW-18S	6.01	1.7	-98
MW-17D	6.61	1.1	-128
MW-17S	7.33	1.2	-156
MW-16S	6.00	0.9	-131
MW-15D	5.15	0.7	-44
MW-15S	7.60	0.6	-200
MW-10	6.99	0.6	-82
MW-7S	6.47	0.8	-81
MW-3	7.74	0.8	-273
MW-18D	5.67	6.0	-107

TABLE 3
SUMMARY OF GEOTECHNICAL DATA

Sample ID	Depth (feet bgs)	Soil Description	TOC (mg/kg)	Specific Gravity	Dry Density (lb/cu ft)	Water Content (%)	Porosity (%)
MW-9-1	2 – 4	Light gray to dark gray fine sand	ND	2.65	93.7	22.2	43.3
MW-9-2	6 – 8	Dark brownish gray fine sand	--	--	103.6	20.6	37.1
MW-11-1	10 – 12	Dark gray fine sand	7010	2.64	97.3	21.0	41.0
MW-11-2	16 – 18	Dark gray fine sand	--	--	106.4	20.1	35.4
MW-11-3	18 – 20	Dark brownish gray silty fine sand	1910	2.70	85.1	36.1	49.5
HP-22-1	1.5 – 2	Light gray to dark gray fine sand	--	2.65	90.3	8.8	45.4
HP-22-2	6 – 7.5	Light gray to dark gray fine sand	ND	2.63	62.5	19.8	61.9
HP-22-3	11 – 12	Light gray to dark gray fine sand	18100	--	106.1	19.8	35.9
HP-26-1	12 – 13	Light gray to dark gray fine sand	--	--	99.9	23.8	39.6
HP-26-2	16 – 17	Light gray to dark gray fine sand	--	2.65	75.2	44.5	54.5
HP-27-1	9 – 10	Light gray to dark gray fine sand	4490	2.61	99.9	21.2	38.7
HP-28-1	13 – 14	Light gray to dark gray fine sand	--	--	93.9	22.8	42.4
HP-27-1	5 – 6	Light gray to dark gray fine sand	--	--	101.0	18.9	38.9

Table 4

Preliminary Screening of Remedial Alternatives

Process Description	Effectiveness	Implementability	Cost	Acceptance for Further Evaluation	
				Yes	No
In-situ enhanced bioremediation (addition of microbes, nutrients, and substrate)	Chemical-specific microorganisms can meet GCTLs, although the available quantity of substrate may limit the effectiveness. Additional nutrients and substrate would be needed.	Pilot tests would be required. Multiple injection events would probably be needed. Private property access may affect optimum placement of injection points. Long treatment time.	Medium to High	X	
In-situ electron donor addition	Proprietary and non-proprietary additives to enhance anaerobic reduction of chlorinated compounds can be expected to meet GCTLs. Demonstrated processes. Additional nutrient and substrate may be needed.	Pilot tests would be needed primarily to determine injection spacing. Multiple injection events would probably be needed. Private property access may affect optimum placement of injection points. Long treatment time.	Medium to High	X	
In-situ natural attenuation	Dispersion, dilution, sorption, and biological action can meet GCTLs. Less effective at source. Evaluation of the existing data suggests limited evidence of natural attenuation.	Limited to outer portions of the plume, and absence of carbon source will limit biological activity. Very long time to meet GCTLs. May not be accepted for the source by the FDEP.	Low	X	
In-situ phytoremediation	Uncertain effectiveness at this depth.	Existing development and land use would hinder placement of vegetation. Pilot testing is required. Long treatment time.	Medium		X

Table 4

Preliminary Screening of Remedial Alternatives

Process Description	**Effectiveness**	**Implementability**	**Cost**	**Acceptance for Further Evaluation**	
				Yes	**No**
In-situ air sparging/vapor extraction (AS/VE); horizontal wells or vertical wells could be used	Would be effective in shallow groundwater and sand, although deeper fines are more difficult to treat.	Potential air emissions to residential area and into residences. Very difficult to employ and secure off-site. While it could be argued that the technology could be used to treat source areas only, the northwest corner private residence impacts the effectiveness and emissions control. Shallow water table may limit efficiency of VE. Private property access may affect optimum placement of AS/VE points. Equipment noise could be a nuisance. Medium treatment time. Long-term O&M of blowers and emission controls.	Medium to High		X
In-situ chemical oxidation (Fenton's reagent, permanganate)	Demonstrated method, although deeper fines sands are more difficult to treat.	Hazardous reagents and heat/vapor generation make this a poor off-site technology, although could be used on-site. Pilot testing needed to determine spacing of injection points. Private property access may affect optimum placement of injection points. Short treatment time.	Medium to High		X
In-situ thermal treatment	Demonstrated method. VE used to collect contaminants in the vapor phase.	Not economical for VOCs when compared to more common methods. Potential air emissions to residential area and into residences. Very difficult to employ and secure off-site, although could be used on-site. Pilot study needed to determine spacing of VE well points. Private property access may affect optimum placement of VE points and the corner private lot impacts effectiveness and emissions control. Short treatment time.	High		X

Table 4

Preliminary Screening of Remedial Alternatives

Process Description	Effectiveness	Implementability	Cost	Acceptance for Further Evaluation	
				Yes	No
In-situ circulating wells (in-well stripping)	Would be effective in shallow groundwater and sand, although deeper fines sands are more difficult to treat.	Potential air emissions to residential area and into residences. Very difficult to employ and secure off-site, although could be used on-site. Private property access may affect optimum placement of wells. Long-term O&M of treatment equipment. Medium treatment time.	High		X
In-situ permeable reactive barriers (PRB) zero-valent iron (ZVI)	Demonstrated process to meet GCTLs.	Optimum placement of barriers may not be possible in residential areas, except in road rights-of-way. Applicable in shallow groundwater layer. Relatively long treatment time until groundwater flows through PRB.	Medium to High	X	
In-situ ZVI micro- or nano-particles	Suspensions of ZVI injected through plume can meet GCTLs.	Optimum placement of injection points may not possible in residential areas, but suspension typically travels well beyond injection point. Pilot testing needed to determine spacing of injection points. Private property access may affect optimum placement of injection points. Medium treatment time.	Medium to High	X	
Ex-situ treatment (biological, oxidation, UV, air stripping, activated carbon)	Several ex-situ methods can meet GCTLs in the extracted groundwater. Initial high contaminant removal rates followed by low removal rates. Pump and treat is not a favored technology.	Difficult to employ and secure off-site, although could be used on-site. Private property access may affect optimum placement of wells. Long-term O&M of treatment equipment. Long treatment time.	Medium to High		X

Table 4

Preliminary Screening of Remedial Alternatives

Process Description	Effectiveness	Implementability	Cost	Acceptance for Further Evaluation	
				Yes	No
Extraction for plume control	Effective at controlling shape and extent of plume. May be needed to bring northeastern portion of plume into area where treatment can be performed. Treatment may be required depending on contaminant concentrations in groundwater.	Disposal method may affect treatment level. Recharge to groundwater will require treatment to GCTLs. Surface water discharge may require higher level of treatment; POTW discharge may require minimal treatment. Private properties may affect optimum placement of extraction wells.	Low to Medium	X	

APPENDIX B

FIGURES

FIGURE 1
SITE LOCATION MAP

Former American Beryllium Company
1600 Tallevast Rd., Tallevast, FL.

FIGURE 2
GROUNDWATER ELEVATION CONTOUR MAP

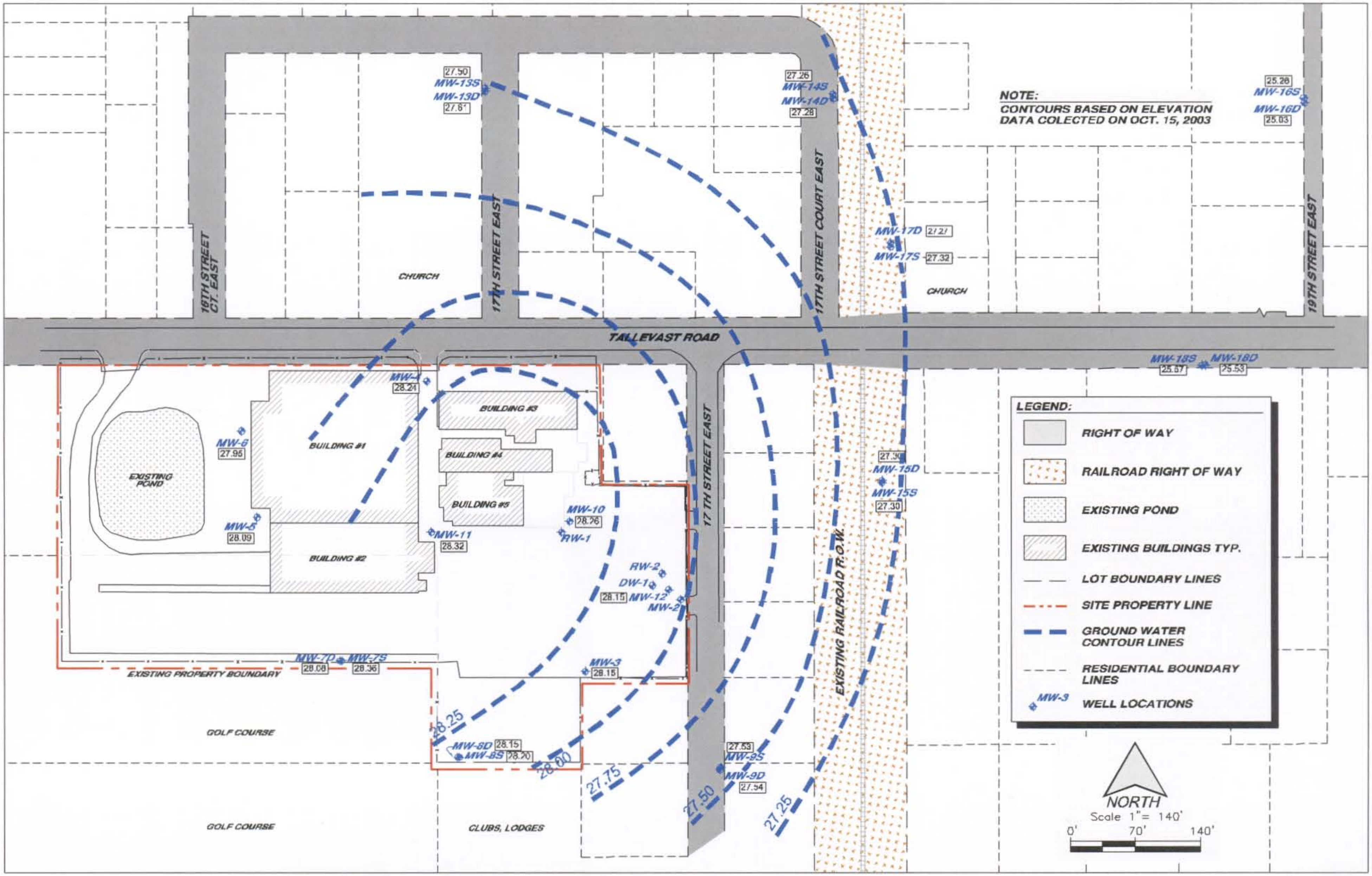
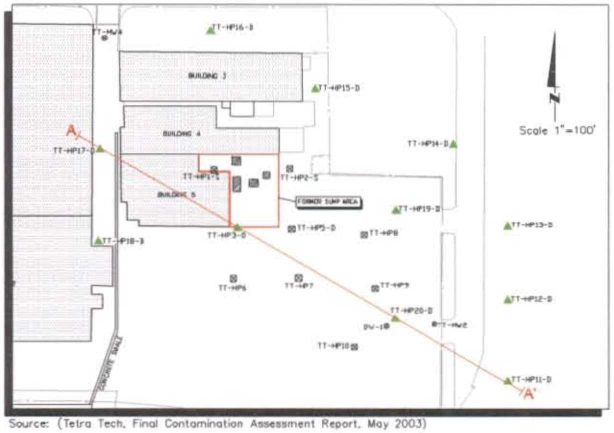


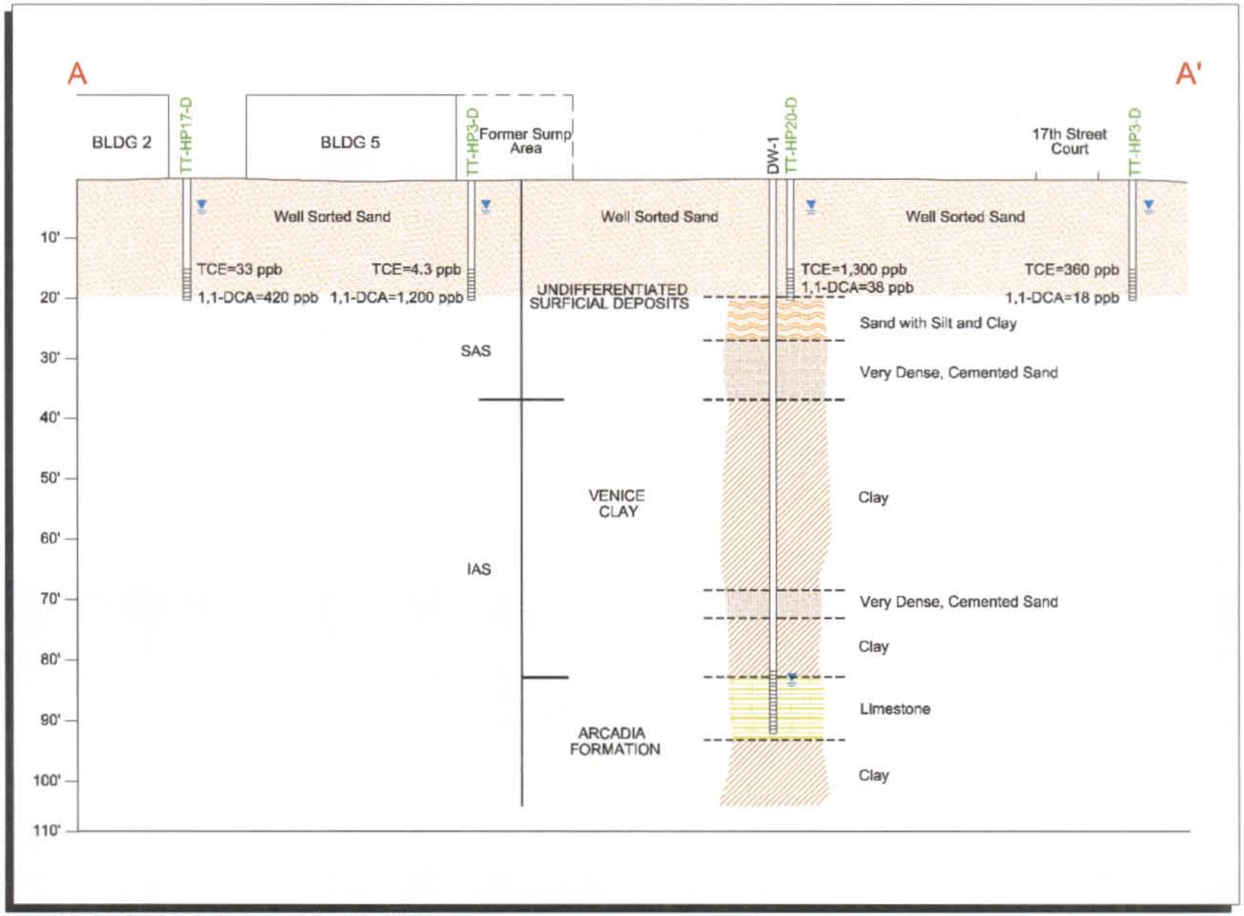
FIGURE 3
CROSS SECTION A-A'



Source: (Tetra Tech, Final Contamination Assessment Report, May 2003)

LEGEND

☒	TEMPORARY MONITORING WELL (INSTALLED FEB. 2001)
▲	TEMPORARY MONITORING WELL (INSTALLED DEC. 2001)
⊗	PERMANENT MONITORING WELL
▼	GROUNDWATER LEVEL
▨	FORMER SUMP



Source: (Tetra Tech, Final Contamination Assessment Report, May 2003)

FIGURE 4
TCE ISOCONCENTRATION MAP

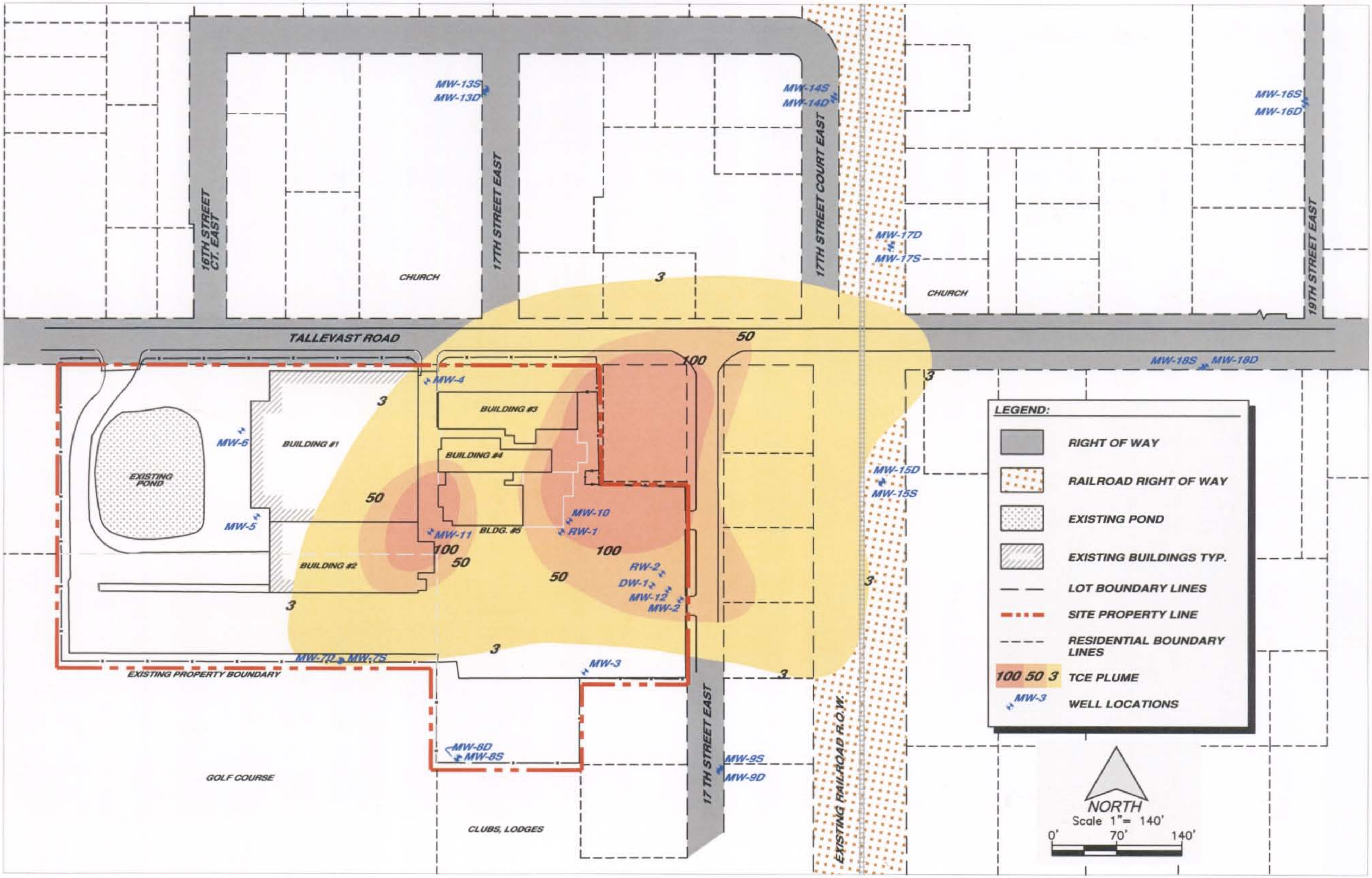


FIGURE 5
ESTIMATED EXTENT OF PCE, 1,1-DCA AND 1,1-DCE

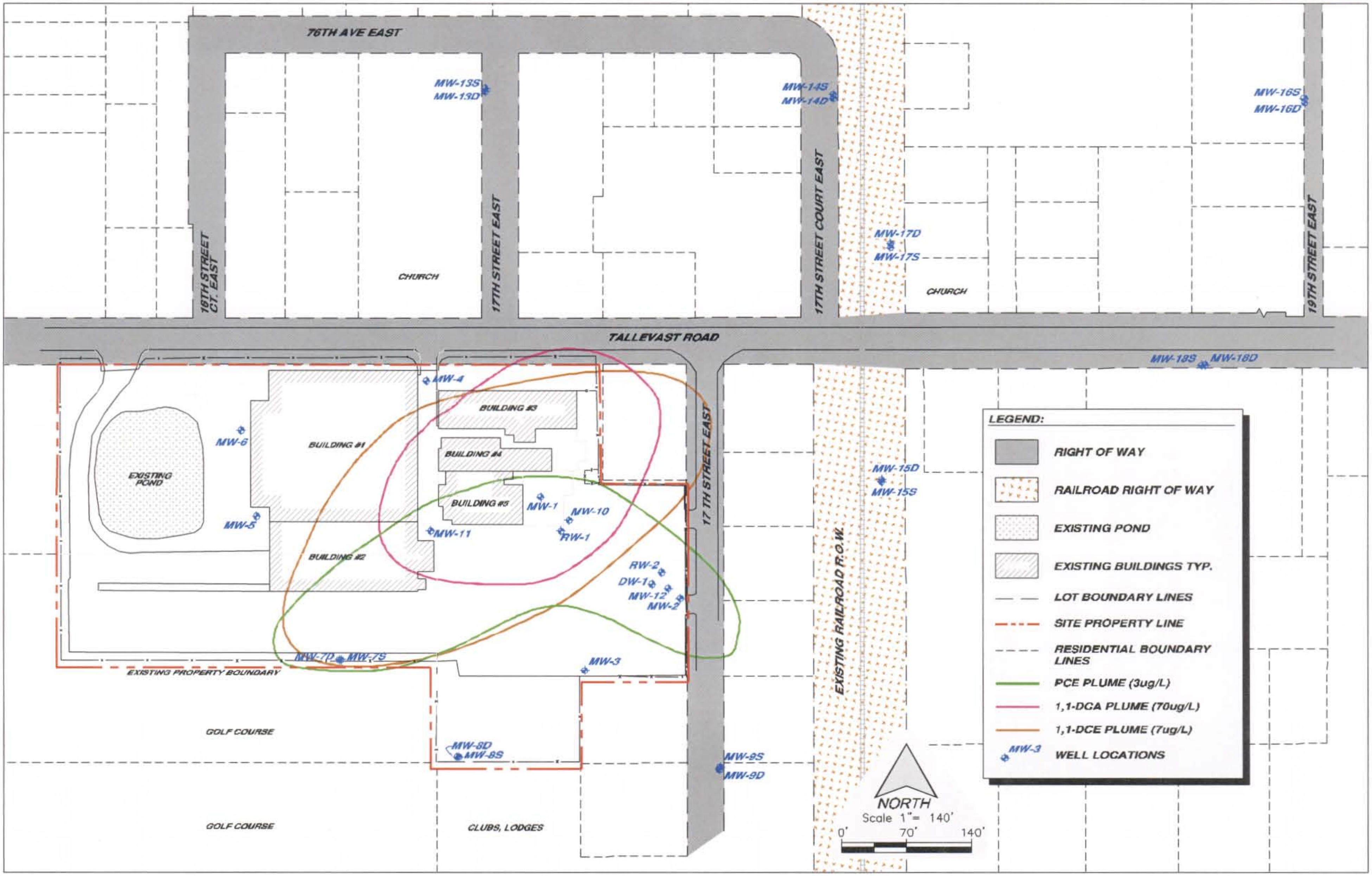
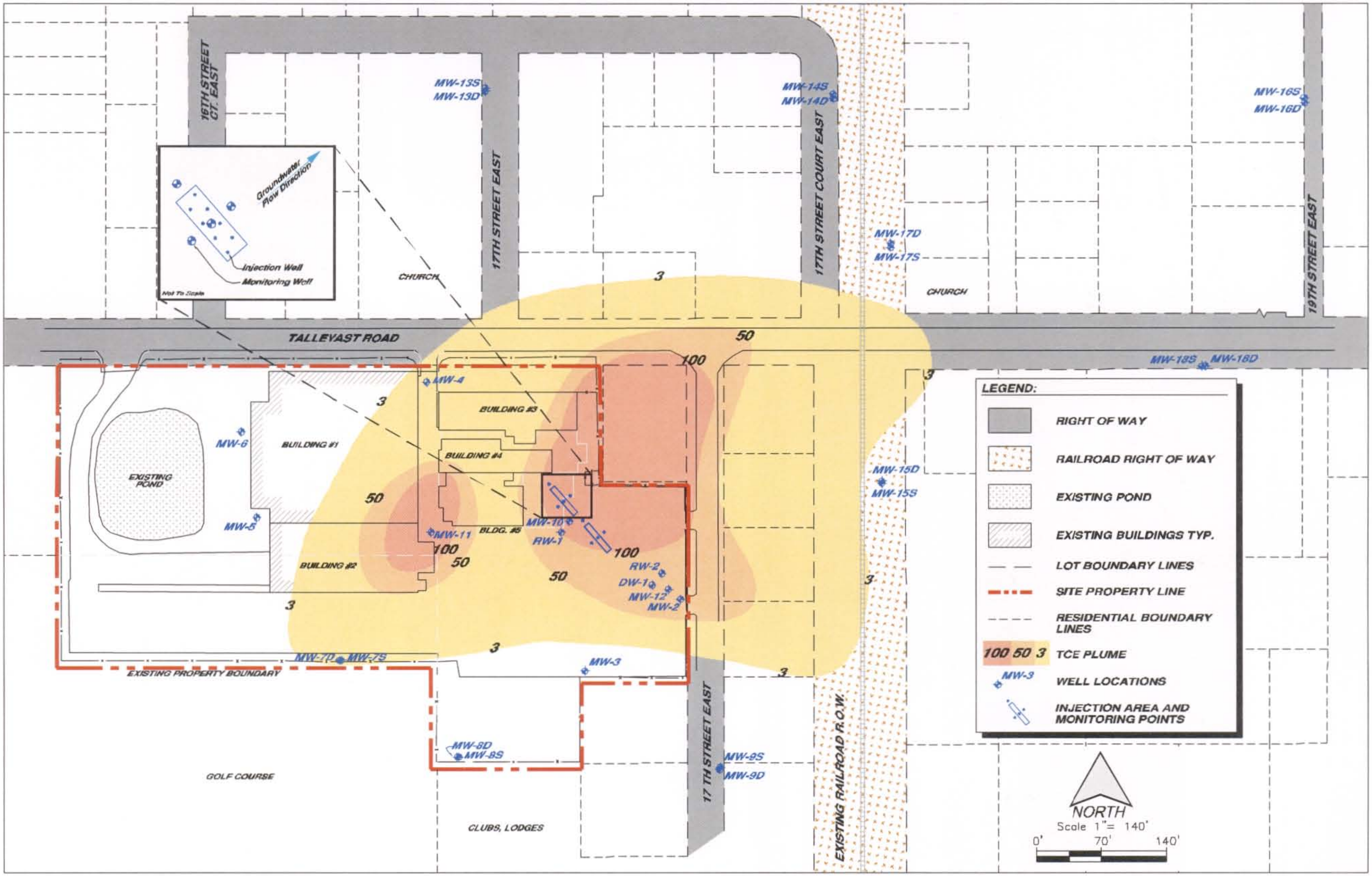


FIGURE 6
TREATABILITY STUDY PLOTS



APPENDIX C

FDEP CORRESPONDENCE

Department of Environmental Protection

Jeb Bush
Governor

Southwest District
3804 Coconut Palm Drive
Tampa, Florida 33619

David B. Struhs
Secretary

July 25, 2003

Gustave Effotte
Project Manager
Corporate Energy, Environment, Safety & Health
6801 Rockledge Drive MS DM 315
Bethesda, MD 20817

Re: **Final Contamination Assessment Report Approval and RAP Request**
Former American Beryllium Company
1600 Tallevast Road
Tallevast, Manatee County

Dear Mr. Effotte,

The Florida Department of Environmental Protection (the Department) has received and reviewed the above referenced report, dated May 9, 2003 and received June 2, 2003. Thank you very much for submitting this information for review. Based on the information provided, the Department believes that the contamination assessment is complete and is approving the assessment document.

Please prepare a remedial action plan (RAP) to address the groundwater contamination on this site within 60 days of receipt of this letter. As part of the remedial action phase for this site, please install permanent point of compliance monitor wells at the locations of TT-HP30-D and TT-HP34-D. If you should have any questions, please contact me at (813) 744-6100 ext. 376.

Sincerely,

Michael Gonsalves
Professional Geologist II
Waste Cleanup Section
FDEP SWD

cc: Dan Batrack, Tetra Tech
Mark Stuckey, BWC
Paul Paneck, Manatee County Pollution Control

"More Protection, Less Process"

APPENDIX D

GEOTECHNICAL DATA REPORTS

LABORATORY TESTING OF SOIL SAMPLES FROM "LOCKHEED SARASOTA ABC," SARASOTA COUNTY, FLORIDA

Ardaman & Associates, Inc.

OFFICES

Orlando, 8008 S. Orange Avenue, Orlando, Florida 32809, Phone (407) 855-3860
Bartow, 1525 Centennial Drive, Bartow, Florida 33830, Phone (863) 533-0858
Cocoa, 1300 N. Cocoa Boulevard, Cocoa, Florida 32922, Phone (321) 632-2503
Fort Lauderdale, 3665 Park Central Boulevard North, Pompano Beach, Florida 33064, Phone (954) 969-8788
Fort Myers, 9970 Bavaria Road, Fort Myers, Florida 33913, Phone (941) 768-6600
Miami, 2608 W. 84th Street, Hialeah, Florida 33016, Phone (305) 825-2683
Port Charlotte, 740 Tamiami Trail, Unit 3, Port Charlotte, Florida 33954, Phone (941) 624-3393
Port St. Lucie, 1017 S.E. Holbrook Ct., Port St. Lucie, Florida 34952, Phone (561) 337-1200
Sarasota, 2500 Bee Ridge Road, Sarasota, Florida 34239, Phone (941) 922-3526
Tallahassee, 3175 West Tharpe Street, Tallahassee, Florida 32303, Phone (850) 576-6131
Tampa, 3925 Coconut Palm Drive, Suite 115, Tampa, Florida 33619, Phone (813) 620-3389
West Palm Beach, 2511 Westgate Avenue, Suite 10, West Palm Beach, Florida 33409, Phone (561) 687-8200

MEMBERS:
A.S.F.E.
American Concrete Institute
American Society for Testing and Materials
Florida Institute of Consulting Engineers

Ardaman & Associates, Inc.

Geotechinical, Environmental and
Materials Consultants

February 5, 2003
File No. 02-8799

TO:
Tetra Tech, Inc.
401 East Ocean Boulevard, Suite 810
Long Beach CA 90802

Attention: Mr. Phil Skorge

SUBJECT: Laboratory Testing of Soil Samples from "Lockheed Sarasota ABC," Sarasota County, Florida

---

Dear Mr. Skorge:

As requested, our firm has completed laboratory testing of soil samples from the subject site. The subject samples were obtained and delivered to our laboratory by others, and the test results are representative of the samples, as received.

The laboratory testing program included determining the soil density (ASTM D-2937), specific gravity (ASTM D-854), moisture content (ASTM D-2216) and total organic carbon content (EPA Method 9060). Soil porosity was also calculated from the specific gravity and dry density test results. All tests were performed by Ardaman & Associates, Inc. except that total organic carbon (TOC) content was determined by PEL Laboratories, Inc. The analytical chemistry reports from PEL Laboratories are also included in Appendix I, for your reference.

The test results are summarized in the attached Table 1. Note that samples TTHP20-2 and TTHP24-2 were received with a significant amount of sample disturbance. This is likely the cause of the relatively low dry density and relatively high porosity reported for these two (2) samples.

We appreciate the opportunity to serve you on this project. Please contact us if we may be of further service or if you should have any questions concerning this report.

Very truly yours,

Ardaman & Associates, Inc.

2/6/03

Jerry H. Kuehn, P.E.
Senior Project Engineer
Eng. Reg. No. 35557

Gary H. Schmidt, P.E.
Vice President
Eng. Reg. No. 12305

JK/GHS:nh

2500 Bee Ridge Road (34239), Post Office Box 15008, Sarasota, Florida 34277-1008 Phone (941) 922-3526 Fax (941) 922-6743
Offices, in: Bartow, Fort Lauderdale, Fort Myers, Miami, Orlando, Port Charlotte, Port St. Lucie, Sarasota, Tallahassee, Tampa, W. Palm Beach

Table 1
LABORATORY TEST RESULTS

Sample I.D.	Depth (feet)	Soil Description	TOC (mg/kg)	Specific Gravity	Dry Density (lb/cu.ft.)	Water Content (%)	Porosity (%)
MW-9-1	2 - 4	Light gray to dark gray (mixed) fine sand	ND	2.65	93.7	22.2	43.3
MW-9-2	6 - 8	Dark brownish gray fine sand	----	----	103.6	20.6	37.1
MW-11-1	10 - 12	Dark gray fine sand	7010	2.64	97.3	21.0	41.0
MW-11-2	16 - 18	Dark gray fine sand	----	----	106.4	20.1	35.4
MW-11-3	18 - 20	Dark brownish gray silty fine sand	1910	2.70	85.1	36.1	49.5
TTHP 20-1	1.5 - 2	Pale brown to brown fine sand	----	2.65	90.3	8.8	45.4
TTHP 20-2*	6 - 7.5	Pale brown to brown fine sand	ND	2.63	62.5	19.8	61.9
TTHP 20-3	11 - 12	Dark brown fine sand with silt	18100	----	106.1	19.8	35.9
TTHP 24-1	12 - 13	Dark brown fine sand with silt	----	----	99.9	23.8	39.6
TTHP 24-2*	16 - 17	Brown silty fine sand	----	2.65	75.2	44.5	54.5
TTHP 25-1	9 - 10	Gray fine sand	4490	2.61	99.9	21.2	38.7
TTHP 26-1	13 - 14	Gray fine sand	----	----	93.9	22.8	42.4
TTHP 27-1	5 - 6	Pale brown fine sand with silt	----	----	101.0	18.9	38.9

ND - not detected
* disturbed sample

APPENDIX

1010000 1000101 1100110
PEL Laboratories, Inc.

ACCREDITED IN ACCORDANCE WITH nelac
Florida Department of Health #E84207
July 1, 2002 - June 30, 2003

CWA - Extractable Organics, General Chemistry,Metals,
Pesticides-herbicides-PCB's, Volatile Organics
RCRA/CERCLS - Extractable Organics, General Chemistry, Metals
Pesticides-Herbicides-PCB's, Volatile Organics

- CERTIFICATE OF ANALYSIS -

Report Date: 12/27/2002

To: Jerry Kuehn
Ardaman & Associates
2500 Bee Ridge Road
Sarasota, FL 34239

W 941-922-3526
F 941-922-6743

PROJECT ID: Lockheed Sarasota ABC

WORK ORDER: 2212146

DATE RECEIVED: Thursday, December 19, 2002

Project Notes:

(†): Short Hold Time Analysis Date

PEL Contact: Mark Gudnason / extension: 242

PEL Laboratories, Inc.

Chain of Custody Record
Record/Work Request

4420 Pendola Point Road
Tampa, Florida 33619
(813) 247-2805 • Fax: (813) 248-1537
E-Mail: login@Pelab.com

2212-1465P

Company: Ardaman & Associates, Inc.
Address: 2500 Bee Ridge Rd.
Sarasota, FL 34239
Phone: 941-922-3526 Fax: 941-922-6779

Project Name/Number: Lockheed Sarasota, ABC
Project Manager: Jerry Kuehn
Purchase Order:

Page 1 of 1
DEP Form #: 62-770.900(2)
Form Title: Chain of Custody Record
Effective Date: September 23, 1997
FDEP Facility No.
Project Name:
Sampling CompQAP No:
Approval Date:
REQUESTED DUE DATE / /

Print Names(s) / Affiliation
Sampler(s) Signature(s) N/A

Preservatives (see codes): none
Analyses Requested: TOC

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	TOC	Remarks	Lab. No.
1	TTHP20-2	12/18/02		grab	SO	1	✓	EPA 9060	01
2	TTHP20-3	↓		↓	↓	1	✓	↓	02
3	TTHP25-1	↓		↓	↓	1	✓	↓	03

Shipment Method
3 ← Total Number of Containers

Out: / / Via:
Returned: / / Via:

Item Nos.	Relinquished by / Affiliations	Date	Time	Accepted by / Affiliation	Date	Time
1-3	X-town	12/19/02	4:40	Gerol Malu	12/19	4:40 pm
					12/19/02	18:00

Additional Comments: report to: Ardaman, but invoice to:
Tetra Tech, Inc.
401 E Ocean Blvd, Suite 810
Long Beach, CA 90802
attn: Phil Skorge

Cooler No. (s) / Temperature(s) (C): Temp upon rec't 4C. Due date: 12-27-02
Sampling Kit No.
Equipment ID No.

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)
PRESERVATION CODES: H-Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212185
PROJECT ID: Lockheed Sarasota ABC

Brian C. Spann	Laboratory Manager
David Cantillo	Quality Assurance
Lisa Pelo	Volatiles Team Leader

DATA QUALIFIER CODES

State of Florida, Department of Environmental Protection &
Department of Health & Rehabilitative Services

J	Estimated value; value not accurate. This code shall be used in the following instances: 1. Surrogate recovery limits have been exceeded. 2. No known quality control criteria exists for the component 3. The reported value failed to meet the established quality control criteria for either precision or accuracy 4. The sample matrix interfered with the ability to make an accurate determination 5. If the data is questionable because of improper laboratory or field protocols (e.g. composite sample was collected instead of a grab sample) Note: a "J" value shall be accompanied by justification for it's use, and shall not be used if another code applies (e.g. L, V, Y, Q).
L	Off-scale high. Actual value is known to be greater then the value given. To be used when the concentration of the analyte is above the acceptable limit for quantitation (exceeds the linear range of the highest calibration standard) and the calibration curve is known to exhibit a negative deflection.
Q	Sample held beyond acceptable holding time. This code shall be used if the value is derived from a sample that was prepared or analyzed after the approved holding time restrictions for the sample preparation or analysis.
U	Indicates that the compound was analyzed for but not detected. This shall be used to indicate that the specified component was not detected. The value associated with the qualifier shall be the laboratory reporting limit. Unless requested by the client, values less than the reporting limit shall not be reported.
V	Indicates that the analyte was detected in both the sample and the associated method blank. Note: The value in the blank shall not be subtracted from associated samples.
Y	The laboratory analysis was from an unpreserved or improperly preserved sample. The data may not be accurate.

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212146
PROJECT ID: Lockheed Sarasota ABC

PEL Lab# : 221214601
Client ID : TTHP20-2
Matrix : SO

Collection Information:
Sample Date: 12/18/2002
ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	ND	12/27/2002	12/27/2002	mg/Kg	90	1

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To:	Jerry Kuehn Ardaman & Associates	**WORK ORDER:**	2212146
		PROJECT ID:	Lockheed Sarasota ABC

PEL Lab# : 221214602

Client ID : TTHP20-3

Matrix : SO

Collection Information:

Sample Date: 12/18/2002

ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	18100	12/27/2002	12/27/2002	mg/Kg	90	1

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212146

PROJECT ID: Lockheed Sarasota ABC

PEL Lab# : 221214603

Client ID : TTHP25-1

Matrix : SO

Collection Information:

Sample Date: 12/18/2002

ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	4490	12/27/2002	12/27/2002	mg/Kg	90	1

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212146
PROJECT ID: Lockheed Sarasota ABC

Brian C. Spann	Laboratory Manager
David Cantillo	Quality Assurance
Lisa Pelo	Volatiles Team Leader

1010000 1000101 1100110
PEL Laboratories, Inc.

ACCREDITED IN ACCORDANCE WITH nelac
Florida Department of Health #E84207
July 1, 2002 - June 30, 2003

CWA - Extractable Organics, General Chemistry,Metals,
Pesticides-herbicides-PCB's, Volatile Organics
RCRA/CERCLS - Extractable Organics, General Chemistry, Metals
Pesticides-Herbicides-PCB's, Volatile Organics

- CERTIFICATE OF ANALYSIS -

Report Date: 01/03/2003

To: Jerry Kuehn
Ardaman & Associates
2500 Bee Ridge Road
Sarasota, FL 34239

W 941-922-3526
F 941-922-6743

PROJECT ID:	Lockheed Sarasota ABC
WORK ORDER:	2212185
DATE RECEIVED:	Monday, December 30, 2002

Project Notes:

(†): Short Hold Time Analysis Date

PEL Contact: Mark Gudnason / extension: 242

PEL Laboratories, Inc.

Chain of Custody Record
Record/Work Request

4420 Pendola Point Road
Tampa, Florida 33619
(813) 247-2805 • Fax: (813) 248-1537
E-Mail: login@Pelab.com

2212-185 SB

Company: Ardaman & Associates.	Project Name/Number: Lockheed Sarasota ABC.
Address: 2500 Bee Ridge Rd. Sarasota, FL 34239	Project Manager: Jerry Kuehn
Phone: 941-922-3526 Fax: 941-922-6743	Purchase Order:

Page of

DEP Form #: 62-770.900(2)
Form Title: Chain of Custody Record
Effective Date: September 23, 1997
FDEP Facility No.
Project Name:
Sampling CompQAP No.
Approval Date:

REQUESTED DUE DATE
/ /

Print Names(s) / Affiliation

Sampler(s) Signature(s) N/A

Preservatives (see codes): none

Analyses Requested

Item No.	Field ID No.	Sampled Date	Sampled Time	Grab or Composite	Matrix (see codes)	Number of Containers	TOC									Remarks	Lab. No.
1	MW9-1	12/23/02		grab	SO	1	✓							0	1	EPA 9060	
2	MW11-1	↓		↓	↓	1	✓							0	2	↓	
3	MW11-3	↓		↓	↓	1	✓							0	3	↓	

Shipment Method

3 ← Total Number of Containers

Out: / / Via:
Returned: / / Via:

Item Nos	Relinquished by / Affiliations	Date	Time	Accepted by / Affiliation	Date	Time
1-3		12/30/02	10:40		12-30	1040
		12/30/02	1150		12/30	11:55

Additional Comments: report to Ardaman but invoice to:
Tetra Tech, Inc.
401 E. Ocean Blvd., Suite 810
Long Beach, CA 90802
Attn: Phil Skorge

Temp upon rec't RT
Due Date: 1-7-03

Cooler No. (s) / Temperature(s) (C)
Sampling Kit No.
Equipment ID No.

MATRIX CODES: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water W = Water (Blanks) O = Other (specify)

PRESERVATION CODES: H-Hydrochloric acid + ice I = Ice only N = Nitric acid + ice S = Sulfuric acid + ice O = Other (specify)

PEL Laboratories, Inc.

DATA QUALIFIER CODES

State of Florida, Department of Environmental Protection &
Department of Health & Rehabilitative Services

J Estimated value; value not accurate. This code shall be used in the following instances:

1. Surrogate recovery limits have been exceeded.
2. No known quality control criteria exists for the component
3. The reported value failed to meet the established quality control criteria for either precision or accuracy
4. The sample matrix interfered with the ability to make an accurate determination
5. If the data is questionable because of improper laboratory or field protocols (e.g. composite sample was collected instead of a grab sample)

Note: a "J" value shall be accompanied by justification for it's use, and shall not be used if another code applies (e.g. L, V, Y, Q).

L Off-scale high. Actual value is known to be greater then the value given. To be used when the concentration of the analyte is above the acceptable limit for quantitation (exceeds the linear range of the highest calibration standard) and the calibration curve is known to exhibit a negative deflection.

Q Sample held beyond acceptable holding time. This code shall be used if the value is derived from a sample that was prepared or analyzed after the approved holding time restrictions for the sample preparation or analysis.

U Indicates that the compound was analyzed for but not detected. This shall be used to indicate that the specified component was not detected. The value associated with the qualifier shall be the laboratory reporting limit. Unless requested by the client, values less than the reporting limit shall not be reported.

V Indicates that the analyte was detected in both the sample and the associated method blank.
Note: The value in the blank shall not be subtracted from associated samples.

Y The laboratory analysis was from an unpreserved or improperly preserved sample. The data may not be accurate.

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212185

PROJECT ID: Lockheed Sarasota ABC

PEL Lab# : 221218501

Client ID : MW9-1

Matrix : SO

Collection Information:

Sample Date: 12/23/2002

ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	ND	12/30/2002	12/30/2002	mg/Kg	90	1

- CERTIFICATE OF ANALYSIS -

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212185

PROJECT ID: Lockheed Sarasota ABC

PEL Lab# : 221218502

Client ID : MW11-1

Matrix : SO

Collection Information:

Sample Date: 12/23/2002

ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	7010	12/30/2002	12/30/2002	mg/Kg	90	1

- CERTIFICATE OF ANALYSIS -

ACCREDITED IN ACCORDANCE WITH nelac

FLDOH #E84207

To: Jerry Kuehn
Ardaman & Associates

WORK ORDER: 2212185
PROJECT ID: Lockheed Sarasota ABC

PEL Lab# : 221218503
Client ID : MW11-3
Matrix : SO

Collection Information:
Sample Date: 12/23/2002
ND = Less than RL

Parameter	Method	Results	Analysis Date	Prep Date	Units	RL	Dilution Factor
TOC	9060	1910	12/30/2002	12/30/2002	mg/Kg	90	1